ICES WGITMO Report 2006

ICES Advisory Committee on the Marine Environment

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# Working Group on Introductions and Transfers of Marine Organisms (WGITMO)

16–17 March 2006

Oostende, Belgium

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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# Contents

# 1 Summary

In 2006 the ICES Working Group on Introductions and Transfers of Marine Organisms met in Oostende, Belgium with Stephan Gollasch (Germany) as Chair. The meeting venue was the Institute for Agricultural and Fisheries Research, Oostende, Belgium with Francis Kerckhof (Management Unit of the North Sea Mathematical Models, Oostende, Belgium) as host. Representatives from Belgium, Canada, France, Germany, Italy, the Netherlands, Norway, Sweden, United Kingdom, and the United States of America contributed to the discussions. National Reports were received from 14 countries.

## Progress with Terms of reference

**ToR a)** National Reports: Highlights and Use of Reports.

National Reports were submitted by the following countries: Belgium, Canada, Estonia, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, United Kingdom, and United States of America. Additional information was made available from Ireland and Spain.

**Status:** completed for 2005, ongoing.

WGITMO Members discussed the use of the National Reports and their potential audience. National Reports continue to be used for:

- Documentation of the spread of intentionally imported and/or invasive species over time and to new geographic areas. This may be a unique data set especially when considering the long time series.
- Determination which species are to be evaluated for an Alien Species Alert Reports.
- Answering information requests for organizations (e.g., REGNS-ToR b of 2006 WGITMO meeting)
- Providing a warning system for ICES member countries that invasives species have been found in neighbouring jurisdictions, or countries having similar habitat conditions and enabling follow up of the spread of previously introduced species, especially for secondary spread across political borders.
- Giving indications which intentionally introduced species (e.g. for aquaculture use) have the potential to become invasive (e.g., Pacific oyster, *Crassostrea gigas*) and to provide a follow-up to track their spread.
- Documenting exports and imports. Often such records are sketchy, but can be improved through records from other jurisdictions.
- Documenting the occurrence of unintentional introductions of parasites and disease agents.
- Providing information to other working groups, both within and outside of ICES and raising awareness of invasive and imported/transferred species in such groups and providing on harmful algae, diseases, ship-mediated introductions and working groups focussed on certain taxa.
- Deliver supporting information for legislations such as the developing EU directive on species in containment.
- Facilitate the coordination of research activities within ICES member countries.
- Promotion of relevant scientific meetings and research initiatives.
- Documenting the success of mitigation measures or management of introduced non-target species, i.e. avoidance to duplicate unsuccessful approaches.

**Informational highlights of the meeting:**

As reported in the National Report from the United Kingdom, a recent review of past introductions of non-native fish in 17 countries of Europe and North America (Copp *et al.*, 2005b) found that the USA (93) and France (35) are at the top of the list of intentional fish introductions, followed by the Czech Republic, Russia, Romania, Austria and Spain (27 to 21), with the other countries (including England & Wales) having <20 intentional introductions but only Germany had <10 such introductions.

ICES Member Countries imported live organisms from 32 countries with fish and molluscs being the most imported taxa. The country with the highest number of source regions in commercial species imports in 2005 was Germany with 17 source regions to be followed by Sweden with 16. Most other importing countries import species from less than 5 source regions. However, it should be noted that the detail level when documenting species varies enormously between certain countries. Several countries refer to source regions as "from various countries" thereby documenting that more detailed information is not available. Germany imports predominantly fish and molluscs. In other countries no clear trend is obvious.

As in previous years, the most commonly moved species in 2005 were Atlantic salmon *Salmo salar* and the Pacific oyster *Crassostrea gigas*.

Accidental species introductions continue to be reported. Of particular concern are the first records of *Neogobius melanostomus* and *Rapana venosa* in the southern North Sea as both species showed negative impacts in other regions they invaded. The previously introduced non-indigenous oyster *Crassostrea gigas* continues to spread in the Wadden Sea. *Didemnum* sp. continue to spread. In an estuary north of Dublin in October 2005 a growth form of *Didemnum* sp. was found to overgrow fouling on marina pontoons and heavily fouled leisure craft. Eleven new invertebrate species have been added to the list of introduced species found in Italian waters. The Red King crab *Paralithodes camtschaticus* has continued its south- and westward migration and several individuals have been caught outside Tromsø. In Sweden every year single specimens of the Chinese mitten crab, *Eriocheir sinensis*, are reported to have been caught by fishermen. Here, the large Asiatic red alga *Gracilaria vermiculophylla*, first recorded during August-September 2003, *Sargassum muticum* and *Aglaothamnion halliae*is were recorded much further south than previously. The raphidophyte *Chattonella* aff. *verruculosa* was noted in low numbers on the Swedish west coast in April 2005 and again in November. In 2006, it was present in abundances up to ca 30 000 cells per litre, both on the Swedish west coast and in S Norway. In February 2006, numbers over 200 000 cells per litre were recorded on the Swedish west coast. The parasite *Gyrodactylus salaris* was found at a fish farm, on the Swedish west coast. IPN-V (infectious pancreatic necrosis) was recorded in a fish farm on the west coast. Dead perch found north of the city of Stockholm died from attacks of the freshwater fungus *Branchiomyces denigrans*, which previously has not been recorded from Sweden. The UK Environment Agency found seven individuals of *Sarsiella* (*Eusarsiella*?) *zostericola*, an alien ostracod species predating in a grab sample at Mucking Flats on the Thames. The Scottish Association of Marine Science has reported *Caprella mutica*. *Sargassum muticum* has continued to spread in Wales and was also found along the west coast of Scotland. The range of Signal crayfish (*Pacifastacus leniusculus*) continues to expand. There was one outbreak of crayfish plague in native crayfish in 2005.

WGITMO recommends that future annual meetings include an opportunity for the participation from non-ICES countries (e.g., Australia, New Zealand, Mediterranean countries, PICES and other international organizations, such as CIESM) on the basis of their expertise relevant to the Alien Species Alert Report in preparation by WGITMO. It is recommended that this ToR should remain on the agenda of WGITMO.

**ToR b)** Prepare a report summarizing introductions and transfers of marine organisms into the North Sea and wherever possible their consequences as input to the 2006 meeting of REGNS.

WGITMO prepared a summary of non-native species known to occur in the North Sea and made the list available prior the 2005 REGNS meeting. The list of introduced species was updated at the 2006 meeting and will be sent to REGNS.

More than 200 marine and brackish water species (including cryptogenic species) are assumed to have been introduced into the North Sea and its adjacent waters. For more details regarding the relative importance of vectors the WGBOSV 2006 report may also be consulted.

An intersessional activity was initiated to assess the monetary impact on introduced species in the North Sea. However, information collected was too scattered to be summarized. Data are not available in a consistent and comprehensive format. In addition the limited information available is geographically scattered. The three species with the greatest economic impact are the ship-worm *Teredo navalis*, the Zebra mussel *Dreissena polymorpha* and the Chinese mitten crab *Eriocheir sinensis*. The monetary impact was assessed for two species, *Eriocheir sinensis* and *Teredo navalis*. It was calculated that these two invaders, since their first records 1912 and 1731 respectively, caused a negative impact of 98.5 to 134.8 Million € in German waters alone (including the Baltic Sea coast). The impact of other species which formed mass developments in the North Sea, such as *Ensis directus* and *Elminius modestus*, where not studied.

**Status:** completed.

**ToR c)** Prepare a summary of National Reports (1992-to date);

**Status:** The summary 1992–2002 was completed at the meeting. Topic areas covered were finfish, invertebrates, plants and pathogens. The material provided is partly based on peer reviewed literature, but the primary basis for the report are the “anecdotal” reports provided through National Reports. The report provides a useful summary of invasive species, their spread and the transfer of commercial species between countries. As for previous summaries, WGITMO asks ICES to consider the publication of this report as ICES Cooperational Research Report.

WGITMO suggests to prepare another 5 year summary at next year’s meeting and further to prepare an overall 25 year summary thereafter.

**ToR d)** Plan Aliens Species Alert reports including evaluation of impacts and increasing public awareness.

**Status:** The draft Aliens Species Alert Report on *Undaria pinnatifida*, submitted with last year´s meeting report was completed. Further Aliens Species Alert reports were planned. This Term of Reference is completed for 2005, but is ongoing to address additional species of concern.

As requested by ICES the group continues planning additional Alien Species Alert Reports. WGITMO also suggests to prepare similar species reports on intentionally introduced species, by outlining the dimension of species movements within ICES Member Countries and their impact on native species. Candidate species here may include the Pacific oyster *Crassostrea gigas* and various salmonids. WGITMO suggests to prepare a report on *Crassostrea gigas* intersessionally with the aim to finalize it at next year’s meeting. Other candidate species are *Didemnum* sp., the Chinese mitten crab *Eriocheir sinensis, Ensis directus* and *Homarus americanus*.

**ToR e)** Develop guidelines for rapid response and control options.

**Status:** A comprehensive draft was prepared and discussed at the meeting. The report will be completed at next year’s meeting.

The purpose of early detection is to identify populations that pose an economic or ecological risk, but have not yet spread beyond a delimited region. A restricted distribution may permit eradication or other management actions that reduce or contain populations to a restricted area. A rapid response may be taken to eradicate or attempt to eradicate the population. Implicit in this action is a rapid assessment of the potential economic and ecological costs, a willingness to take action, the likelihood of success, an acceptance of consequences of actions, and anticipated outcomes if no action is taken (cost/benefit analysis).

The 2006 meeting of WGITMO was closed on Friday, March 17th at 3.00 pm. There was consensus that there is an ongoing demand for WGITMO to meet on an annual basis. The invitation of Croatia to host next years meeting of WGITMO was much appreciated and the group suggested meeting in Dubrovnik for at least 2 days during the week beginning Monday, March 19th 2007.

# 2 Opening of the meeting and introduction

In 2006 the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) met in Oostende, Belgium with Stephan Gollasch (Germany) as Chair. The meeting venue was the Institute of Marine Research, Oostende, Belgium with Francis Kerckhof as host. Representatives from Belgium, Canada, France, Germany, Italy, the Netherlands, Norway, Sweden, United Kingdom, and the United States of America contributed to the discussions (Annex 1). National Reports were received from 14 countries (Annex 4).

Apologies were received from Ulrika Borg, Swedish Maritime Safety Inspectorate; Ingrid Bysveen, Directorate for Nature Management, Norway; Gordon Copp, CEFAS, United Kingdom; Tracy Edwards, Joint Nature Conservation Committee, United Kingdom; Dan Minchin, Ireland and Greg Ruiz, Smithsonian Environmental Research Center, USA.

The meeting was opened at 9 am on Thursday, 16 March 2006 with Stephan Gollasch and Francis Kerckhof welcoming participants. The chair highlighted the recent meeting of ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors which was held at the same venue just prior the WGITMO meeting.

The group notes with appreciation that the ICES Code of Practice on the Introductions and Transfers of Marine Organisms was translated into French and was printed recently. Copies were distributed to WGITMO paprticipants at the meeting. Also the Alien Species Alert report on the Red King Crab, *Paralithodes camtschaticus*, prepared by WGITMO participants was released as ICES Cooperational Research Report Series.

# 3 Terms of reference, adoption of agenda, selection of rapporteur

## 3.1 Terms of Reference

The terms of reference were received as ICES Resolution 2005/2/ACME/05 (Annex 2) and the Agenda was structured so as to allow each ToR to be addressed. To work efficiently on the ToRs the preparation of documents in advance was essential. The Chair thanked the members for preparing these reports and papers, and these are contained in the Annexes of this report.

## 3.2 Adoption of agenda

The Agenda was adopted (Annex 3) with amendments to reflect unforeseen changes.

## 3.3 Selection of rapporteur

As in previous years, Dorothee Kieser, Canada, was appointed as rapporteur.

# 4 Progress with terms of reference at the 2006 meeting of WGITMO

The status of the Terms of Reference are as follows:

**ToR a) National Reports: Highlights and Use of Reports**

The following countries submitted National Reports: Belgium, Canada, Estonia*, Finland*, France, Germany, Ireland*, Italy, the Netherlands, Norway, Spain*, Sweden, United Kingdom and the United States of America. Asterisks indicate that reports were received by correspondence. Complete copies of all reports submitted are found in Annex 4.

**Status:** completed for 2005, ongoing.

**ToR b)** prepare a report summarizing introductions and transfers of marine organisms into the North Sea and wherever possible their consequences as input to the 2006 meeting of REGNS (Regional Ecosystem Study Group for the North Sea) and to review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant (Annex 6).

**Status:** completed.

**ToR c)** prepare a summary of National Reports (1992-to date);

**Status:** The summary 1992–2002 was completed at the meeting (Annex 8). WGITMO suggests to prepare another 5 year summary at next year's meeting and further to prepare an overall 25 year summary thereafter.

**ToR d)** plan Aliens Species Alert reports including evaluation of impacts and increasing public awareness.

**Status:** The draft Aliens Species Alert Report on *Undaria pinnatifida*, submitted with last year´s meeting report was completed and is attached as Annex 9. Further Aliens Species Alert reports were planned. This Term of Reference is completed for 2005, but is ongoing to address additional species of concern.

**ToR e)** develop guidelines for rapid response and control options.

**Status:** A comprehensive draft was prepared and discussed at the meeting (Annex 7). The report will be completed at next year's meeting.

# 5 ICES alien species alert reports (ToR d)

At last year's meeting the *Undaria pinnatifida* was suggested to be dealt with as Alien Species Alert report and a draft version of this report was provided. In 2006, a revised draft of the Alien Species Alert on the NW Pacific kelp *Undaria pinnatifida* was handed out and briefly presented by Inger Wallentinus, Sweden. Some small changes in the content were discussed and several suggestions of participants who could provide photos and other illustrations to the publication were made. WGITMO member Inger Wallentinus (Sweden) prepared the final version of the Alien Species Alert Report on *Undaria pinnatifida* (Annex 9).

As requested by ICES the group continues planning additional Alien Species Alert Reports. Candidate species are *Crassostrea gigas* (volunteer is Deniz Haydar, the Netherlands), *Didemnum* sp. (volunteers Judy Pederson, USA and Darleen Smith, Canada), the Chinese mitten crab *Eriocheir sinensis* (volunteer Stephan Gollasch, Germany), *Ensis directus* and *Homarus americanus*. A first review on introduction, transfer and farming of live oysters, prepared by Fredrik Nordwall, is attached to the Swedish National Report and background information on mollusc culturing was provided by Laurence Miossec (see attachment of French National Report). This study was carried out in 2002 and aimed to provide updated production information, including number and structure of the farms, and an in depth review of the production system (e,g, leases, plants, equipment, labour, etc,) and a survey of cultural practices. Other important objectives were both to quantify the bivalve sales dedicated to consumption and to measure the livestock transfers between shellfish production areas at different stages: spat, intermediate products and fully grown marketable products.

### 5.1 Conclusions

- The Alien Species Alert Report on *Undaria pinnatifida* was finalized (attached as Annex 9).
- It is hoped that awareness resulting from Alien Species Alert Reports will reduce the risk of further spread of these species.
- Future species to be dealt with as Alien Species Alert Report were selected.

### 5.2 Recommendations

- WGITMO appreciates the continuing positive feedback of ICES regarding the preparation of Alien Species Alert Reports. Therefore, WGITMO continues to plan to have one Alien Species Alert Report finalized at each meeting with an additional Alien Species Alert Report being ready as first draft as an outcome of the meeting. These accounts are seen as essential tools for e.g. public awareness campaigns.
- WGITMO also suggests to prepare similar species reports on intentionally introduced species, by outlining the dimension of species movements within ICES Member Countries and their impact on native species. Candidate species here may include the Pacific oyster *Crassostrea gigas* and various salmonids. WGITMO suggests to prepare a report on *Crassostrea gigas* intersessionally with the aim to finalize it at next year's meeting.
- The final version of the *Undaria pinnatifida* Species Alert Report is attached (Annex 9) and WGITMO asks ICES to consider publishing this account as ICES Cooperational Research Report.
- The information provided in relevance of this ToR may also be of relevance to REGNS.

## 6 Report for rapid response and control options (Tor e)

The purpose of early detection is to identify populations that pose an economic or ecological risk, but have not yet spread beyond a delimited region. A restricted distribution may permit eradication or other management actions that reduce or contain populations to a restricted area. A rapid response may be taken to eradicate or attempt to eradicate the population. Implicit in this action is a rapid assessment of the potential economic and ecological costs, a willingness to take action, the likelihood of success, an acceptance of consequences of actions, and anticipated outcomes if no action is taken (cost/benefit analysis).

Draft Guidelines for Rapid Response and Control Options, developed by J. Pederson, USA, were discussed in detail at the meeting (Annex 7). The documents includes an overview of control options for several taxonomic groups modified from McEnnulty *et al.,* 2001 and other references.

Also a database framework was developed including taxonomic expertise, case studies, monitoring efforts, practical treatment experience, species histories and an inventory of national lists of introduced species. This database will be completed by WGITMO intersessionally.

### 6.1 Conclusions

- WGITMO reviewed the draft Guidelines for Rapid Response and Control Options developed by J. Pederson, USA.
- Developing and implementing Early Detection/Rapid Response programs for ICES countries necessitate cooperation between neighboring countries.
- Geographic Information Systems mapping should be explored as a tool for assisting with introduced species detection or potential spread.

## 6.2 Recommendations

- WGITMO will intersessionally finalize a report for rapid response and control options.

# 7 Summary of national reports 1992–2002 (TOR c)

This summary was prepared intersessionally by S. Gollasch (Germany), D. Minchin (Ireland), I. Wallentinus (Sweden), and D. Kieser (Canada). Topic areas covered were finfish, invertebrates, plants and pathogens. The material provided is partly based on peer reviewed literature, but the primary basis for the report are the "anecdotal" reports provided through National Reports. The report provides a useful summary of invasive species, their spread and the transfer of commercial species between countries (Annex 8).

## 7.1 Conclusions

- It was agreed by WGITMO that this 10 year summary of National Reports may also be of interest to REGNS.

## 7.2 Recommendations

- As for previous summaries, WGITMO asks ICES to consider the publication of this report as ICES Cooperational Research Report (Annex 8).
- WGITMO recommends to prepare another 5 year summary at next year's meeting and further to prepare an overall 25 year summary thereafter.

# 8 Regional Ecosystem Study Group for the North Sea (REGNS) (Tor b)

To support the REGNS integrated assessment WGITMO prepared a summary of non-native species known to occur in the North Sea and made the list available prior the 2005 REGNS meeting. The list contains intentionally introduced species and accidental introductions which form self-sustaining populations or are only known to occur occasionally. The list of introduced species which was provided earlier was updated and will be sent to REGNS.

It should be noted that the time series of National Reports developed by WGITMO were a key source of information when preparing the report to REGNS. WGITMO wishes to draw REGNS´ attention to the highlights of this year's WGITMO National Reports (see below).

More than 200 marine and brackish water species (including cryptogenic species) are assumed to have been introduced into the North Sea and its adjacent waters. Most invaders are benthic species, of which animals form the clear majority. More than half of the invaders known have established self-sustaining populations. For 14 % of the recorded species the population status is unknown. A total of 37 cryptogenic species are also listed. For these species it is unknown whether they are native or introduced. Whereas the majority of the introduced species shows a locally limited distribution, 13 taxa are found in coastal waters of all countries around the North Sea. With 193 species (88 %) marine taxa are dominating. The dominating vectors of introduction are fouling of ships' hulls, ballast water release and introduction of aquaculture species and their associated biota. The basis of this overview is a publication in press (Gollasch *et al.*, in press) (see Annex 6). For more details regarding the relative importance of vectors the WGBOSV 2006 report may also be consulted.

It may be of interest to REGNS to note the European Research Network on Aquatic Invasive Species (ERNAIS), which currently includes more than 100 experts (scientists, managers and administrators) from 27 countries (http://www.zin.ru/rbic/projects/ernais/) and continues to grow. A main objective of ERNAIS is facilitation of international cooperation in research, scientific information exchange and management of aquatic invasive species in Europe and worldwide. Another objective is the new electronical journal Aquatic Invasions – the

European journal of applied research on biological invasions in aquatic ecosystems. Aquatic Invasions is a rapid on-line journal focusing on biological invasions in European (geographic Europe) inland and coastal waters and is available for free at http://www.aquaticinvasions.ru/. The journal provides the opportunity of timely publication of first records of biological invaders for consideration in risk assessment and early warning systems. The journal´s first issue was released early in 2006 including new records of introduced species in the North Sea, *Rapana venosa* and *Neogobius melanostomus*.

Further details were already provided with earlier WGITMO reports and are therefore not summarized here again. Material provided to REGNS includes

- selected introduced species case histories of impacting invaders in the North Sea region. These accounts are a result of the EU Concerted Action "Introductions with Ships" and were published as: Gollasch, S., Minchin, D., Rosenthal H. & Voigt, M. (eds.) (1999): Exotics Across the Ocean. Case histories on introduced species: their general biology, distribution, range expansion and impact. Logos Verlag, Berlin. 78 pp. ISBN 3-89722-248-5, and
- Alien Species Alert Reports.

As indicated in last years meeting report, an overall impact assessment for invaders cannot be carried out due to the lack of relevant information. Data are not available in a consistent and comprehensive format. In addition the limited information available is geographically scattered. The three species with the greatest economic impact are the ship-worm *Teredo navalis*, the Zebra mussel *Dreissena polymorpha* and the Chinese mitten crab *Eriocheir sinensis*. The monetary impact was assessed for two species, *Eriocheir sinensis* and *Teredo navalis*. It was calculated that these two invaders, since their first records 1912 and 1731 respectively, caused a negative impact of 98.5 to 134.8 Million € in German waters alone (including the Baltic Sea coast). The impact of other species which formed mass developments in the North Sea, such as *Ensis directus* and *Elminius modestus*, where not studied.

## 8.1 Conclusions

- An intersessional activity was initiated to assess the monetary impact on introduced species in the North Sea. However, information collected was too scattered to be summarized. As stated in last year's meeting report, with today's knowledge no further reliable monetary impact calculation can be made.
- WGITMO suggests that the Alien Species Alert reports may be brought to REGNS attention including the final version of the Alien Species Alert Report on *Undaria pinnatifida* (Annex 9).

## 8.2 Recommendations

- A summary of introduced species in the North Sea for the consideration of REGNS is attached as Annex 6.
- WGITMO asks REGNS to consider the material provided and to inform the group in case additional questions may arise.

# 9 Information from national reports (ToR a)

National Reports were submitted by the following countries: Belgium, Canada, Estonia, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, United Kingdom, and United States of America. Additional information was made available from Ireland and Spain (Annex 4).

### National Reports: Audience and use of the reports

WGITMO Members discussed the use of the National Reports and their potential audience. National Reports continue to be used for:

- Documentation of the spread of intentionally imported and/or invasive species over time and to new geographic areas. This may be a unique data set especially when considering the long time series.
- Determination which species are to be evaluated for an Alien Species Alert Reports.
- Answering information requests for organizations (e.g., REGNS-ToR b of 2006 WGITMO meeting)
- Providing a warning system for ICES member countries that invasives species have been found in neighbouring jurisdictions, or countries having similar habitat conditions and enabling follow up of the spread of previously introduced species, especially for secondary spread across political borders.
- Giving indications which intentionally introduced species (e.g. for aquaculture use) have the potential to become invasive (e.g., Pacific oyster, *Crassostrea gigas*) and to provide a follow-up to track their spread.
- Documenting exports and imports. Often such records are sketchy, but can be improved through records from other jurisdictions.
- Documenting the occurrence of unintentional introductions of parasites and disease agents.
- Providing information to other working groups, both within and outside of ICES and raising awareness of invasive and imported/transferred species in such groups.
- Providing information to related ICES working groups, such as the working groups on harmful algae, diseases, ship-mediated introductions and working groups focussed on certain taxa.
- Deliver supporting information for legislations such as the developing EU directive on species in containment.
- Facilitate the coordination of research activities within ICES member countries.
- Promotion of relevant scientific meetings and research initiatives.
- Documenting the success of mitigation measures or management of introduced non-target species, i.e. avoidance to duplicate unsuccessful approaches.

## 9.1 Summary and highlights of 2005 National Reports (ICES member countries, countries with observer and guest status)

### Highlights of National Reports

National Reports contain details of new laws and regulations, deliberate releases, accidental introductions and transfers, live imports, live exports, planned introductions, and meetings.

### Belgium

- During 2005 a third specimen of the Atlantic croaker *Micropogonias undulatus* was fished in Belgian coastal waters and there were 2 findings of the veined whelk *Rapana venosa* in waters of the southern bight of the North Sea, one was close to Belgian waters.
- Most alien species reported during the recent years are still present and they seem to be well established.

### Canada

- In 2005, Canada changed its lead federal agency responsible for aquatic animal health from Fisheries and Oceans Canada (DFO) to the Canadian Food Inspection

Agency (CFIA). Canada published draft ballast water regulations in Canada Gazette I in 2005. These regulations will become law scheduled for 2006.

- While a number of activities and introductions are described in this report, these are primarily updates on issues reported in past years.

## Estonia

- The gibel carp C*arassius gibelio* has became invasive: the fish have colonized all Estonian coastal sea and in some coastal areas it is even the dominant biomass. The round goby *Neogobius melanostomus* has expanded its distribution area and appeared to reach the status of relatively common fish species in Muuga harbour (Gulf of Finland) in 2005.
- The amphipod *Chelicorophium curvispinum* was observed for the first time in the Estonian coastal sea in 2005. This is the northernmost documented location of *C. curvispinum* in the Baltic Sea. Together with juvenile gammarids, *C. curvispinum* was a prevailing invertebrate species in the samples.
- The gammarid *Gammarus tigrinus* was observed for the first time in the Estonian coastal sea in 2003. In 2004, *G. tigrinus* was already found in the whole Kõiguste Bay area and in 2005, the species already strongly dominated in the benthic invertebrate community.

## Finland

- In 2005, two fish species were reported for the first time in Finland; the round goby, *Neogobius melanostomus*, and prussian carp/gibel carp, *Carassius gibelio.*

## France

- A 3 year research program, PROGIG, is starting in 2006 in order to better understand the *Crassostrea gigas* proliferation mechanisms and impacts on marine ecosystem. Economical consequences on human activities will be evaluated as measures for management and restoration to limit this expansion and identify decision-making.
- Few data on accidental introduction of exotic species in the marine environment have been recorded this year, concerning mainly invertebrates. Only one *Rapana venosa* was recorded in 2005 in the bay of Quiberon where this species was previously observed. A Japanese prawn *Penaeus (Marsupenaeus) japonicus* was caught in the same area. Presence of these two species in this area is probably linked to shellfish transfer for the first one and to aquaculture escaping for the second.
- An International Scientific Conference « Biodiversity: Science and Governance » took place in January 2005 in Paris in order to assess current knowledge and needs for research and scientific expertise and to examine public and private approaches to biodiversity preservation and management

## Germany

- In summer 2005 the macroalga *Gracilaria vermiculophylla* (vegetative) was found for the first time in the Kiel Fjord near the port (marina) of Schilksee. The algae was formerly found in Sweden (2003), Sylt (2004?) and also along the North- and Baltic Sea coasts of Denmark.
- The previously introduced non-indigenous oyster *Crassostrea gigas* continues to spread in the Wadden Sea. Activities on aquaculture and restocking focussed in 2005 on eels, sturgeon and salmon. Ornamental trade is continuing to be popular. The opening of new public aquariums may prompt this trend further. For direct human consumption, various crustaceans, blue mussels, common carp, and *Tilapia* species are imported. Live exports to ICES Member Countries focus on *Mytilus edulis* predominantly for the Belgium and Dutch markets.
- Stephan Gollasch is also a contributing partner of the new EU project Delivering Alien Invasive Species Inventories for Europe (DAISIE). One of the key

objectives of this initiative is to prepare a European-wide list of biological invasions (including terrestrial habitats) which will eventually be made available via the Internet. Another objective is to create European Alien Species Expertise Registry. The expertise registry has recently been set up and contains already details of more than 800 experts from 64 countries. Now there is an opportunity to register yourself at the DAISIE European Alien Species Expertise Registry. The registration process is only a matter of minutes and in return you may get new contacts with experts from European Countries as well as from overseas. This registry is open to the public, for governmental bodies and for stakeholders, searching for a given expertise. Thus, it may become rewarding, to be included there. Please take time to register at http://daisie.ckff.si/.

- Ballast water issues become more and more into focus. Germany continues to be active in the Ballast Water Working Group of the International Maritime Organization. Onboard tests of two ballast water treatment systems developed by German vendors will be undertaken later in 2006.

## Ireland

- There are three notable species range expansions within Ireland and two new introductions during 2005: The amphipod *Caprella mutica*, first recorded in July 2003 on the west coast of Ireland has been found in abundance in Dublin Bay on the east coast of Ireland in April 2005 however a recent January survey failed to find any. The brown alga *Sargassum mutica* was found for the first time. The tunicate *Styela clava* has extended its range.
- In an estuary north of Dublin in October 2005 a growth form of *Didemnum* sp. was found to overgrow fouling on marina pontoons and heavily fouled leisure craft.
- The southern hemisphere tunicate *Corella eumyota* was found for the first time in Ireland in 2005.

## Italy

- New findings of alien species in Italian marine waters are reported for the year 2005. Eleven new invertebrate species have been added to the list of introduced species found in Italian waters. Many species are enlarging their distribution in Italian waters and data have been gathered on the biology of some of the most important ones.

## Netherlands

- In 2005 three species were added to the list of introduced species in The Netherlands: *Palaemon macrodactylus*, *Rapana venosa* and *Neogobius melanostomus* were recorded for the first time in Dutch waters.
- *Didemnum* sp. ("*lahillei*" in Dutch literature) has been present in the Dutch Oosterschelde estuary since 1991. It remained rare until 1998 after which it dramatically expanded its population size and overgrew almost all hard substrata present, including organisms like algae, plants, bivalves, hydroids, sponges, sea anemones and other ascidians.
- The Pacific oyster *Crassostrea gigas* is still spreading in the Wadden Sea.

## Norway

- No new laws or bylaws have been enacted in 2005, but a law on biodiversity (NOU 2004:28) has been on hearing. The biodiversity law is put on hold for a harmonization with a EU directive before being enacted, likely in 2007.
- Some 14 lobsters with suspect habitus-characteristics were collected in southern Norway. Eight were confirmed to be the American lobster and two of the specimens were females carrying fertilized eggs. Intensive capturing efforts were initiated at a "hot spot" outside Bergen where the majority of specimens were found, but no additional specimens were recovered.

- The Red King crab *Paralithodes camtschaticus* has continued its south- and westward migration and several individuals have been caught outside Tromsø. The southernmost individual was caught at Folla, well south of the Lofoten Archipelago. A free fishery W. of 26 deg E. yielded 22 tons, but the fishery was abandoned when not profitable.
- The snow crab *Cionoecetes opilio* has increased considerably in numbers, and increasing numbers of smaller, young individuals are being reported. The stock on the Goose Bank have been estimated to approximately 500 000 individuals.
- The red algae *Heterosiphonia japonica* has continued to expand its range, and have now been found in significant numbers in the "Oslofjord" area.
- A new cross-sectorial databank for biodiversity-data has been established (www.artsdatabanken.no). In addition to a thorough review of the "Red list" of endangered species, the databank will establish and maintain a searchable list of alien species in Norway (both terrestrial, limnic and marine).

## Spain

- Studies on non native species in Spanish coast are very scarce. In this sense more of the studies are related to macro-organisms as benthos macroalgae, terrestrial plants, crabs and fishes. A few studies have focused on the ecological impact of the alien species. In the last years, the number the non native species has been increased, but at the moment there is not an institution or agency that coordinates the work on this topic. Several studies are ongoing.

## Sweden

- There are still NO reports of the round goby *Neogobius melanostomus* from Swedish coastal waters
- Every year single specimens of the Chinese mitten crab, *Eriocheir sinensis*, are reported to have been caught by fishermen. There are NO reports of mass occurrences.
- The large Asiatic red alga *Gracilaria vermiculophylla*, first recorded during August-September 2003 was recorded much further south than previously.
- *Aglaothamnion halliae*is has spread from previously recorded areas 100 km to the south.
- *Sargassum muticum* has moved around 120 km to the south.
- The raphidophyte *Chattonella* aff. *verruculosa* was noted in low numbers on the Swedish west coast in April 2005 and again in November. In 2006, it was present in abundances up to ca 30 000 cells per litre, both on the Swedish west coast and in S Norway. In February 2006, numbers over 200 000 cells per litre were recorded on the Swedish west coast.
- The parasite *Gyrodactylus salaris* was found at a fish farm, on the Swedish west coast.
- IPN-V (infectious pancreatic necrosis) was recorded in a fish farm on the west coast.
- Dead perch found north of the city of Stockholm died from attacks of the freshwater fungus *Branchiomyces denigrans*, which previously has not been recorded from Sweden.
- One very large (>20 cm), live individual of *Crassostrea gigas* was found in northern Bohuslän in 2004. Also, there is a growing interest for farming of European oysters. To cover the demand for juveniles, imports from hatcheries in Norway and Denmark have been done during 2002 and 2003. These actions open for potentially genetic contamination and also risks for spreading of notifiable diseases among Swedish stocks.

### United Kingdom

- The deliberate release of unwanted pet fish and associated plants by the general public is a problem identified long ago but only recently subjected to scientific study. Wheeler's (1998) suggestion on ponds close to roads and to fairgrounds has been tested and corroborated in a recent study of ponds in the greater London area.
- There has been no apparent extension to the range of *Styela clava* in the UK.
- The UK Environment Agency found seven individuals of *Sarsiella* (*Eusarsiella*?) *zostericola*, an alien ostracod species predating in a grab sample at Mucking Flats on the Thames.
- The Scottish Association of Marine Science have reported *Caprella mutica.*
- *Sargassum muticum* has continued to spread in Wales and was also found along the west coast of Scotland.
- The range of Signal crayfish (*Pacifastacus leniusculus*) continues to expand. There was one outbreak of crayfish plague in native crayfish in 2005.
- *Caulacanthus okamurae*, has crossed the Channel to Devon and Cornwall.
- *Heterosiphonia japonica* is now widespread along the south coast from Devon to the Isle of Wight.

### United States of America

- No new nonindigenous species legislation was passed at the national level even though several bills are before Congress. For the past two years *Crassostrea ariakensis* triploids have been introduced to the Chesapeake Bay area and work on the Environmental Impact Statement continues. The state of Virginia passed its own legislation allowing transplantation to move forward, but its relationship to the federal regulations is unclear.
- Most of the introduced fish and invertebrate species reported here are range expansions from earlier reported introductions, although some species were reported earlier in the literature but not in previous National reports. Some species are of unknown status. Two new species of *Porphyra, P. katadae* and *P. yezoensis* were recently identified by molecular analysis. *P. yezoensis* was introduced several years ago, but the strain that has been found throughout New England is not the same as the mariculture species.
- A lack of good data on fish, invertebrate, and seaweed imports as live organisms was reported.

## 9.2 New laws and regulations

Some countries have made changes or are planning to change their laws and regulations as outlined in the National Reports submitted. A brief overview is presented in the Table 1 below. Additional details can be found in the individual National Reports. It should be noted that this table is not fully comprehensive as not all ICES-member countries provided National Reports to WGITMO (Annexes 3 & 4).

**Table 1. New laws and regulations relevant to species movements and biological invasions (based on information provided in the National Reports)**

| COUNTRY | NEW LAWS AND REGULATIONS |
|---|---|
| Belgium | No changes in 2005 |
| Canada | 1) Draft ballast water regulations will become law when published in Canada Gazette II, which is scheduled for 2006.<br>2) The Canadian Food Inspection Agency (CFIA) and the Department of Fisheries and Oceans (DFO) will co-deliver a new National Aquatic Animal Health Program |
| Estonia | No changes in 2005 |
| Finland | The use of fresh, frozen and ensiled wild marine fish for food for aquaculture fish is banned because of virus risk (Ministry of Agriculture and forestry (157/2005). |
| France | A Council regulation is currently in preparation setting rules governing the use of alien species in aquaculture |
| Germany | Nothing new reported in 2005 |
| Ireland | Nothing new reported in 2005 |
| Italy | Nothing new reported in 2005 |
| Sweden | The $16^{th}$ Environmental Quality Objectives on Biodiversity were adopted by the Swedish parliament in November 2005 |
| United Kingdom | The list of countries from which imports of live molluscs can be imported for relaying has been further restricted to parts of the USA only (Commission Decision 2005/409/EC). |
| USA | The U.S. Congress has not passed new legislation on aquatic invasions since the reauthorization of the Nonindigenous Species Act (NISA) of 1996 which expired in 2002.<br>The Ballast Water Management Act of 2005 (S.B. 363) focuses on managing ballast water and proposes standards for ballast water discharge that are more strict than those proposed by the International Maritime Organization (IMO). The legislation would amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. |

## 9.3 Live imports, live exports, planned introductions and deliberate releases

It has to be noted that the following tables do not claim to be fully comprehensive as not all ICES member states submitted National Reports to the meeting. Further, the origin of several importations remains unclear as some countries exhibit a lack of import and/or export documentation. As in last years meeting report, it is interesting to note that on several occasions a country states that a species was imported from another country whereby the exporting country has no mention of this movement in its National Report. This further indicates the patchiness of information available. In general, information on exports appears more difficult to collect than information on imports (Tables 2 and 3).

**Table 2. Species exported by ICES-member countries according to the National Reports submitted prior March 2006**

| EXPORTING COUNTRY | SPECIES |
|---|---|
| Belgium | No information for 2005 |
| Canada | Live exports requiring health certification: Arctic char, rainbow trout, brook trout, Atlantic sturgeon, scallop *(Placopecten magellanicus)*, oyster *(Crassostrea virginica)* |
| Estonia | Unidentified fish |
| Finland | Rainbow trout, Arctic Charr, grayling (*Thymallus thymallus*) |
| France | No data available for 2005 |
| Germany | Blue mussel (*Mytilus edulis*) |
| Italy | Nothing reported |
| Ireland | Nothing reported |
| Sweden | Eel, ornamental fish, blue mussel, scallop |
| United Kingdom | Atlantic salmon, Pacific oyster, blue mussel |
| USA | Accurate data difficult to obtain because of labelling as live/fresh. Exported live oyster seed. |

**Table 3. Species imported by ICES-member countries according to the National Reports submitted prior March 2006.**

| IMPORTING COUNTRY | SPECIES |
|---|---|
| Belgium | Uncontrolled imports (no species listed) |
| Canada | Atlantic salmon, wolf eel (*Anarhinchas minor*), oysters (*C. gigas, C. sikamea*), Manila clams, mussels (*M. edulis* and *M. galloprovincialis*), cockles (Clinocardium nuttali, cod (Gadus morhua), barramundi (*Lates calcarifer*); cobia (*Rachycentron canadum*); Florida pompano (*Trachinotus carolinus*); and red drum (*Sciaenops ocellatus*), tilapia; genetically modified Atlantic salmon, genetically modified rainbow trout diploid rainbow trout; green crab (*Cancer maenas*); and purple sea urchins (*Strongylocentrotus purpuratus*). Note some species were for research in closed containment only. |
| Estonia | carp, ornamental fish, unidentified fish |
| Finland | Sturgeon, rainbow trout, freshwater crayfish, perch, zander |
| France | Only 2004 data available |
| Germany | Koi, goldfish, sterlett, Asian carp, *Tilapia*, glass eel, sturgeon (*Acipenser baeri*), salmonid species including Atlantic salmon, common carp, marine, brackish and freshwater ornamentals, blue mussels, *Nephrops norvegicus, Homarus gammarus, H. americanus, Callinectes spidus, Laminaria saccharina, Palmaria palmata.* |
| Italy | No information listed |
| Ireland | No information listed |
| Sweden | Eels, carp, Ornamental species, *Mylilus*, scallops, oysters lobsters, |
| United Kingdom | Rainbow, eel, Atlantic salmon, non-native bivalves and crustaceans for human consumption. |
| USA | Data is difficult to obtain. Imported eels observed.. Lobster |

The following table (Table 4) summarizes live imports and exports of aquatic species according to higher taxa and area of origin based on National Reports considered.

**Table 4. Summary of live imports and exports of aquatic species (including ornamental trade and imports for containment) according to National Reports submitted prior March 2005. (cr = crustacean, fi = fish, mo = molluscs, pl = plants, Ban = Bangladesh, Bel = Belgium, Bra = Brazil, Can = Canada, Col = Columbia, Cze. R = Czech Republic, Den = Denmark, Est = Estonia, Fin = Finland, Fra = France, Ger = Germany, Gre = Greece, Hon = HongKong, Hun = Hungaria, Ice = Iceland, Ind = Indonesia, Ire = Ireland, Isr = Israel, Ita = Italia, Jap = Japan, Mala =Malaysia, Net = the Netherlands, Nig = Nigeria, Nor = Norway, Pol = Poland, Por = Portugal, Rus = Russia, S. Afr = South Africa, Sin = Singapore, Spa = Spain, Sri = Sri Lanka, Swe = Sweden, Tai = Taiwan, Tha = Thailand, UK = United Kingdom, USA = the United States of America, Vie = Vietnam).**

| | IMPORT (LIMITED TO ICES MEMBER COUNTRIES) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exporting country | **Bel** | **Can** | **Den** | **Est** | **Fin** | **Fra** | **Ger** | **Ire** | **Net** | **Nor** | **Pol** | **Rus** | **Spa** | **Swe** | **UK** | **USA** |
| **Austral** | | | | | | | | | | | | | | | fi | |
| **Ban** | | | | | | | | | | | | | | | | fi |
| **Bel** | | | | | | mo | | | | | | | | | | |
| **Bra** | | | | | | | | | | | | | | fi | | |
| **Can** | | | | | | fi | fi | fi | | cr | fi | | | cr | fi, cr | |
| **Cze. R** | | | | fi | | | fi | | | | | | | fi | | |
| **Den** | | | | fi | fi | mo | fi. mo | | | | | | | fi, mo, cr | fi | |
| **Est** | | | | | | | | | | | | fi | | | | |
| **Fin** | | | | fi | | | fi | | | | | fi | | | | |
| **Fra** | mo | | | | fi | | fi, mo | mo | mo | | | mo | mo | mo | fi | |
| **Ger** | mo | | | | fi | | | | mo | | | | | fi | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gre** | | | | | | mo | | | | | | | | | | |
| **Hun** | | | | | | | fi | | | | | | | | | |
| **Ice** | | fi, mo | | | | | | | | | | | | | fi | |
| **Ind** | | | | fi | | | fi | | | | | | | fi | | |
| **Ire** | | | | | | mo | fi | | | | | | | mo, cr | fi | |
| **Isr** | | | | | | | | | | | | | | fi | | |
| **Ita** | | | | | fi | mo | fi | | | | | | | | | |
| **Jap** | | | | | | | | | | fi | | | | | | |
| **Lat** | | | | fi | | | | | | | | | | | | |
| **Net** | | | | | | mo | fi | | | | | | | fi, mo | fi | |
| **Nor** | | fi | | | | mo | | | | | | | | fi, mo, cr | fi | |
| **Phil** | | | | | | | fi | | | | | | | | | |
| **Pol** | | | | | | | fi | | | | | | | | | |
| **Por** | | | | | | mo | | | | | | | | | | |
| **Rus** | | | | | | | fi | | | fi | | | | | | |
| **Spa** | | | | | | mo | | | | | | | | | fi | |
| **Sin** | | | | fi | | | fi | | | | | | | fi | | |
| **Sri** | | | | | | | | | | | | | | fi | | |
| **Swe** | fi, mo | | fi, mo | fi | fi, mo | mo | fi, mo | mo | fi, mo | fi, mo | fi, mo | fi | mo | | mo | |
| **Tha** | | | | fi | | | fi | | | | | | | fi | | |
| **UK** | | mo | | fi | | mo | | mo | | | | | | fi, mo | | |
| **USA** | | fi, mo | | | | | fi | | | | | | | mo, cr | fi, cr | |

As reported in the National Report from the United Kingdom, a recent review of past introductions of non-native fish in 17 countries of Europe and North America (Copp *et al.* 2005b) found that the USA (93) and France (35) are at the top of the list of intentional fish introductions, followed by the Czech Republic, Russia, Romania, Austria and Spain (27 to 21), with the other countries (including England & Wales) having <20 intentional introductions but only Germany had <10 such introductions.

ICES Member Countries imported live organisms from 32 countries with fish and molluscs being the most imported taxa. The country with the highest number of source regions in commercial species imports in 2005 was Germany with 17 source regions to be followed by Sweden with 16. Most other importing countries import species from less than 5 source regions (Table 4). However, it should be noted that the detail level when documenting species varies enormously between certain countries. Several countries refer to source regions as "from various countries" thereby documenting that more detailed information is not available. Germany imports predominantly fish and France molluscs. In other countries no clear trend is obvious.

As in previous years, the most commonly moved species in 2005 were Atlantic salmon *Salmo salar* and the Pacific oyster *Crassostrea gigas*.

## 9.4 Accidental introductions

Many new records of accidentally introduced species were reported in 2005 (Table 5). Table 5 also provides details on the spread of previously introduced species (see also National Reports in Annex 4).

**Table. 5. New records of accidental species introductions and notes on the spread of previously reported accidental introductions in ICES-member countries according to the National Reports submitted prior March 2006. For references see National Reports in Annex 4.**

| COUNTRY | SPECIES |
|---|---|
| Belgium | On August 24th 2005, a specimen of the Atlantic croaker *Micropogonias undulatus* was captured by a Belgian commercial shrimper, working in Belgian inshore waters. The specimen measured 19cm. This is the third record of this species in Belgian waters. There are also 3 recent records from Dutch waters (Dekker *et al.,* 2004). As for all the Belgian and Dutch records, also the latest Belgian find was a first year and not sexually mature. The Atlantic croaker is native to the east coast of the USA and northern Gulf of Mexico, where it is one of the most abundant inshore, demersal fish species. Stevens et all. 2004 believe that all specimens were recent arrivals and that they probably reached European waters as (post-) larval or young fish in ballast water and were subsequently released during deballasting in one of the major ports of the region. However, Dekker *et al.,* 2003 suggest that small reproductive populations might reside in certain waters of the southern bight of the North Sea.<br>*Rapana venosa*: This species has been found in 2005 twice in de southern North Sea (Kerckhof *et al.,* 2006). Although not in Belgian waters proper, one of the findings was in an area very close to Belgian waters. An alerting campaign has been started up.<br>*Mytilopsis leucophaeata* (=*Congeria cochleata*): This species is present in the harbour of Antwerpen, causing nuisance by the obstruction of water intake pipes of some chemical plants. A Ph.D. study is ongoing at the University of Gent, with the aim to find a possible biological control of the problems caused by this species.<br>*Caprella mutica*: This species has been first recorded in 1998 when it was present on several buoys marking the entrance to the harbour of Zeebrugge. In the Zeebrugge area, the species is still present.<br>*Ficopomatus enigmaticus*: As in previous years this species was also in 2005 very abundant in the harbours of Oostende en Nieuwpoort, forming reef like structures on several submerged substrates en vessels.<br>*Megabalanus coccopoma*: This species proved to be already present on buoys off the Dutch coast (off Terschelling) in 1976 and 1977 but was apparently not properly recognised. From 1997 on this species has been found each year in the southern bight of the North Sea, mainly on buoys but also on floating objects and even in the littoral zone. The continuos and increasing findings along the Belgian and Dutch coast prove that it is well established in this region of the North Sea.<br>*Hemigrapsus penicillatus*: This species was recorded for the first time from the coasts of Belgium and Northern France in 2003. The pencil-crab is now very abundant especially in estuaries and harbour areas for instance amongst reefs of pacific oysters *Crassostrea gigas.*<br>*Hemigrapsus sanguineus*: This species has not been found yet in Belgium.<br>*Palaemon macrodactylus*: This Asian shrimp was first identified from Zeebrugge, were it was fished on 12 June 2004 among the epiflora and epifauna of the pontoons of the marina (d'Udecem d'Acoz *et al.,* 2005) were it also was present during 2005.<br>*Telmatogeton japonicus*: This giant chironomid has recently been identified from buoys off the Belgian coast. T. japonicus is common on all of the offshore buoys even the remote ones. Specimens live in the splash zone, i.e. the vertical zone of the buoy, above the algae zone, were they from a characteristic zone. The species is present during most of the year and apparently the only Chironomid living on the buoys.<br>Undaria pinnatifida: After the first record in 2000, this species is still present in de marina of Zeebrugge, but apparently not spreading due to predating of Coots Fulica atra. |

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| | *Sargassum muticum*, *Codium fragile* subspecies *tomentosoides:* After a presence for some years in the Spuikom of Oostende, there have been no recent records anymore of both species since 2002. This is probably due to changes in the water regime of the pond. However *Polysiphonia senticulosa* is still present. |
| Canada | **Atlantic**<br>Two reports of release of aquarium trade species into natural water bodies were investigated in Newfoundland. Ornamental species of carp (species undetermined) were seen at Janes Pond, Burin Peninsular, and on private property waters near Heart's Delight, Trinity Bay. Origins of the fish are unknown.<br>**Ontario**<br>The only new invader in 2005 is the sideswimmer (*Gammarus tigrinus*), which has been documented in all five Great Lakes.<br>**Québec**<br>No green crab (*Carcinus maenas*) were found in 2005. Studies on a caprellid (*Caprella mutica*), a new species detected for the first time in 2003 in the Baie des Chaleurs and in 2005 in the Magdalen Island Archipelago, are in progress to identify the impact of this new species on mussel culture.<br>**Atlantic Coast**<br>Since the identification of the presence of the clubbed tunicate (*Styela clava*) on mussel leases in Prince Edward Island, three additional tunicates have been confirmed as established. The golden star tunicate (*Botryllus schlosseri*) was transferred to the province in 2001, the violet tunicate (*Botrylloides violaceus*) in 2004, and the vase tunicate (*Ciona intestinalis*) in 2004. All four species are competing with mussel culture in waters in which they are established, adding costs to production, harvest and processing. Managing the spread and impact of each species has been a collaborative effort between the aquaculture industry and the provincial and federal governments. Regulating the movement of bivalves into, out of and within waters infested with one or more species has been successful in slowing the spread of tunicates between water bodies. The clubbed tunicate is well established in the Murray River, St Mary's Bay, Montague and Brudenell Rivers. It is also present in Cardigan River, but in lower densities. The population density in March Water, a portion of Malpeque Bay, increased substantially in 2005. The species was confirmed to be present in Darnley Basin in 2005, but in low numbers. The presence of clubbed tunicate in Orwell River is now suspect, with no animals being detected in routine surveys. The vase tunicate is currently restricted to Montague and Brudenell River estuaries and St. Mary's Bay. Vase tunicate numbers in these waters were particularly high and troublesome to the mussel industry in 2005. Since its identification in St. Peters Bay, the golden star tunicate was confirmed to be present in Cardigan River and St. Mary's Bay in 2005. The species also has been present in Savage Harbour since 2004. Population densities increased in St. Peters Bay and Savage Harbour in 2005.The violet tunicate is well established in Savage Harbour and Cape Borden, and was detected in five new estuaries in 2005. These included Cardigan River, Brudenell River, St. Peters Bay, Rustico Bay and March Water.<br>As a result of their ability to reproduce sexually and asexually, the violet and golden star tunicates will prove much more difficult to control than the solitary clubbed and vase tunicates, which only reproduce sexually. Nova Scotia and Newfoundland/Labrador are monitoring for tunicates and other alien invasive species. There were no reports of new invasive species being identified in 2005. A workshop on identification of invasive tunicates was held in the Atlantic region in fall 2005.<br>The green crab (*Carcinus maenas*), a predator of shellfish, particularly soft shelled clams, was first identified in Prince Edward Island in 1997. Since that time the species has spread, and is now well established in all estuaries in the eastern portion of the province. Its presence in the Cape Borden area was |

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|---|---|
| | confirmed in 2005, and it is likely that the species will continue to expand its presence in Island waters. In addition to its predation of soft shelled clams, the green crab has been observed to inflict wounds to American eel (*Anguilla rostrata*) in eel traps.<br>**Atlantic Coast**<br>Oyster thief (*Codium fragile*) presence in Prince Edward Island was first noted in 1997. Its population is classified as high in Malpeque Bay, Cascumpec Bay/Mill River and Enmore River. The species is confirmed to be present in low densities in Rustico Bay, Tracadie Bay/Winter Bay, Savage Harbour, St. Peters Bay, Murray River and Sunbury Cove, a section of Bedeque Bay. No new sightings for oyster thief were recorded for 2005. The last updates were for Rustico Bay in 2004 and Tracadie Bay/Winter River and St. Peters Bay in 2003.<br>*Bonamia ostreae* in *Ostrea edulis* – Reported for the first time in Canada (British Columbia but not yet detected in Atlantic Canada) in November 2004. Examination of archived samples collected from the index site between 1999 and 2004 in conjunction with seed introduction records suggests that *B. ostreae* may have been inadvertently introduced into British Columbia around 2003 with *O. edulis* seed imports from enzootic areas in the State of Washington, USA.<br>*Haplosporidium nelsoni* (MSX) in *Crassostrea virginia* - Reported for the first time in Canada in October 2002 (see report to WGITMO in 2003), associated with mortalities greater than 90 % on several leases in Cape Breton, Nova Scotia. In 2005, MSX was confirmed in oysters from an isolated population on the north shore of Cape Breton. No evidence found to date of presence of *H. nelsoni* (or *H. costale*) in historic samples from within the Bras d'Or Lakes. |
| Estonia | The gibel carp C*arassius gibelio* was first deliberately introduced into fish ponds and small lakes of Estonia in 1948. The fish was first found in Estonian marine waters in 1985 in the Gulf of Riga. During the recent years the species became invasive: the fish have colonized all Estonian coastal sea and in some coastal areas is even the biomass dominant. At least one of the likely reasons is consecutive warm summers in recent years. While in some shallow sheltered areas the species can reproduce and thrives well, in more open coastal areas only large adult specimens are caught. Ecological impact unknown.<br>The fist specimen on the round goby *Neogobius melanostomus* was found in Estonian waters in 2002. The recent contacts with leisure fishermen fishing in Muuga Harbour (Gulf of Finland) in 2005 suggest that the fish has further colonised northern-eastern parts of the Baltic Sea. According to fishermen reports in this area, *N. melanostomus* is, although not very abundant, but relatively common fish species in their catches. The distribution vector of the fish is most likely secondary spread within the Baltic Sea. Wider ecological impact in Estonian coastal sea insignificant.<br>The second finding of the bighead carp *Aristichthys nobilis* in Pärnu Bay (NE Gulf of Riga) was reported in 2005 (the species was first found in Estonian waters in 2002 in the same area), most likely originating from aquaculture. Ecological impact impact insignificant.<br>***Gammarus tigrinus*** was observed for the first time in the Estonian coastal sea (Kõiguste Bay, northern Gulf of Riga) in 2003 in connection to the performance of a mesocosm experiment. The species was mainly associated to the communities that contained the cockle *Cerastoderma glaucum*. In 2003 the gammarid was not found in traditional benthos stations although the bay was intensively monitored throughout ice-free season. In 2004 *G. tigrinus* was already found in the whole Kõiguste Bay area. In 2005 *G. tigrinus* was also found in the bays adjacent to Kõiguste Bay but also in Rame Bay located about 50 km eastwards from Kõiguste Bay. So far there are practically no records of *G. tigrinus* from other parts of the Gulf of Riga including Riga and Pärnu Port areas. An important yacht harbour is located at the inner part of |

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<tr><td></td><td>Kõiguste bay. Thus, it is likely that the species was introduced to the northern part of the Gulf of Riga due yacht traffic and the donor region was likely Curonian, Odra or Vistula Lagoon.<br><br>Chelicorophium curvispinum was observed for the first time in the Estonian coastal sea in 2005. The invasive amphipod was found in connection with traditional monitoring of phytobenthic communities in Sillamäe area in the eastern Gulf of Finland. Thus, this is the northernmost documented location of C. curvispinum in the Baltic Sea. Curonian Lagoon is the closest basin where the invasive amphipod is found. C. curvispinum was likely introduced to the Gulf of Finland either at Sillamäe or Kunda Port area by the mean of ship traffic (ballast water). The catch index of the Chinese mitten crab Eriocheir sinensis was substantially higher in 2002–2005 than in the previous years studied (i.e. 1991–2001). Highest catch indexes were observed in the periods of May-June and October-November compared to other months. Questionnaire surveys on findings of E. sinensis in the various sub-basins of the NE Baltic Sea (southern Gulf of Finland, northern Gulf of Riga, Väinameri Arhipelago) revealed that the species is commonly found all over the Estonian coastal sea. As reproduction of mitten crabs in the Baltic Sea is unlikely, due to low salinities, it is assumed that the individuals caught actively migrate into the area from its main European distributional area (south-eastern North Sea), a more than 1500 km migration distance.<br><br>There is a strong signal from our earlier field observations that population abundance of a dominant native cladoceran Bosmina coregoni maritima is depressed and seasonal abundance dynamics of copepod nauplii (Eurytemora affinis and Acartia spp.) is changed after the invasion of the predatory cladoceran Cercopagis pengoi into the Baltic Sea (Gulf of Riga). Given the very limited knowledge on feeding habits of C. pengoi (largely due to species-specific peculiarities), we have conducted a set of laboratory feeding experiments with this species as a predator and several native more abundant mesozooplankton species (B. c. maritima, copepods E. affinis and Acartia spp., nauplii of copepods and the cirriped Balanus improvisus larvae) as a prey. It appeared that C. pengoi was able to consume in laboratory conditions all the provided prey with one exception: newly born youngs were unable to prey on copepods, most probably due to too large body size of the prey. These experiments confirm that C. pengoi could be, at least partly, responsible for structural changes in the mesozooplankton community observed after the invasion.</td></tr>
<tr><td>Finland</td><td>Round goby, Neogobius melanostomus (Pallas) was caught in the south-western archipelago of Finland for the first time in February 2005. So far only one round goby has been known to be caught by an angler.<br><br>In November 2005, several specimens of prussian carp/gibel carp, Carassius gibelio (Bloch), were caught off the Helsinki, Finland, and then for the first time identified to species. However, more observations along the southern coast of Finland were reported after the announcement news and spread information on prussian carp in several papers and other media. Today, the identification of prussian carp has been verified in five places and possible occurrence in three other places along the south coast of Finland. In general, it is still under discussion whether prussian carp or gibel carp is a species in its own right (C. gibelio), a subspecies of the goldfish (C. auratus gibelio) or whether it is a hybrid between the crucian carp and other related species (http://www.hull.ac.uk/molecol/Carp.html). Anyway, the prussian carp has most probably been in waters off Helsinki at least since 2001.<br><br>In 2003 in the Gulf of Finland, a new mussel species was found in the cooling water discharge area of the nuclear power plant of Loviisa (E Gulf of Finland). The mussel was identified as Conrad's false mussel, Mytilopsis leucophaeata, which is known to be a serious biofouling organism. Since the first findings, STUK in co-operation with the Finnish Institute of Marine Research has followed the occurrence and reproduction of Mytilopsis leucophaeata using artificial plates and making observations by scuba diving</td></tr>
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| | in the sea area of Loviisa. www.fimr.fi/en/itamerikanta/bsds/3185.html. |
| France | In 2005 one veined whelk adult *Rapana venosa,* weighed 682g was caught in an area called Anse du Pô in the bay of Quiberon (South Brittany) where other Rapana's were previously collected. This species, observed annually in this area over the last few years, was likely introduced with clam commercial transfers originating from Italy. The small number of captured animals probably indicates limited consequences of this introduction.<br>A Japanese prawn *Penaeus (Marsupenaeus) japonicus* (Bate, 1888) was caught in the bay of Quiberon (South Brittany) in May 2005. This male adult was 19 cm long. This species was introduced for farming in France in 1969 and is cultured until now in Mediterranean lagoons and in natural salt water ponds along the French Atlantic coast. A farm located in Plouharnel (Southern Brittany), at the near vicinity of the bay of Quiberon, was commonly producing this prawn semi-extensively in the ninety's. The production was stopped in 2003. Individuals, probably escaped from farming ponds, have been occasionally captured since the beginning of the ninety's in the Gulf of Biscay and in the English Channel. There is no conclusion until now about a permanent establishment of a *P. japonicus* population since reproduction is unlikely at this temperature range characterizing those areas.<br>The expansion of *Crepidula fornicata* was monitored from 12 to 19 May 2005 in the Bay of St Brieuc (North Brittany) using acoustic imaging system (side scan sonar), divers and under-water video. This survey is part of a scientific program initiated 4 years ago to exploit the crepidula stock for agro-food purposes. The first results showed an increase in the settlement of this species, therefore inducing new harvesting measures.<br>*Ocinebrellus inornatus* was recorded in 2003 for the first time in the bay of Mont St Michel (North Brittany), but this information was only available in 2005. This species was probably introduced with oysters' transfers.<br>The Dinoflagellate, *Ceratium candelabrum* (Ehrenberg) Stein 1883, has been recorded in the bay of Concarneau (south west coast of Brittany) for a few weeks at the end of November. It is the first time that this species which is currently observed in warm temperate and tropical water, is identified up north in France. This is likely correlated to the climate change.<br>A zoosanitary surveillance program (REPAMO) on cultured and wild populations of shellfish, demonstrated the presence of *Perkinsus olseni* in wild clams *Ruditapes philippinarum* collected in the English Channel (in Blainville and Agon Coutainville in Normandy) in 2005. This parasite was first recorded in 1987 in Portugal. Since then, it has been frequently detected in the Mediterranean Sea and in the Atlantic Ocean. It was previously observed in a cultivated area of clams in the Normand- Britain Gulf. However, it is the first record of this parasite in wild clams in the English Channel. |
| Germany | In summer 2005 the macroalga Gracilaria vermiculophylla (vegetative) was found for the first time in the Kiel Fjord near the port (marina) of Schilksee. The algae was formerly found in Sweden (2003), Sylt (2004?) and also along the North- and Baltic Sea coasts of Denmark.<br>*Crassostrea gigas*. Culturing the Pacific Oysters resulted also in oyster settlement outside the farm. As there is not much hard substrate in the German Wadden Sea to settle mussel beds of Mytilus edulis became the first foothold for oyster spat. Crassostrea gigas continues to spread southwards and competes with native Mytilus edulis for habitat and food. It was documented at certain sites that the oysters have overgrown mussel beds with an increasing tendency.<br>*Eriocheir sinensis.* The Chinese Mitten Crab population declines further in density after its mass occurrence in the 1990s. |
| Ireland | There are three notable species range expansions within Ireland and two new introductions during 2005. The amphipod *Caprella mutica*, first recorded in July 2003 on the west coast of Ireland has been found in abundance in Dublin |

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| | Bay on the east coast of Ireland in April 2005 however a recent January survey failed to find any. The brown alga *Sargassum mutica* was found in Carlingford Lough, north-east coast of Ireland for the first time. There were also many detached specimens stranded on the upper shore. The tunicate *Styela clava* has extended its range and occurs in low abundance in Dublin Bay and on the south-west coast in Dingle and Tralee bays (Martin Davis pers. comm.). *S. clava* has been known only from Cork Harbour since 1972.<br>In an estuary north of Dublin in October 2005 a growth form of *Didemnum* sp. was found to overgrow fouling on marina pontoons and heavily fouled leisure craft. Sheet like growth overgrew mussels and may have smothered some. Long prolonged growths hang from both the hulls of craft and pontoons with extensions of up to ~60cms. The tunicate bears a strong resemblance to populations in the Rade de Brest and Le Havre and in Dutch waters. *Didemnum* sp. with a similar growth form are known from the east and west coasts of North America and from New Zealand.<br>The southern hemisphere tunicate *Corella eumyota* was found for the first time in Ireland at Cork Harbour in 2005 (Christine Woods of the Marine Biological Association, Plymouth pers. comm.). |
| Italy | *Fistularia commersonii* continues to be found in numerous groups in the Sicily Straits; it was also caught along the SW shore of Sicily (Milazzo *et al.*, in press) and other localities in the Tyrrhenian sea (Micarelli *et al.*, in press).<br>For *Siganus luridus*, that had been found in the Linosa island in 2000, the genetic variability of the early phase of invasion and the genetic variation within and between colonist and source populations (Red Sea) were tested (Azzurro *et al.*, in press). A lowering of the genetic diversity of the invading population has been found. Within the Mediterranean populations of Israel, Greece and Italy, there was no pattern of regional separation and mitochondrial diversity appeared to be preserved during the Linosa colonization, with no traces of founder events. *Siganus luridus* has been found also near Capo d'Orlando, along the Northern coast of Sicily (Castriota and Andaloro, 2005).<br>The Bryozoan *Pherusella brevituba* has been collected at Ustica Island in 1996. It was known only from California; several colonies were growing on Posidonia leaves (Chimenz Gusso and d'Hondt, 2005). Together with other species of Bryozoa, that had been recorded before in Italian waters, it must be considered a cryptic species, being surely unconspicuous and having a difficult taxonomic status. The two other species are:<br>*Bugula serrata* is an indopacific species, was described in the beginning of 1900 from Corsica and was found again in the small Tyrrhenian islands of Vulcano and Ponza (1992) and Ustica (1994) (Chimenz Gusso *et al.*, 2004).<br>*Arachnoidea protecta* is known from Celebes and had been found in the island of Vulcano near Sicily in 1994 (Chimenz Gusso *et al.*, 1998).<br>Four species of Polychaetes had been recorded in the Italian seas in previous years, but were not registered into the list of Italian alien species.<br>*Epidiopatra hupferiana hupferiana* had been recorded for the first time in 1991 in the Mediterranean Sea at Augusta (Sicily). It belongs to the Onuphidae and it is known from the Atlantic and Eastern Pacific, South Africa and the Antarctic (Cantone *et al.* 1991).<br>*Lumbrinerides acutiformis*, an indopacific species, was recorded for the first time in the Mediterranean Sea in the islands of the Sicily Straits (Albertelli *et al.*, 1995).<br>*Hyboscolex longiseta* had been recorded for the first time in the Mediterranean Sea in Tunisia and later on in the Latium region in Italy. It belongs to the Scalibregmatidae and is cosmopolitan; since it is known from the Red Sea and Suez, it might be an Erithrean alien (Cantone *et al.*, 1978).<br>*Loimia medusa*, a Terebellid indopacific species, was recorded for the first time in the Mediterranean Sea in the islands of the Sicily Straits (Albertelli *et al.*, 1995). |

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| | Among the molluscs, the indopacific bivalve, *Theora lubrica*, was found in Leghorn in 2001 (Balena *et al.*, 2002), and since then it is colonizing a few stations inside the harbour, forming a large population (Campani *et al.*, 2004).<br>An Isopod species belonging to the genus *Mesanthura*, known from tropical areas and new for the Mediterranean, was found in the harbour of Salerno (Tyrrhenian Sea, southern Italy): it is probably *M. romulea* (Lorenti *et al.*, submitted).<br>A single adult male individual of *Eriocheir sinensis* (Crustacea, Decapoda Grapsidae) has been collected by catch in the lagoon of Venice in May 2005 and sent alive to the Venice Fish Market Veterinary Service. Passive transport of larvae in ballast water is one of the way of introduction but in this case the import of live material is most likely: in 2003 living individuals of this species coming from U.K. had been sold in the local fish market (Mizzan, 2005).<br>The non-indigenous ascidian, *Distaplia bermudensis*, from the western Atlantic Ocean was found for the first time in the year 2000 in the Taranto Seas (Ionian Sea, southern Italy), where an abundant population of colonies is present (Mastrototaro and Brunetti, 2006).<br>*Clytia hummelinckii* : this hydroid species was recorded for the first time from the Mediterranean (Ionian coasts of Calabria and Apulia) by Boero *et al.* in 1997 and, since then, from both the Adriatic and the Tyrrhenian seas (albeit unpublished). The species is expanding rapidly. It forms dense carpets at 1-2 m depth, in full light, on rocks covered by encrusting coralline algae, especially those intensively grazed by sea urchins. The species is present in the summer, but the whole cycle is still unknown. Being present both in the Atlantic and in the Pacific, it is not clear if it entered the Mediterranean either from Suez Canal or from Gibraltar. The rapid expansion of this species of hydroid witnesses a great success of the medusa stage, since dispersal is mainly obtained by displacement with currents. Unfortunately, Clytia medusae are very similar to each other and are invariably identified as Clytia hemisphaerica by plankton ecologists, so the diversity of species is undetected (Boero *et al.*, 2005).<br>*Aplysia dactylomela* had been found in 2002 in Lampedusa Island (Chemello, in press).<br>*Cerithium scabridum* is expanding in the western shores of Sicily, it builds up large populations in some locations, but they disappear after an year or so.<br>*Musculista senhousia* has built up a large population inside the harbour of Leghorn, enlarging its Tyrrhenian distribution (Campani *et al.*, 2004).<br>The distribution of *Branchiomma luctuosum*, *Microcosmus squamiger* (= *M. exasperatus*) and *Musculista senhousia* has been described in the sea inlets facing the town of Taranto (Mastrototaro *et al.*, 2004). *Microcosmus squamiger* was also fond in the harbour of Salerno (Tyrrhenian Sea) (Mastrototaro and Dappiano, 2005).<br>*Caprella scaura*, an Asian Amphipod collected for the first time in 1994 in the Lagoon of Venice, was recently reported as very abundant also in the harbour of Ravenna (Sconfietti *et al.*, 2005).<br>In 2002, during a survey for control and detection of NIS in the lagoon of Venice (Mizzan *et al.*, 2005), the crustacean decapod *Rhithropanopeus harrisii* was found in two inner areas of the lagoon characterized by mean annual salinity lower than 24 PSU (Mizzan, 2005). It was previously known from a basin used for rearing *Penaeus japonicus* in the Po river delta.<br>The invasive crab *Percnon gibbesi* has reached the Central Tyrrhenian (Russo and Villani, 2005). The success of this species has been related to reproductive characteristics (Puccio *et al.*, 2003) and to its strictly herbivorous feeding habits (Puccio *et al.*, 2006).<br>The planktonic centric diatom *Skeletonema tropicum* was found for the first time in the Gulf of Naples, and in the Mediterranean Sea, in autumn 2002 (Sarno *et al.* 2005). This species is considered tropical and subtropical, with a distribution not beyond 30° North in the western Atlantic Ocean. Since the |

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| | first finding, it regularly occurred in late summer and autumn in the Gulf.<br>A green alga belonging to the genus *Prasiola*, known from polar and cold-temperate regions, has been recorded in 2002 in the Lagoon of Venice (Miotti *et al.*, 2005) in three different occasions, with few and small specimens; it is the first finding in Italy, while it has been reported from the Black and Azov Sea, and doubtfully from the Aegean.<br>Besides the detailed information on all the Italian localities where *Caulerpa racemosa* has been found (Piazzi *et al.*, 2005), the expansion of *Caulerpa racemosa*, starting from a small initial point near Taranto in 1996, has been monitored till 2004, encompassing 70 km of the coast (Cecere *et al.*, 2005). The distribution of *Womersleyella setacea* is now extended to three localities in the Apulian region (Cecere *et al.*, 2005). Other algal species have also expanded in the same area of the Gulf of Taranto (Cecere and Petrocelli, 2004; Mastrototaro *et al.*, 2004).<br>The study on the interactions of *Caulerpa* species with native algae has been continued. In an area near Leghorn, where *Caulerpa racemosa* and *C. taxifolia* co-occur, macroalgal communities were more different from reference areas when invaded by *C. racemosa*; the structure of invaded communities was related to the invader also in terms of growth habit (Piazzi *et al.*, 2003; Balata *et al.*, 2004). In habitats where four introduced macroalgae are present with very high percentages of macroalgal abundance, the native community was deeply affected (Piazzi and Cinelli, 2003). The effect of the increase in sediment deposition on the spread of *Caulerpa racemosa var. cylindracea* and the interactive effects of sedimentation and *C. racemosa* on native macroalgal assemblages have been evaluated by means of field experiments near Leghorn (Piazzi *et al.*, 2005). Results showed that *C. racemosa* was not affected by an increase of sedimentation rate. Synergistic mechanisms between sediment deposition and *C. racemosa* colonization resulted in a strong decrease in percent cover of the main algal species in areas where the two disturbances co-occurred.<br>The distribution and dynamics of the introduced green alga, *Codium fragile* ssp. *tomentosoides*, was investigated on breakwaters in the north Adriatic Sea, and the mechanisms underlying its establishment have been investigated. The artificial structures provide suitable habitats for non-indigenous marine species and function as corridors for their expansion (Bulleri and Airoldi, 2005). |
| The Netherlands | In 2005 three species were added to the list of introduced species in The Netherlands: *Palaemon macrodactylus*, *Rapana venosa* and *Neogobius melanostomus* were recorded for the first time in Dutch waters.<br>*Didemnum* sp. ("*lahillei*" in Dutch literature) has been present in the Dutch Oosterschelde estuary since 1991. It remained rare until 1998, after which it dramatically expanded its population size and overgrew almost all hard substrata present, including organisms like algae, plants, bivalves, hydroids, sponges, sea anemones and other ascidians.<br>The Pacific oyster *Crassostrea gigas* is still spreading in the Wadden Sea. At this moment it is the dominant invader in Dutch waters. Its spread and interaction with native shellfish species are being studied by Wageningen IMARES Yerseke, the University of Groningen and the Royal NIOZ at Texel. |
| Norway | The red king crab *Paralithodes camtchaticus* has continued its west and southwards migration as well as indications of a northward migration towards Spitzbergen. One specimen has been collected at "Folla" (N64 40, E 11), substantially south of the Lofoten archipelago (N68, E15), but this is believed to be a released individual. Suspected migrating individuals, have been caught close to Tromsø (N70, E19 30).<br>The snow crab *Cionoecetes opilio* has become fairly common in bottom trawls east in the Barents Sea / Goose Bank, and an increasing number of young individuals/juveniles is reported. The stock have been estimated to some 500 000 individuals on the Goose Bank (N 70-75, E35-45) in the |

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| | Russian EZ.<br>During the pot fishery for lobster, some 14 lobsters with suspect habitus-characteristics were collected several places in Southern Norway. Eight were confirmed to be the American lobster, and two of these were females carrying fertilized eggs. Intensive capturing efforts were initiated at the "hot spot" outside Bergen (N60 19, E05 10) where the majority of specimens were found, but no additional specimens were captured. Several of the American lobsters had rubber band on their claws.<br>The red alga *Heterosiphonia japonica* has continued to expand its range both northward and south-/eastward. It is now easily found and well established in the "Oslofjord" area (N59, E 10).<br>Japanese driftweed, *Sargassum muticum* continues to increase in biomass in areas where established (sheltered to semi-sheltered localities from the Swedish border (N59 03, E 11 08) to North of the "Sognefjord" (N61 14, E4 56). |
| Spain | Recently found species in Spain include:<br>*Asparagopsis armata-Falkembergia rufolanosa*, 2003, Asturias (Biscay Bay)<br>*Grateolupia filicina*, 2003, Asturias (Biscay Bay)<br>*Codium fragile*, 2005, Asturias (Biscay Bay)<br>*Coccinasterias tenuispina*, 2000, Asturias (Biscay Bay)<br>*Dreissena polimorpha*, 2001, Ebro estuary<br>*Rhitropanopeus harrisii*, 2001, Guadalquivir Estuary<br>*Eriocheir sinensis*, 2001, Guadalquivir estuary, Cataluña coast,<br>*Callinectes sapidus*, 2005, Guadalquivir Estuary, Gijón (Port of Musel) |
| Sweden | One very large (>20 cm), live individual of *Crassostera gigas* was found in northern Bohuslän in 2004 and brought to the closeby Tjärnö Marine Biological Station for examination (H-G Hansson, Göteborg univ., pers. comm.). In the early 1970s a few specimens of Pacific oysters were introduced and cultivated in Sweden, just south of the town Strömstad in the province of Bohuslän, close to this area (J. Haamer, pers. comm.).<br>During 2005 studies (Elena Gorokhova, Stockholm univ., pers. comm.) have been made on *Cercopagis pengoi*, an invasive predatory cladoceran, which has become a permanent member of the Baltic Sea pelagic ecosystem. The results suggest e.g. that the fish predation may have a strong impact on *Cercopagis* abundance and population structure, and possibly cause cascading effects of *Cercopagis* predation on herbivorous zooplankton, thus mediating the effects of this newcomer on the ecosystem.<br>The polychaete *Marenzelleria*, still refered to as *M.* cf. *viridis*, is found in several of the monitoring programmes along the Swedish east and south coasts, and in the Öresund and Skälderviken. However, it has not been recorded in monitoring samples from the Swedish west coast (Stefan Agrenius, Göteborg univ., pers. comm.). It is not known if the findings from the Öresund area belong to the true *M. viridis*, which has been introduced to the European Atlantic coasts, or should be named *M. neglecta*, following a revision of this genus (Sikorski and Bick 2004). In 2005, *Marenzelleria* was recorded only from one single site in the Helsingborg area in relatively low abundances (Hellfalk *et al.*, 2005), while it the previous year was found in four different areas. In the S Bothnian Sea, outside the nuclear power plant at Forsmark, the province of Uppland, *Marenzelleria* was first recorded in 1997, and in 2004 it comprised 55% of the total number of individuals at a station 16 m deep, and 77% at a station 41 m deep, where it also comprised 32 % of the biomasses (Abrahamsson *et al.*, 2005).<br>Every year single specimens of the Chinese mitten crab, *Eriocheir sinensis*, are reported to have been caught by fishermen (e.g. in the Södertälje city, Lake Mälaren, in June 2005, and one specimen as far north as in the Gulf Norrfällsviken, the Bothnian Sea). There are NO reports of mass occurrences. However, it has been told that commercial fishermen in Lake Mälaren during the fishing season catch 20–30 mitten crabs each day in their nets. |

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| | Details on the large Asiatic red alga *Gracilaria vermiculophylla,* first recorded during August-September 2003 in the Göteborg archipelago, have been given in the WGITMO-reports 2004 and 2005. In 2005 it was recorded much further south than previously, in Bua and Treslövsläge, in the middle of the province of Halland. Thus, from the first site of record, its distribution now has been extended around 72 km to the north and 80 km to the south.<br>The first Swedish records of the red alga *Aglaothamnion halliae*, common in harbour areas on the south coast of Norway since at least 1980, was in 2003 (in harbour areas in Strömstad, Grebbestad and Rönnäng, the northern and middle parts of the province of Bohuslän; WGITMO, 2004). In 2005, it was recorded in the marina at Bua, in the middle-northern part of the province of Halland, which is an extension of around 100 km to the south. It is quite likely that it is more frequent than reported, since the size and shape, similar to many closely related native species, makes it easily overlooked.<br>In late summer 2005, two attached plants of the Japanese brown alga *Sargassum muticum* were found in the northern part of the city of Helsingborg, northern Öresund (Hellfalk *et al.*, 2005), and drifting specimens were seen in several areas around Helsingborg. For a long number of years only drifting specimens have been seen along the coasts south of Treslövsläge, in the middle part of the province of Halland. The southern border for attached plants thus has moved around 120 km to the south.<br>The Japanese red alga *Heterosiphonia japonica* (i.e. "*Dasysiphonia* sp." in WGITMO reports until 2003) was during 2005 very common on both sides of the Kosterfjord, N Bohuslän. The southernmost known locality is still the very exposed offshore "shallow" area, Persgrunden, about 20–25 km south of Koster, where it has been found down to 19 m depth, although not as a dominant alga (Jan Karlsson, Göteborg univ., pers. comm.).<br>For several years we have reported of the raphidophyte *Chattonella* aff. *verruculosa* as a potentially introduced species in Scandinavian waters. In April 2005, small populations were noted on the Swedish west coast, and again in November. In 2006, it was present in abundances up to ca 30 000 cells per litre, both on the Swedish west coast and in S Norway. In February 2006, numbers over 200 000 cells per litre were recorded on the Swedish west coast, while Danish samples had up to 1–4 million cells per litre (Skejvik 2005–2006). In March 2006, slightly lower numbers (145 000 cells per litre) were found on the Swedish west coast, while they were still 2.6 millions in Århus, Denmark, and it is assumed that it caused the death of 18 tonnes of farmed fish in the northern part of the Great Belt area (Kalundborg Fjord; Skjevik 2006). Thus, since the species can cause fish kills, there is concern of bloom events. |
| United Kingdom | Topmouth gudgeon *Pseudorasbora parva*, which originally entered the UK in the mid-1980s as a contaminant of an ornamental fish consignment from Continental Europe, continues to spread via accidental transfers (Pinder *et al.*, 2005), increasing the concern over the potential impact of this highly invasive species, which was discovered in 2005 to be the healthy host of a rosette-like agent (Gozlan *et al.*, 2005). However, an attempt to eradicate topmouth gudgeon from a small lake in Cumbria, using rotenone, appears to have succeeded (M. Brazier, personal communication). Also, data on the species' presence in a pond of Epping Forest (Greater London) suggests that removal of the species (i.e. Copp *et al.*, 2005c), when initially found in small numbers (i.e. Wheeler 1998), may result in the species extirpation (G.H. Copp, unpublished data).<br>SAMS (Scottish Association of Marine Science) have reported *Caprella mutica* identifications with date of reporting, site description (if known) and the possible mechanism of introduction. These reports are as follows: England (Southampton Harbour, 2003) less than 10 km from the port, by shipping (L. Baldock and M. Marley, pers. comm.). England (Harwich Harbour, 2004) within 10 km of port, by shipping, (Ashelby, in press). Scotland (Shetland Is, 2003) on mussel lines, probably by aquaculture |

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| | or hull fouling, noted within 30 km of port (G. Duncan, pers. comm.). Wales (Anglesey, 2003) on mooring lines, probably by hull fouling/recreational boats, within 20 km of port (T. Stoker, pers. comm.). Although this represents some pre-2005 data, this is the first time we understand the reports to have been noted. Richard Shucksmith (CASE NERC PhD at SAMS in association with Scottish Natural Heritage has shown *Caprella mutica* to displace the native caprellids, *Caprella linearis* and *Pseudoprotella* spp. from artificial structures at relatively low densities in aquarium trials. These trials will be repeated in the field in 2006 using a variety of potential native competitors.<br>Chinese mitten crabs have anecdotally been reported on the intake screens of Shoreham Power Station, situated on the River Adur, Sussex (Southern England).<br>A paper has been published (Elliot *et al*,. 2005) documenting current problems associated with zebra mussels in English waterworks. Questionnaires and manual surveys conducted between 2001 and 2003 have revealed that over 30 water treatment works in England suffer problems associated with zebra mussels. Hundreds of tonnes of mussels are being removed each year from raw water intakes, pipelines and reservoirs. Problems have increased in the last five years, due to a spread in the range of zebra mussels around England and the cessation of chemical treatment at the intakes of many treatment facilities during the 1990s.<br>The range of Signal crayfish (*Pacifastacus leniusculus*) continues to expand. There was one outbreak of crayfish plague in native crayfish in 2005. This was in the River Dove, Derbyshire.<br>*Sargassum muticum* has continued to spread in Wales (see figure). Sediment cores were collected under and outside canopies of *S. muticum* in Strangford Lough (*S. muticum* first recorded in 1995) and Langstone Harbour, English Channel (*S. muticum* first found in 1974) to investigate modification of the infaunal assemblages. At both study sites, community analyses highlighted significant differences between the assemblages under the canopies and those in adjacent unvegetated areas. In Strangford Lough, the invertebrate community under the canopy contained a higher abundance of smaller, opportunistic, *r*-selected species than outside the canopy. By contrast, the communities under and outside the canopy at Langstone Harbour were similar in species composition, diversity and dominance, but overall faunal abundance was greater under the canopy. Sediment characteristics were not affected by *S. muticum* canopies, but the infaunal changes may be related to environmental modification; shading, flow suppression and temperature stratification were also investigated. The differences between these two sites indicate that localized conditions and/or the duration of colonization of *S. muticum* are important in determining the nature of habitat modification (Strong, *et al.,* 2006).<br>*Caulacanthus okamurae*, has crossed the Channel to Devon and Cornwall where it was found at Plymouth in 2004 and at Looe in 2005 (Mineur *et al*., 2006).<br>*Heterosiphonia japonica* is now widespread along the south coast from Devon to the Isle of Wight. |
| USA | *Pterois volitans* (Lionfish) appears to be well established from North Carolina to Florida. Experimental studies indicate that this fish tolerates temperatures as low as 10-16ºC and is capable of surviving winter conditions as far north as Cape Hatteras. Juveniles have been caught on Long Island, New York, carried north by currents and suggesting that the southern populations are breeding.<br>Two introductions of predatory freshwater fishes in U.S. Atlantic Coast rivers pose concerns for anadromous fish populations such as Alewife and American Shad (*Alosa* spp.) Individuals of *Channa argus*, Northern Snakehead, native to Asia, were caught in 2004 in both the Potomac and Delaware Rivers, in the vicinities of Washington and Philadelphia, respectively, and are now established in both estuaries. *Pylodictus olivaris*, |

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| | the Flathead Catfish, native to the Mississippi River and other Gulf of Mexico tributaries was introduced to Atlantic watersheds in North Carolina and Virginia in the 1990s by state agencies. In 2002, this catfish was first caught in Pennsylvania tributaries of the Delaware River and in 2004, it was caught in the Susquehanna River, the largest tributary of Chesapeake Bay. The Flathead Catfish is now established in both rivers, reaching tidal fresh waters in the states of Maryland, Pennsylvania, and New Jersey. For both species, the likeliest vector of introduction is illegal stocking by private individuals.<br>**Atlantic/Gulf Coasts**<br>*Tubastrea coccinea* (Orange Cup Coral) - This Indo-Pacific coral first appeared in the Caribbean in 1943, probably transported on ship fouling. It gradually expanded its range north into the Gulf of Mexico, reaching oil platforms off Texas and Louisiana by 1991. By 2002, it had invaded the Flower Garden Banks National Marine Sanctuary off Texas, an important deep-water reef, and had also been collected on shipwrecks off the East Coast of Florida.<br>*Hyotissa hyotis* (an Indo-Pacific Oyster) - A native Atlantic oyster, *H. mcgintyi*, had long been misidentified as *H. hyotis*. However, *H. hyotis* differs in shell coloration and reaches a much larger size. During a molecular study of *H. mcgintyi*, two oyster specimens, found near Marathon Key, Florida in 2003, proved almost identical to specimens of *H. hyotis* from Guam. Earlier records of *'H. hyotis'* in Western Atlantic waters refer to *H. mcgintyi*. Several specimens of true *H. hyotis* have been collected in Florida, but established populations have not confirmed. Hull fouling and ballast water are possible vectors for the transport of this oyster.<br>*Perna viridis* (Green Mussel) - This mussel continues to expand its range northward. In 2003, it was collected for the first time in Georgia waters, along the entire coast of the state, from St. Simons Island north to the Savannah River.<br>*Synidotea laevidorsalis* - This isopod, native to the Indo-West Pacific, was collected in New York City Harbor, at South Street Seaport in 2003, in MIT Sea Grant Surveys, and in 2002, was found on fouling plates in lower Chesapeake Bay (Elisabeth Jewett, personal communication). On the Pacific coast, it is known from San Francisco Bay (since 1897) and from Willapa Bay, Washington. It was first found on the East Coast in 1998 in Charleston, South Carolina, and in 1999 in Delaware Bay. *Synidotea laevidorsalis* is likely to be present in other East Coast estuaries, and has also been collected on the Atlantic Coasts of France and Spain.<br>*Charybdis helleri (*Asian Swimming Crab)- U.S. Records of this Indo-Pacific crab, now extend from Sarasota Bay, Florida, on the Gulf of Mexico (first collected in 2004) north to Core Sound, North Carolina, about 50 miles south of Cape Hatteras (also first collected in 2004).<br>*Didemnum* sp. (compound ascidian)- This species has been referred to as *D. vexillum* and *D. lahillei*, but neither are accepted at the definitive identification for the U.S. organisms. This represents a change from last year when *D. lahillei* was preferred nomenclature. The current accepted identification is *Didemnum* sp. New reports of the species include Cobscook Bay, Maine; Strong Island, Osterville Strong Island, and Woods Hole Iselin Dock, Massachusetts; Fort Point, New Hampshire; and Beavertail Point, Rhode Island. The species has been reported from the West Coast at several locations in California and Washington. An unsuccessful eradication effort was undertaken in the Friday Harbor, Washington area. It has been found offshore in approximately 45-65 meters of water throughout areas surveyed and may cover more than 67 sq. $m^2$, representing about a 10 fold increase in last year's report. In areas where it has been observed it may cover up to 75% of the bottom cobble area.<br>**Pacific Coast**<br>*Orthione griffenis* - *Orthione griffenis* is a bopyrid isopod which inhabits the gill chambers of the burrowing mud shrimps of the genus *Upogebia*. It is |

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| | apparently native to Japan, and was first collected in U.S. waters in 1985. It now infests *U. pugettensis* from Santa Barbara, California, north to British Columbia. In Oregon estuaries, up to 80% of the shrimps are infected, and are rendered incapable of reproduction. Mud shrimps are important as a suspension-feeder and as food for a wide range of fishes and shorebirds. Impacts of this parasite on mud shrimp abundances are currently being studied by John Chapman and colleagues. Ballast water is considered to be the likeliest vector of introduction.<br>*Perophora japonica*- This colonial tunicate was found for the first time in Humboldt Bay, California by Gretchen Lambert in 2003. So far, it has not been reported from other U.S. waters. It has colonized European waters, where it was first collected off Brittany in 1982. In the East Pacific and East Atlantic, hull fouling is the probable mode of introduction.<br>*Antithamnion nipponicum*- This Northwest Pacific red alga (formerly known as *A. pectinatum* in Atlantic waters and *A. hubbsi* in U.S. Pacific waters) is newly reported from Beaufort, North Carolina (2003), Baja California, Mexico (1962, as *A. hubbsi*), and Halfmoon Bay, California (2003). It has been introduced to New England waters (Buzzards Bay to Long Island Sound, first reported 1985), the Azores, and the Mediterranean, and may be also introduced in West Coast waters. Fouling, ballast water, and oysters are all possible vectors.<br>*Caulacanthus ustulatus*- This mat-forming red alga is reported as a recent invader in California, where it was first reported in 1999 at Cape Fermin, near San Pedro. It has subsequently spread into Elkhorn Slough and San Francisco Bay. Earlier records have been reported from Baja California (1961), British Columbia (1974), and Prince William Sound, Alaska (1996). Molecular analyses indicate that two major lineages exist, an East Atlantic group, and an Indo-West Pacific group. Populations from British Columbia populations belonged to the Indo-West Pacific lineage, as did local introduced populations in Brittany, France. Pacific oysters (from Asia), ship fouling, and ballast water are likely vectors for this alga.<br>*Caulerpa taxifolia*- In the previously infested areas, Aqua Hedionda Lagoon and Huntington Harbor, eradication efforts appear to have been successful. No new plants have been seen since 2002, but monitoring continues.<br>*Gracilaria vermiculophylla*- This West Pacific red alga was identified by molecular methods. In 1999–2000, nuisance blooms of a fouling and drifting species of *Gracilaria* were noted in the Cape Fear River, near Wilmington, North Carolina, and in Hog Island Bay, Virginia, a coastal lagoon just north of the mouth of Chesapeake Bay. These were initially assumed to be native *Gracilaria* species, but mitochondrial DNA analyses indicate that the dominant species is the introduced G. *vermiculophylla*. This species has been found on the West Coast as well, at Elkhorn Slough, California, where specimens were collected in 1994. More extensive genetic surveys are needed to determine the range of this introduced species in U.S. waters. This alga has been reported in European waters from Spain to Sweden.<br>*Porphyra katadae*- This Japanese red alga was identified using molecular methods, by Arthur Matheison and associates, at unspecified locations north and south of Cape Cod in 2005. Ballast water and fouling are likely vectors of introduction,<br>*Porphyra yezoensis* (Nori)-. Although this edible Asian red alga was cultivated in Cobscook Bay, Maine, from 1991 to 1998, and carefully monitored, no evidence of reproduction was seen. However, “wild” plants were collected near Portsmouth NH by Arthur Mathieson and associates in 1999, and identified by molecular methods. Subsequently, populations were found at several locations from Maine to Long Island. Molecular analysis indicated that at least two strains were present, but both were distinct form the cultivated form.<br>*Bonamia* sp. In Bogue Sound, North Carolina, transplanted Suminoe Oysters (*Crassostrea ariakensis*) suffered extensive mortality from an unknown |

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| | pathogen. DNA analysis indicated that the pathogen was a species of *Bonamia*. Since this infection was not detected in *C. ariakensis* in Chesapeake Bay, or Pamlico Sound, the parasite is assumed to have a local distribution. Its native/introduced status is not known. |

## 9.5 Conclusions

- As in previous years, the most commonly moved species in 2005 were Atlantic salmon Salmo salar and the Pacific oyster *Crassostrea gigas*.
- As reported in the National Report from the United Kingdom, a recent review of past introductions of non-native fish in 17 countries of Europe and North America (Copp *et al.,* 2005b) found that the USA (93) and France (35) are at the top of the list of intentional fish introductions, followed by the Czech Republic, Russia, Romania, Austria and Spain (27 to 21), with the other countries (including England & Wales) having <20 intentional introductions but only Germany had <10 such introductions.
- ICES Member Countries imported live organisms from 32 countries with fish and molluscs being the most imported taxa. The country with the highest number of source regions in commercial species imports in 2005 was Germany with 17 source regions to be followed by Sweden with 16. Most other importing countries import species from less than 5 source regions. However, it should be noted that the detail level when documenting species varies enormously between certain countries. Several countries refer to source regions as "from various countries" thereby documenting that more detailed information is not available. Germany imports predominantly fish and France molluscs. In other countries no clear trend is obvious.
- Accidental species introductions continue to be reported. Of particular concern are the first records of *Neogobius melanostomus* and *Rapana venosa* in the North Sea as both species showed negative impacts in other regions they invaded. The previously introduced non-indigenous oyster *Crassostrea gigas* continues to spread in the Wadden Sea. *Didemnum* sp. continue to spread. In an estuary north of Dublin in October 2005 a growth form of *Didemnum* sp. was found to overgrow fouling on marina pontoons and heavily fouled leisure craft. Eleven new invertebrate species have been added to the list of introduced species found in Italian waters. The Red King crab *Paralithodes camtschaticus* has continued its south- and westward migration and several individuals have been caught outside Tromsø. In Sweden every year single specimens of the Chinese mitten crab, *Eriocheir sinensis,* are reported to have been caught by fishermen. Here, the large Asiatic red alga *Gracilaria vermiculophylla,* first recorded during August-September 2003, *Sargassum muticum* and *Aglaothamnion halliae*is were recorded much further south than previously. The raphidophyte *Chattonella* aff. *verruculosa* was noted in low numbers on the Swedish west coast in April 2005 and again in November. In 2006, it was present in abundances up to ca 30,000 cells per litre, both on the Swedish west coast and in S Norway. In February 2006, numbers over 200,000 cells per litre were recorded on the Swedish west coast. The parasite *Gyrodactylus salaris* was found at a fish farm, on the Swedish west coast. IPN-V (infectious pancreatic necrosis) was recorded in a fish farm on the west coast. Dead perch found north of the city of Stockholm died from attacks of the freshwater fungus *Branchiomyces denigrans,* which previously has not been recorded from Sweden. The UK Environment Agency found seven individuals of *Sarsiella* (*Eusarsiella*?) *zostericola*, an alien ostracod species predating in a grab sample at Mucking Flats on the Thames. The Scottish Association of Marine Science have reported *Caprella mutica. Sargassum muticum* has continued to spread in Wales. The range of Signal crayfish (*Pacifastacus leniusculus*) continues to expand. There was one outbreak of crayfish plague in native crayfish in 2005.
- WGITMO plans to re-formate the National Report structure at the next meeting with the aim to collate information in a table format and to ease the annual

reporting, documentation and synthesis of the spread and impact of introduced species. A spreadsheet format is likely to allow a continuous overview of information from National Reports and the annual preparation of a concise summary report on the ecological significance of any new proposed introductions. It is further suggested to use a "rolling format" covering ten years and by doing so to simplify future ten year summaries of National Reports.

### 9.6 Recommendations

- WGITMO recommends that future annual meetings include an opportunity for the participation from non-ICES countries (e.g., Australia, New Zealand, Mediterranean countries, PICES and other international organizations, such as CIESM) on the basis of their expertise relevant to the Alien Species Alert Report in preparation by WGITMO.
- It is recommended that this ToR should remain on the agenda of WGITMO.

## 10 Other Agenda Items

### 10.1 Conference on invasive species

The Fifth International Conference on Marine Bioinvasions, May 15–18, 2007 will be held in the Massachusetts Institute of Technology, Cambridge, Massacusetts, USA. The conference is sponsored by ICES, PICES, and the National Sea Grant College Program. The deadline for abstract submission is in November 2006. Selected papers will be published in the ICES Journal. Travel funds for students can be applied for.

### 10.2 New journal on biological invasions

**Aquatic Invasions** is a rapid on-line journal focusing on biological invasions in European inland and coastal waters and potential donor areas of aquatic invasive species for Europe (http://www.aquaticinvasions.ru/). The journal provides the opportunity of timely publication of first records of biological invaders for consideration in risk assessments and early warning systems. Also, the journal provides opportunity to publish relevant technical reports and other accounts not publishable in regular scientific journals. Aquatic Invasions is a part of the developing European early warning system on aquatic invasive species, with an important service of protection of authors rights on primary geo-referenced information on species records. The journal is edited by Dr Vadim E. Panov (Zoological Institute, Russia) and Dr Stephan Gollasch (GoConsult, Germany). **Aquatic Invasions** is published on behalf of the International Association of Theoretical and Applied Limnology (SIL) with support of ICES/IOC/IMO WGBOSV, with start-up funding from the European Commission Sixth Framework Programme for Research and Technological Development Integrated Project ALARM (GOCE-CT-2003-506675, http://www.alarmproject.net ).

### 10.3 New database in Norway

A new cross-sectorial databank for biodiversity-data has been established (www.artsdatabanken.no). In addition to a thorough review of the "Red list" of endangered species, the databank will establish and maintain a searchable list of alien species in Norway (both terrestrial, limnic and marine).

### 10.4 Research networks

#### Canada

A new research network is developing in Canada, the Canadian Aquatic Species Network. Work items include invasion pathways, vectors and the analysis of ecosystem impacts caused ba aquatic alien spcies.

### Delivering Alien Invasive Species Inventories for Europe (DAISIE)

This European Union funded programme on biological invasion was launched in Feb. 2005 and will continue until Feb. 2008. For more information please see http://www.europe-aliens.org/. The overall objectives include the preparation of a database of all introduced cpesies in Europe (including terrestrial, freshwater and marine taxa) and to create a European Alien Species Expertise Registry. The expertise registry has recently been set up and is now in his early phase, already containing more than 800 experts from 64 countries http://daisie.ckff.si/ .

### Environmental impacts of alien species in aquaculture

The newly developed project proposal was submitted to the European Union recently for evaluation. The projects objectives are of direct relevance to WGITMO:

- guidelines for environmentally sound practices for introductions and translocations in aquaculture,
- guidelines on quarantine procedures, and
- risk assessment protocols and procedures for assessing the potential impacts of invasive alien species in aquaculture.

The project mobilises a consortium of experts in the management of aquatic alien species, including persons who drafted the ICES and EIFAC Codes of Practice on Introductions and Transfers of Aquatic Organisms, and key contributors in complimentary projects.

## 10.5 Discussion on ICES Code of Practice on the Introduction and Transfer of Marine Organisms

### 10.5.1 Poliploidy

ICES has now published the updated Code of Practice. This document was tabled by the chair for any updates or discussion. Sweden (Dr. I. Wallentinus) submitted the following concerns which should be taken into account during the next revision of the code:

*I have no objections to the new paragraphs in the Code of Practice BUT for that they are mostly valid just for animals. Among plants polyploids are quite common and for marine species the polyploidization of the hybrid Spartina x townsendi (6n), originating from crossings of the European S. maritima (6n) with the North American S. alterniflora (6n), has resulted in S. anglica (12n). This species has spread to many European coasts, where it has become very dominant and it also been introduced to several other coastal areas (China, Australia, New Zealand) where later eradication programmes have been started. Triploids are not uncommon among plants and may develop into fertile hexaploids.*

*Thus we have information since quite long ago that polyploid plants can have severe ecological impact and in the 2nd sentence under VIII, maybe aquatic ORGANISMS should be replaced by aquatic ANIMALS. Also I would like to add a short sentence on plants as a 3 rd sentence under VIII, something like:*

*For plants there are examples of polyploids having caused dramatic ecological effects (e.g. Spartina anglica, 12n) and polyploids may be created naturally both within a species or in a hybrid.*

### 10.5.2 Detailed Appendices of the ICES Code of Practice

ICES informed the Chair during the meeting that the detailed description of the Codes appendices are now available on the Internet. Due to severe Internet access problems at the venue this information could not be forwarded to the participants at the meting.

### 10.6 Conclusions

- WGITMO concluded that organisms should be changed for animals in the GMO section of the Code of Practice.
- WGITMO also appreciates that the more detailed Annexes of the Code of practice are now available on the Internet at http://www.ices.dk/pubs/Miscellaneous/Codeofpractice.asp

## 11 Recommendations to ICES Council

The recommendations from this year's discussions are provided in Annex 10 of this report.

## 12 Planning of next years meeting

The invitation of Croatia to host next years meeting of WGITMO was much appreciated by the group. The group suggested meeting in Dubrovnik for at least 2 days during the week beginning Monday, March $19^{th}$ 2007.

## 13 Closing of the meeting

The 2006 meeting of WGITMO was closed on Friday, March 17th at 3.00 pm. There was consensus that there is an ongoing demand for WGITMO to meet on an annual basis. The various planned intersessional activities (see Recommendations Annex 10) make a meeting obligatory in 2007 to reach final agreement.

The invitation of Croatia to host next year's meeting of WGITMO was much appreciated and the group suggested meeting in Dubrovnik for at least 2 days during the week beginning Monday, March 19th 2007.

The Chair thanked the host Francis Kerckhof and the hosting organizations the Management Unit of the North Sea Mathematical Models, and the Institute for Agricultural and Fisheries Research, Oostende, Belgium. He also thanked all presenters and facilitators of round table discussions and last but not least the rapporteur Dorothee Kieser, Canada, for keeping the Chair and the meeting organized.

He further thanked all participants and especially those who contributed material to this and previous WGITMO meetings during his chairmanship since 2001. All Terms of Reference given to the group over the years were addressed. However, due to time constraints some Terms of Reference were delayed. In summary, the group worked very effectively with long working hours at meetings and also intersessional and by correspondence, which would not have been possible without the tremendous enthusiasm of the group participants. Further, he wishes the new Chair a successful time and looks forward to continue to work on aspects relevant to WGITMO.

# Annex 1: List of participants at the meeting of WGITMO 2006

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# Annex 2: Terms of Reference

2005/2/ACME/05 The **ICES Working Group on Introduction and Transfers of Marine Organisms (WGITMO)** (Chair: S. Gollasch, Germany) will meet in Oostende, Belgium for 2 days during the week beginning 13th March, 2006 to:

a ) synthesise and evaluate National Reports, and report on the audience for and use of these reports;

b ) prepare a report summarizing introductions and transfers of marine organisms into the North Sea and wherever possible their consequences as input to the 2006 meeting of REGNS (Regional Ecosystem Study Group for the North Sea) and to review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant. The data tables will be subject to thematic assessment to be undertaken at a REGNS thematic assessment workshop;

c ) prepare a summary of National Reports (1992-to date);

d ) plan Aliens Species Alert reports including evaluation of impacts and increasing public awareness;

e ) develop guidelines for rapid response and control options.

WGITMO will report by 11 April 2006 for the attention of ACME.

# Annex 3: Agenda

Working Group on Introductions and Transfers of Marine Organisms

(WGITMO)

Oostende, Belgium 2006

March 16 – 17

Agenda

**Thursday, March 16th**

**9.00 am Opening of the meeting**

- Welcoming remarks and housekeeping issues
- Introduction of participants
- Review of the Terms of Reference
- Review and Adoption of the Agenda

- Status of WGITMO/ICES Publications
  - Code of Practice

- ICES/PICES Collaboration
  (Darlene Smith, Canada; Stephan Gollasch, Germany)
  - PICES Annual Meeting in Vladivostock 2005
  - PICES Annual Meeting in Yokohama 2006
  - New PICES Working Group on biological invasions

- National Reports, Highlights **(ToR a)**

**10.30 am – 11.00 am Coffee break**

- National Reports, **Highlights**, continued

**12.45 pm – 2.00 pm Lunch**

- Plan future Special Advisory Reports **(ToR d)**
  - Review of final Alien Species Alert Report on *Undaria pinnatifida* prepared by Inger Wallentinus, Sweden

- Summary of National Reports 1992-2002 **(ToR c)**
  - Review of draft material for the summary of National Reports

**4.00 pm – 4.30 pm** Coffee Break

- Guidelines for rapid response and control options **(ToR e)**
  - Review of draft prepared by Judy Pederson, USA

**6.00 pm** Adjourn of day 1

**-----------------------------------------------------------------------------------------------------------**

**Friday, March 17th**

**9.00 am**

- Summarizing introductions and transfers of marine organisms into the North Sea and wherever possible their consequences as input to the 2006 meeting of REGNS (Regional Ecosystem Study Group for the North Sea) **(ToR b)**
  - Review of draft material for REGNS

**10.45 am – 11.15 am Coffee break**

- Any other business
- Summary of group findings

**12.00 pm – 1.00 pm** Lunch

- WGITMO Recommendations
- Concluding Remarks
- New Chairperson of WGITMO
- Planning of next meeting

**3.00 pm** Adjournment of the 27th Meeting of WGITMO

# Annex 4: National Reports

# NATIONAL REPORT Belgium, 2005

Prepared by Francis Kerckhof

## Highlights

- During 2005 a third specimen of the Atlantic croaker *Micropogonias undulatus* was fished in Belgian coastal waters and there were 2 findings of the veined whelk *Rapana venosa* in waters of the southern bight of the North Sea, one was close to Belgian waters.
- Most alien species reported during the recent years are still present and they seem to be well established.

## 1.0 Laws and regulations

There is no new legislation to report.

## 2.0 Deliberate releases

### 2.1 Fish

A private company, the N.V. Joosen-Luyckx Aqua Bio in Turnhout, is still elevating 6 species of sturgeons the European speceis *Acipenser baeri, A. gueldenstaedti, A. ruthenus* (sterlet) *A. baeri* and the American *Polyodon spatula* and *Scaphirhynchus platorynchus* (shovelnose). The firm uses *A. baeri* for the production of caviar (Royal Belgian Caviar) and an albino population of *A. ruthenus* for the production of white caviar. Research is ongoing on the production of caviar and some species are cultivated for ornamental use.

## 3.0 Accidental Introductions and transfers

### 3.1. Vertebrates

*Micropogonias undulatus*: On August 24th 2005, a specimen of the Atlantic croaker *Micropogonias undulatus* was captured by a Belgian commercial shrimper, working in Belgian inshore waters. The specimen measured 19cm. This is the third record of this species in Belgian waters. There are also 3 recent records from Dutch waters (Dekker *et al*., 2004). As for all the Belgian and Dutch records, also the latest Belgian find was a first year and not sexually mature.

The Atlantic croaker is native to the east coast of the USA and northern Gulf of Mexico, where it is one of the most abundant inshore, demersal fish species.

Stevens *et al.*, 2004 believe that all specimens were recent arrivals and that they probably reached European waters as (post-) larval or young fish in ballast water and were subsequently released during deballasting in one of the major ports of the region. However, Dekker *et al.*, 2003 suggest that small reproductive populations might reside in certain waters of the southern bight of the North Sea.

### 3.2 Invertebrates

*Rapana venosa*: This species has been found in 2005 twice in de southern North Sea (Kerckhof *et al.*, 2006). Although not in Belgian waters proper, one of the findings was in an area very close to Belgian waters. An alerting campaign has been started up.

*Mytilopsis leucophaeata* (=*Congeria cochleata*): This species is present in the harbour of Antwerpen, causing nuisance by the obstruction of water intake pipes of some chemical plants. A Ph.D. study is ongoing at the University of Gent, with the aim to find a possible biological control of the problems caused by this species.

*Caprella mutica*: This species has been first recorded in 1998 when it was present on several buoys marking the entrance to the harbour of Zeebrugge. In the Zeebrugge area, the species is still present.

*Ficopomatus enigmaticus*: As in previous years this species was also in 2005 very abundant in the harbours of Oostende en Nieuwpoort, forming reef like structures on several submerged substrates en vessels.

*Megabalanus coccopoma*: This species proved to be already present on buoys off the Dutch coast (off Terschelling) in 1976 and 1977 but was apparently not properly recognised. From 1997 on this species has been found each year in the southern bight of the North Sea, mainly on buoys but also on floating objects and even in the littoral zone. The continuos and increasing findings along the Belgian and Dutch coast prove that it is well established in this region of the North Sea.

*Hemigrapsus penicillatus*: This species was recorded for the first time from the coasts of Belgium and Northern France in 2003. The pencil-crab is now very abundant especially in estuaries and harbour areas for instance amongst reefs of pacific oysters *Crassostrea gigas.*

*Hemigrapsus sanguineus*: This species has not been found yet in Belgium.

*Callinectes sapidus*: During 2005 there were no new records.

*Palaemon macrodactylus*: This Asian shrimp was first identified from Zeebrugge, were it was fished on 12 June 2004 among the epiflora and epifauna of the pontoons of the marina (d'Udecem d'Acoz *et al*., 2005) were it also was present during 2005.

*Telmatogeton japonicus*: This giant chironomid has recently been identified from buoys off the Belgian coast. *T. japonicus* is common on all of the offshore buoys even the remote ones. Specimens live in the splash zone, i.e. the vertical zone of the buoy, above the algae zone, were they from a characteristic zone. The species is present during most of the year and apparently the only Chironomid living on the buoys.

### 3.3 Algae and higher plants

*Undaria pinnatifida*: After the first record in 2000, this species is still present in de marina of Zeebrugge, but apparently not spreading due to predating of Coots *Fulica atra*.

*Sargassum muticum, Codium fragile* subspecies *tomentosoides:* After a presence for some years in the Spuikom of Oostende, there have been no recent records anymore of both species since 2002. This is probably due to changes in the water regime of the pond. However *Polysiphonia senticulosa* is still present.

## 4.0 Live imports

In Belgium there is a lot of (uncontrolled) import and export of a wide variety of marine and fresh water species, for research, human consumption, aquaculture and aquariums. It is almost impossible to obtain figures on quantities or on origin.

## 8.0 Bibliography

Dekker, W, Daan, N., Heessen, H. and van de Heij, W. 2005. De knorrepos *Micropogonias undulatus*. De Levende Natuur, 106(2): 66–67.

Kerckhof, F., Vink, R. J., Nieweg, D. C. and Post, J.N J 2006. The veined whelk *Rapana venosa* has reached the North Sea. Aquatic Invasions, 1(1): 35–37.

Stevens, M., Rappé, G., Maes, J., Van Asten, B. and Ollevier, F. 2004. *Micropogonias undulatus* (L.), another exotic arrival in European waters. J. Fish. Biol., 64(4): 1143–1146.

# National Report Canada, 2005

Prepared by Linda MacMillan, Darlene Smith and Dorothee Kieser

## Highlights

- In 2005, Canada changed its lead federal agency responsible for aquatic animal health from Fisheries and Oceans Canada (DFO) to the Canadian Food Inspection Agency (CFIA). CFIA intends to use a new regulatory framework for aquatic animal health based on the Health of Animals Act and the Health of Animals Regulations. DFO will remain involved, but will focus its efforts on research and surveillance of diseases in wild stocks. Additionally, Canada published draft ballast water regulations in Canada Gazette I in 2005. These regulations will become law when published in Canada Gazette II, which is scheduled for 2006.
- While a number of activities and introductions are described in this report, these are primarily updates on issues reported in past years. There were no significant new releases or planned introductions reported for 2005. Tunicates, which have invaded Prince Edward Island waters, continue to affect the shellfish aquaculture industry by fouling production facilities and increasing the costs of harvest and cleaning. The affected region has introduced measures to contain the organisms, and other regions are monitoring for possible, natural spread. Canada also continues to import a range of organisms for aquaculture as described in this report. The pattern of these imports is much the same as in past years, however, and no new activities were reported in 2005 that would raise particular concerns with respect to risks to aquatic resources.

## 1.0 Laws and regulations

### National

The Canadian Food Inspection Agency (CFIA) and the Department of Fisheries and Oceans (DFO) will co-deliver a new National Aquatic Animal Health Program (NAAHP), which was announced by the Canadian government in spring 2005. CFIA will lead the new program and develop new regulations for aquatic animal health under its *Health of Animals Act* over the next 18–24 months. In the interim period, DFO will maintain regulatory responsibility under the Fish Health Protection Regulations (FHPR) for salmonid diseases. The new program will address increasingly stringent international science standards set by the World Organization for Animal Health (OIE).

### Ballast Water Initiatives:

Canada published draft Ballast Water Control and Management Regulations in Canada Gazette I. (http://canadagazette.gc.ca%5CpartI%5C2005%5C20050611%5Chtml%5Cregle6-e.html/) The regulations will become law when published in Canada Gazette II, scheduled for 2006.

## 2.0 DELIBERATE RELEASES AND PLANNED INTRODUCTIONS

### Deliberate Releases

### 2.1 Finfish

#### *Pacific Region*

Under the Canada-US Transboundary agreement, and in compliance with the Fish Health Protection Regulations (FHPR), approximately 5 million sockeye (*Oncorhynchus nerka*) fry were returned to Tahltan Lake, Tuya Lake and Tatsamenie Lake in northern British Columbia after initial incubation in an isolation unit at an Alaskan Hatchery.

#### *Atlantic Provinces*

No releases reported

# 3.0 Accidental Introductions and transfers

The 2005 Federal Budget allocated $10 million (CAD) over 5 years to address aquatic invasive species. Activities will focus on research, monitoring, risk assessment and outreach.

## 3.1 Fish

#### *Pacific Region*

No new reports

#### *Great Lakes area (Central and Arctic Region)*

No new reports

#### *Atlantic*

Two reports of release of aquarium trade species into natural water bodies were investigated in Newfoundland. Ornamental species of carp (species undetermined) were seen at Janes Pond, Burin Peninsular, and on private property waters near Heart's Delight, Trinity Bay. Origins of the fish are unknown.

## 3.2 Invertebrates

#### *Pacific Region*

A workshop on the identification on invasive tunicates was held by DFO at the Pacific Biological Station in fall 2005.

#### *Ontario*

The only new invader in 2005 is the sideswimmer (*Gammarus tigrinus*), which has been documented in all five Great Lakes.

#### *Québec*

No green crab (*Cancer maenas*) were found in 2005. Studies on a caprellid (*Caprella mutica*), a new species detected for the first time in 2003 in the Baie des Chaleurs and in 2005 in the Magdalen Island Archipelago, are in progress to identify the impact of this new species on mussel culture.

#### *Atlantic Coast*

Since the identification of the presence of the clubbed tunicate (*Styela clava*) on mussel leases in Prince Edward Island, three additional tunicates have been confirmed as established. The golden star tunicate (*Botryllus schlosseri*) was transferred to the province in 2001, the violet tunicate (*Botrylloides violaceus*) in 2004, and the vase tunicate (*Ciona intestinalis*) in 2004. All four species are competing with mussel culture in waters in which they are established, adding costs to production, harvest and processing. Managing the spread and impact of each species has been a collaborative effort between the aquaculture industry and the provincial and federal governments. Regulating the movement of bivalves into, out of and within waters infested with one or more species has been successful in slowing the spread of tunicates between water bodies.

The clubbed tunicate is well established in the Murray River, St Mary's Bay, Montague and Brudenell Rivers. It is also present in Cardigan River, but in lower densities. The population density in March Water, a portion of Malpeque Bay, increased substantially in 2005. The species was confirmed to be present in Darnley Basin in 2005, but in low numbers. The presence of clubbed tunicate in Orwell River is now suspect, with no animals being detected in routine surveys.

The vase tunicate is currently restricted to Montague and Brudenell River estuaries and St. Mary's Bay. Vase tunicate numbers in these waters were particularly high and troublesome to the mussel industry in 2005.

Since its identification in St. Peters Bay, the golden star tunicate was confirmed to be present in Cardigan River and St. Mary's Bay in 2005. The species also has been present in Savage Harbour since 2004. Population densities increased in St. Peters Bay and Savage Harbour in 2005.

The violet tunicate is well established in Savage Harbour and Cape Borden, and was detected in five new estuaries in 2005. These included Cardigan River, Brudenell River, St. Peters Bay, Rustico Bay and March Water.

As a result of their ability to reproduce sexually and asexually, the violet and golden star tunicates will prove much more difficult to control than the solitary clubbed and vase tunicates, which only reproduce sexually.

Nova Scotia and Newfoundland/Labrador are monitoring for tunicates and other alien invasive species. There were no reports of new invasive species being identified in 2005. A workshop on identification of invasive tunicates was held in the Atlantic region in fall 2005.

The green crab (*Carcinus maenus*), a predator of shellfish, particularly soft shelled clams, was first identified in Prince Edward Island in 1997. Since that time the species has spread, and is now well established in all estuaries in the eastern portion of the province. Its presence in the Cape Borden area was confirmed in 2005, and it is likely that the species will continue to expand its presence in Island waters.

In addition to its predation of soft shelled clams, the green crab has been observed to inflict wounds to American eel (*Anguilla rostrata*) in eel traps.

## 3.3 Algae and higher plants

### *Pacific Region*

No new reports

**Quebec**

No new reports

### *Atlantic Coast*

Oyster thief (*Codium fragile*) presence in Prince Edward Island was first noted in 1997. Its population is classified as high in Malpeque Bay, Cascumpec Bay/Mill River and Enmore River. The species is confirmed to be present in low densities in Rustico Bay, Tracadie Bay/Winter Bay, Savage Harbour, St. Peters Bay, Murray River and Sunbury Cove, a section of Bedeque Bay. No new sightings for oyster thief were recorded for 2005. The last updates were for Rustico Bay in 2004 and Tracadie Bay/Winter River and St. Peters Bay in 2003.

Efforts to control the spread of oyster thief provided poor results, and were abandoned as being impractical.

## 3.4 Pathogens and Parasites

***Bonamia ostreae*** in ***Ostrea edulis*** **–** Reported for the first time in Canada (British Columbia but not yet detected in Atlantic Canada) in November 2004. Examination of archived samples collected from the index site between 1999 and 2004 in conjunction with seed introduction records suggests that *B. ostreae* may have been inadvertently introduced into British Columbia around 2003 with *O. edulis* seed imports from enzootic areas in the State of Washington, USA.

***Haplosporidium nelsoni* (MSX) in *Crassostrea virginia* -** Reported for the first time in Canada in October 2002 (see report to WGITMO in 2003), associated with mortalities greater than 90 % on several leases in Cape Breton, Nova Scotia. In 2005, MSX was confirmed in oysters from an isolated population on the north shore of Cape Breton. No evidence found to date of presence of *H. nelsoni* (or *H. costale*) in historic samples from within the Bras d'Or Lakes.

# 4.0 Live imports and transfers

## Importations of Finfish and Shellfish

Note: Country of origin is given in brackets.

### Pacific

***Imports***

The pattern of importation matches that of previous years, including the importation of Atlantic salmon (*Salmo* salar) eggs (Iceland), rainbow trout (*Oncorhynchus mykiss*) (USA), oysters (*Crassostrea gigas* and *C. sikamea*) (USA), Manila clams (*Venerupis philippinarum*) (USA), mussels (*Mytilus edulis*, *M. galloprovincialis*) (USA), and cockles (*Clinocardium nuttali*) (USA). The molluscs are primarily used for beach seeding and grow-out on open water structures.

A request to import *C. gigas* from the UK was submitted to CFIA for a risk analysis review. The results from the review are expected in April 2006.

Fisheries administrators in British Columbia have received requests to import several marine species to be raised in closed circulation, land-based aquaculture facilities. The species under consideration include: barramundi (*Lates calcarifer*); cobia (*Rachycentron canadum*); Florida pompano (*Trachinotus carolinus*); and red drum (*Sciaenops ocellatus*).

***Within Region transfers***

Finfish: All *Oncorhynchus* species (chinook, coho, steelhead, rainbow, chum, pink, sockeye, kokanee), wolf eel, white sturgeon (*Acipenser transmontanus*), sablefish (*Anoplopoma fimbria*), halibut (*Hippoglossus stenolepis*), eulachon (*Thaleichthys pacificus*), koi carp (*Cyprinus carpio*), burbot (*Lota lota*).

Shellfish: Japanese scallop (*Pecten yessoensis*), sea urchin (*Strongylocentratus* sp.), abalone (*Haliotus kamtschatkana*), cockles, Manila clam, horse clam (*Tresus capax*), Pacific oysters and Kumamoto oysters, blue and gallo mussels, geoduck (*Panope generosa*).

### Great Lakes Basin

***Imports***

Ontario reported imports of rainbow trout eggs (Washington, USA) and Arctic charr eggs (Yukon).

### Atlantic (including Quebec)

#### *Imports*

Quebec imported spotted wolf eel (*Anarhinchas minor*) eggs (Norway).

New Brunswick imported the following species for aquaculture: Atlantic salmon from USA, and cod (*Gadus morhua*) from USA. New Brunswick also imported rainbow trout from Ontario for research.

Nova Scotia reported imports of rainbow trout eggs (Washington, USA), Atlantic cod (Massachusetts, USA) and red abalone (*Haliotis rufescens*) (Iceland) for aquaculture. Zebra fish (*Danio rerio*) (Massachusetts and Oregon, USA) were imported to contained facilities for research.

Newfoundland and Labrador reported imports of the following species for aquaculture: Atlantic salmon (Washington, USA, PEI, Nova Scotia), rainbow trout triploid eggs and fingerlings (Quebec, Nova Scotia). The following species were imported to land-based laboratories for research: Male tilapia (Ontario); genetically modified Atlantic salmon (Prince Edward Island); genetically modified rainbow trout (Prince Edward Island); diploid rainbow trout (Ontario); green crab (*Cancer maenas*) (Maine, USA); and purple sea urchins (*Strongylocentrotus purpuratus*) (British Columbia).

#### *Within Region transfers*

Atlantic salmon, speckled/brook trout (*Salvelinus fontinalis*), arctic charr (*Salvelinus alpinus*), halibut (*Hippoglossus hippoglossus*), haddock (*Melanogrammus aeglifinus*), cod, Atlantic sturgeon (*Acipenser oxyrhynchus*), shortnose sturgeon (*A. brevirostrum*), oysters (*Crassostrea virginica*) bay scallop (*Argopecten irradians*), blue mussels, quahaugs (*Venus mercenaria*) and softshell clams (*Mya arenaria*).

## 5.0 Live exports to other countries

*(Require health certification only)*

| Canada | To | Species | Stage |
|---|---|---|---|
| Pacific | France, Austria, Italy, Northern Ireland, England, Slovenia, Chile, China | Arctic Charr (Salvelinus alpinus) | Eggs |
| Québec | St. Pierre et Miquelon, Iran | Rainbow trout (Oncorhynchus mykiss) | Eggs |
| | Poland, France | Brook trout (Salmo trutta) | Eggs |
| | Germany | Arctic Charr (S. alpinus) | Eggs |
| Atlantic | Germany, Poland | Atlantic sturgeon (Acipenser oxyrhynchus) | Eggs, Larvae, and Juveniles |
| | St. Pierre et Miquelon | Scallops (Placopecten magellanicus) | 1 yr |
| | St. Pierre et Miquelon | Oysters (Crassostrea virginica) | Adults for human consumption – subject to health certification to permit re-emersion to refresh |

## 6.0 Meetings, conferences, symposia or workshops on introductions and transfers (I&T)

The DFO Aquaculture Management Directorate held a National I&T Workshop in February 2005, to discuss progress in administering the review and risk assessment of I&T proposals.

The Workshop was well attended by representatives from Introductions and Transfers Committees established in provinces/territories.

Another National I&T Workshop is tentatively planned for mid-2006. The purpose of this Workshop will be to discuss procedures for reviewing I&T proposals, and potential changes to improve the I&T regulatory framework.

DFO held workshops in September 2005 to develop a Regulatory Framework for Aquatic Invasive Species, and in November 2005 to develop the national Aquatic Invasive Species Science Program.

In 2004, DFO conducted two peer-review workshops, one on risk assessment for Asian Carp and the second on alternative ballast water exchange zones. The published Research Documents are available on the Canadian Science Advisory Secretariat website (http://www.dfo-mpo.gc.ca/CSAS/) as "Research Document - 2004/103" for carp and "Research Document - 2004/118 to 120" for ballast water.

**Upcoming Workshop:** Exotics, should non-indigenous species be used in aquaculture? 5th Annual SABS/AAC Workshop, October 17–19, 2006.St Andrews, New Brunswick.

## 7.0 Bibliography

Anon. 2005. Introductions and transfers of aquatic animals – A survey of procedures and activities in Canada (2002–2005). Internal report prepared by Tim Carey and Associates under contract for Fisheries and Oceans Canada, Aquaculture Management Directorate. 43 pp.

# National report Estonia, 2005

Prepared by Henn Ojaveer and Jonne Kotta

## Summary


- The gibel carp C*arassius gibelio*, first deliberately introduced into fish ponds and small lakes of Estonia over 50 years ago, was first found in marine waters in 1985. During the recent decade or so, the species have became invasive: the fish have colonized all Estonian coastal sea and in some coastal areas is even the biomass dominant. At least one of the likely reasons is consecutive warm summers in recent years.
- The first specimen on the round goby *Neogobius melanostomus* was found in the Baltic Sea (Polish waters) early 1990s. Since then, the species has expanded its distribution area and appeared to reach the status of relatively common fish species in Muuga harbour (Gulf of Finland) in 2005.
- The amphipod *Chelicorophium curvispinum* was observed for the first time in the Estonian coastal sea in 2005. This invasive species was found in connection with traditional monitoring of phytobenthic communities in the eastern Gulf of Finland. This is the northernmost documented location of *C. curvispinum* in the Baltic Sea. Together with juvenile gammarids *C. curvispinum* was a prevailing invertebrate species in the samples.
- The gammarid *Gammarus tigrinus* was observed for the first time in the Estonian coastal sea (Kõiguste Bay, northern Gulf of Riga) in 2003 in connection to the performance of a mesocosm experiment. In 2003, the gammarid was not found in traditional benthos stations although the bay was intensively monitored throughout ice-free season. In 2004, *G. tigrinus* was already found in the whole Kõiguste Bay area and in 2005, the share species already strongly dominated in the benthic invertebrate community.
- Laboratory feeding experiments with the predatory cladoceran *Cercopagis pengoi* as a predator and various smaller native mesozooplankton taxa as prey show that *C. pengoi* was able to consume all the provided prey with one exception: newly born youngs were unable to prey on copepods, most probably due to too large body size of the prey. These experiments confirm that *C. pengoi* could be, at least partly, responsible for structural changes in the mesozooplankton community observed after the invasion.


## 2.0 Deliberate releases and planned introductions

### 2.1 Fish

Official data on fish releases of Estonia for 2004 and 2005 (in thousands)

| Species/year | 2004 | 2005 |
|---|---|---|
| Salmon (*Salmo salar*) | 304.94 | 213.96 |
| Sea trout (*Salmo trutta trutta*) | 54.16 | 30.96 |
| Pike (*Esox lucius*) | 400 | 500 |
| Eel (*Anguilla anguilla*) | 11.3 | 0 |

## 3.0 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

### 3.1 Fish

The gibel carp C*arassius gibelio* was first deliberately introduced into fish ponds and small lakes of Estonia in 1948. The fish was first found in Estonian marine waters in 1985 in the

Gulf of Riga. During the recent years the species became invasive: the fish have colonized all Estonian coastal sea and in some coastal areas is even the biomass dominant. At least one of the likely reasons is consecutive warm summers in recent years. While in some shallow sheltered areas the species can reproduce and thrives well, in more open coastal areas only large adult specimens are caught. Ecological impact unknown.

The fist specimen on the round goby *Neogobius melanostomus* was found in Estonian waters in 2002. The recent contacts with leisure fishermen fishing in Muuga Harbour (Gulf of Finland) in 2005 suggest that the fish has further colonised northern-eastern parts of the Baltic Sea. According to fishermen reports in this area, *N. melanostomus* is, although not very abundant, but relatively common fish species in their catches. The distribution vector of the fish is most likely secondary spread within the Baltic Sea. Wider ecological impact in Estonian coastal sea insignificant.

The second finding of the bighead carp *Aristichthys nobilis* in Pärnu Bay (NE Gulf of Riga) was reported in 2005 (the species was first found in Estonian waters in 2002 in the same area), most likely originating from aquaculture. Ecological impact impact insignificant.

## 3.2 Invertebrates

*Gammarus tigrinus* was observed for the first time in the Estonian coastal sea (Kõiguste Bay, northern Gulf of Riga) in 2003 in connection to the performance of a mesocosm experiment. The species was mainly associated to the communities that contained the cockle *Cerastoderma glaucum*. In 2003 the gammarid was not found in traditional benthos stations although the bay was intensively monitored throughout ice-free season. In 2004 *G. tigrinus* was already found in the whole Kõiguste Bay area. The species had higher abundances and biomasses in spring and autumn than in summer. The gammarid abundances were usually estimated at 25 ind. $m^{-2}$ and biomasses at 0.01 g $m^{-2}$, respectively. In the inner parts of the bay the abundances and biomasses exceeded 250 ind. $m^{-2}$ and 1 g $m^{-2}$. These abundance and biomass values were comparable to native gammarid densities prior to the invasion of *G. tigrinus*. Though, if *G. tigrinus* was mainly confined to the inner parts of Kõiguste Bay then the native gammarids had higher densities in more exposed parts of the bay. Concurrent with the invasion of *G. tigrinus* the abundance and biomass of native species have significantly declined. Nowadays, the share of *G. tigrinus* among the native amphipods usually reaches to 25 % in total gammarid abundances and biomass. In the inner part of Kõiguste Bay, however, the share of the invasive gammarid may exceed 75% both in abundance and biomass. In 2005 *G. tigrinus* was also found in the bays adjacent to Kõiguste Bay but also in Rame Bay located about 50 km eastwards from Kõiguste Bay. So far there are practically no records of *G. tigrinus* from other parts of the Gulf of Riga including Riga and Pärnu Port areas. An important yacht harbour is located at the inner part of Kõiguste bay. Thus, it is likely that the species was introduced to the northern part of the Gulf of Riga due yacht traffic and the donor region was likely Curonian, Odra or Vistula Lagoon.

*Chelicorophium curvispinum* was observed for the first time in the Estonian coastal sea in 2005. The invasive amphipod was found in connection with traditional monitoring of phytobenthic communities in Sillamäe area in the eastern Gulf of Finland. Thus, this is the northernmost documented location of *C. curvispinum* in the Baltic Sea. Curonian Lagoon is the closest basin where the invasive amphipod is found. *C. curvispinum* was likely introduced to the Gulf of Finland either at Sillamäe or Kunda Port area by the mean of ship traffic (ballast water). *C. curvispinum* was found between 1 and 4.9 m depth associated with the belt of *Cladophora glomerata*. The average density and biomass of the species ranged between 125–1425 ind. $m^{-2}$ and 0.05–0.27 g $m^{-2}$. The maximum densities were found at 3 m. Together with juvenile gammarids *C. curvispinum* was a prevailing invertebrate species in the samples.

The catch index of the Chinese mitten crab *Eriocheir sinensis* was substantially higher in 2002–2005 than in the previous years studied (i.e. 1991–2001). Highest catch indexes were observed in the periods of May-June and October-November compared to other months. Questionnaire surveys on findings of *E. sinensis* in the various sub-basins of the NE Baltic Sea (southern Gulf of Finland, northern Gulf of Riga, Väinameri Arhipelago) revealed that the species is commonly found all over the Estonian coastal sea. As reproduction of mitten crabs in the Baltic Sea is unlikely, due to low salinities, it is assumed that the individuals caught actively migrate into the area from its main European distributional area (south-eastern North Sea), a more than 1500 km migration distance.

There is a strong signal from our earlier field observations that population abundance of a dominant native cladoceran *Bosmina coregoni maritima* is depressed and seasonal abundance dynamics of copepod *nauplii* (*Eurytemora affinis* and *Acartia* spp.) is changed after the invasion of the predatory cladoceran *Cercopagis pengoi* into the Baltic Sea (Gulf of Riga). Given the very limited knowledge on feeding habits of *C. pengoi* (largely due to species-specific peculiarities), we have conducted a set of laboratory feeding experiments with this species as a predator and several native more abundant mesozooplankton species (*B. c. maritima*, copepods *E. affinis* and *Acartia* spp., *nauplii* of copepods and the cirriped *Balanus improvisus larvae*) as a prey. It appeared that *C. pengoi* was able to consume in laboratory conditions all the provided prey with one exception: newly born youngs were unable to prey on copepods, most probably due to too large body size of the prey. These experiments confirm that *C. pengoi* could be, at least partly, responsible for structural changes in the mesozooplankton community observed after the invasion.

# 4.0 Live imports

## 4.1 Fish

| *Country* | *Fish* | *Quantity (kg)* |
|---|---|---|
| ***2004*** | | |
| Czech Republic | ornamental freshwater fish | 40.0 |
| Indonesia | ornamental freshwater fish | 271.0 |
| Singapore | ornamental freshwater fish | 1205.5 |
| Thailand | ornamental freshwater fish | 176.0 |
| Singapore | ornamental marine fish | 148.5 |
| Denmark | unidentified fish | 105.0 |
| Sweden | unidentified fish | 2008.0 |
| United Kingdom | eel (*Anguilla spp.*) | 300.0 |
| ***2005*** | | |
| People s Republic of China | ornamental freshwater fish | 18.0 |
| Finland | ornamental freshwater fish | 225.0 |
| Indonesia | ornamental freshwater fish | 90.6 |
| Latvia | ornamental freshwater fish | 50.0 |
| Singapore | ornamental freshwater fish | 1046.2 |
| Thailand | ornamental freshwater fish | 72.0 |
| Indonesia | ornamental marine fish | 28.4 |
| Singapore | ornamental marine fish | 32.2 |
| Latvia | carp | 327.6 |
| Finland | unidentified freshwater fish | 130.0 |
| Latvia | unidentified freshwater fish | 662.8 |
| Latvia | unidentified marine fish | 117.1 |

# 5.0 Live exports

## 5.1 Fish

| *Country* | *Fish* | *Quantity (kg)* |
|---|---|---|
| ***2005*** | | |
| Russian Federation | unidentified fish | 1600.0 |

# 6.0 Meetings, conferences, symposia or workshops on introductions and transfers

### Participation at:

- BSRP/HELCOM/COLAR Workshop on "Ballast water introductions of alien species into the Baltic Sea" (21–25 February 2005, Klaipeda, Lithuania);
- MARBEF Workshop on “Aquatic invasive species and the functioning of European coastal ecosystems.” January 27–30, 2005, Alfred Wegner Institute (AWI), Island of Sylt in the North Sea, Germany.

### Planned participation at:

- EuroCoML workshop on ‘Alien species and their contribution to biodiversity in pristine parts *vs.* anthropogenically impacted ports of European seas’ (March, 2006, Oostende, Belgium);
- BSRP/HELCOM Workshop on "Ballast water introductions of alien species into the Baltic Sea" (April, 2006, Helsinki, Finland).

# 7.0 Bibliography

Herkül, K., Kotta, J., Kotta, I. Distribution and population characteristics of the alien talitrid amphipod *Orchestia cavimana* in relation to environmental conditions in the northeastern Baltic Sea. Helgoland Mar. Res., 60, in press.

Kotta, J., Kotta, I., Simm, M., Lankov, A., Lauringson, V., Põllumäe, A., Ojaveer, H. Ecological consequences of biological invasions: three invertebrate case studies in the north-eastern Baltic Sea. Helgoland Mar. Res., 60, in press.

Kotta, J., Orav-Kotta, H., Vuorinen, I. 2005. Field measurements on the variability in biodeposition and grazing pressure of suspension feeding bivalves in the northern Baltic Sea. In: R. Dame & S. Olenin (eds) The Comparative Roles of Suspension Feeders in Ecosystems. Springer, The Netherlands, Dordrecht, pp. 11–29.

Kotta, J., Lauringson, V., Martin, G., Simm, M., Kotta, I., Herkül, K., Ojaveer, H. 2005. Gulf of Riga and Pärnu Bay. In: "Ecology of Baltic Coastal waters". Schiewer, U. (ed.), Springer, in press.

Põllumäe, A., Kotta, J. Factors affecting zooplankton community of the Gulf of Finland, with respect to native and introduced predatory cladoceran interactions. Hydrobiologia, in press.

Simm, M. and Ojaveer, H. Taxonomic status and reproduction dynamics of the non-indigenous *Cercopagis* in the Gulf of Riga (Baltic Sea). Hydrobiologia (in press).

Vetemaa, M., Eschbaum, R., Albert, A. and Saat, T. 2005. Distribution, sex ratio and growth of *Carassius gibelio* (Bloch) in coastal and inland waters of Estonia (north-eastern Baltic Sea). Journal of Applied Ichthyology, 21: 287–291.

# National report Finland, 2005

Prepared by Erkki Leppäkoski and Lauri Urho

## Highlights

- In 2005, two fish species were reported for the first time in Finland; the round goby, *Neogobius melanostomus*, and prussian carp/gibel carp, *Carassius gibelio.*

## 1.0 Laws and regulations

According to the statute of the Ministry of Agriculture and forestry (157/2005) the use of fresh, frozen and ensiled wild marine fish for food for aquaculture fish is banned because of virus risk.

## 2.0 Deliberate releases and planned introductions

### 2.1 Fish

Deliberate releases into the Baltic Sea were (including rivers draining into the Baltic) for fisheries and fish stock enhancement purposes in 2004 (2005 data not yet available) as follows

0.29 million newly hatched and 2.5 million older salmon (*Salmo salar*), and

0.05 million newly hatched and 1.2 million older sea trout (*Salmo trutta* m. *trutta*),

40.2 million newly hatched and 9.2 million older whitefish (*Coregonus lavaretus*).

## 3.0 Accidental introductions and transfers

### 3.1 Fish

Round goby, *Neogobius melanostomus* (Pallas) was caught in the south-western archipelago of Finland for the first time in February 2005. So far only one round goby has been known to be caught by an angler. In November 2005, several specimens of prussian carp/gibel carp, *Carassius gibelio* (Bloch), were caught off the Helsinki, Finland, and then for the first time identified to species. However, more observations along the southern coast of Finland were reported after the announcement news and spread information on prussian carp in several papers and other media. Today, the identification of prussian carp has been verified in five places and possible occurrence in three other places along the south coast of Finland. In general, it is still under discussion whether prussian carp or gibel carp is a species in its own right (*C. gibelio*), a subspecies of the goldfish (*C. auratus gibelio*) or whether it is a hybrid between the crucian carp and other related species (http://www.hull.ac.uk/molecol/Carp.html). Anyway, the prussian carp has most probably been in waters off Helsinki at least since 2001.

### 3.2 Invertebrates

The Finnish Radiation and Nuclear Safety Authority (STUK) carries out ecological studies in the sea areas around the Finnish nuclear power plants. In 2003 in the Gulf of Finland, a new mussel species was found in the cooling water discharge area of the nuclear power plant of Loviisa (E Gulf of Finland). The mussel was identified as Conrad’s false mussel, *Mytilopsis leucophaeata*, which is known to be a serious biofouling organism. Since the first findings, STUK in co-operation with the Finnish Institute of Marine Research has followed the occurrence and reproduction of *Mytilopsis leucophaeata* using artificial plates and making observations by scuba diving in the sea area of Loviisa. www.fimr.fi/en/itamerikanta/bsds/3185.html.

# 4.0 Live imports

## 4.1 Fish

Sturgeons were imported from Italy and France to inland area. Perch and zander were imported from Sweden and rainbow trout from Denmark to Åland Islands. Rainbow trout were imported from Germany to Archipelago and from Sweden to inland area.

## 4.2 Invertebrates

Freshwater crayfish were imported to inland area for cooking and on growing.

# 5.0 Live exports

## 5.1 Fish

As in previous years, rainbow trout (*Oncorhynchus mykiss*) juveniles and eggs were exported to Russia and Estonia. In addition, fertilized eggs of char (*Salvelinus alpinus*) and grayling (*Thymallus thymallus*) were exported to inland farms in Austria and Germany. Rainbow trout eggs were exported to Chile for the first time.

# 6.0 Meetings, conferences, symposia or workshops on introductions and transfers

2007. Alien Species – Environment, Biorisks, and Future. Fifth Environment Symposium of Maj and Tor Nessling Foundation 18–19 January 2007, Turku, Finland.

# 7.0 Bibliography

Finnish Institute of Marine Research launched a well-illustrated three-language Internet tool "Alien species in the Baltic Sea" at the Baltic Sea Portal (http://www.fimr.fi/en/itamerikanta/tietoa/eliot/tulokaslajit.html).

Behrens, H.L., Leppäkoski, E., Olenin, S. 2005. Ballast Water Risk Assessment Guidelines for the North Sea and the Baltic Sea. NT Techn Rep 587, Nordic Innovation Centre, Oslo. 63 pp. www.nordicinnovation.net.

Blank, M., Laine, A.O., Jürss, K., Bastrop, R. 200x. *Marenzelleria neglecta* meets *Marenzelleria viridis* meets *Marenzelleria arctia*: recent unnoticed invasions of polychaete sibling species into the Baltic Sea (submitted to Marine Biology, January 2006).

Hajdu, S., Pertola, S., Kuosa, H. 2005. *Prorocentrum minimum* (Dinophyceae) in the Baltic Sea: morphology, occurrence -A Review. Harmful Algae, 4: 471–480.

Helavuori, M. 2005. The dispersal of species to new areas from the northern Baltic through shipping. MSc Thesis, Environmental and Marine Biology, Åbo Akademi University. 62 pp (in Swedish, English summary).

Laine, A.O. 2006. First record of Conrad's false mussel, *Mytilopsis leucophaeata* in the northern Baltic Sea – a local population found in the Gulf of Finland. www.fimr.fi/en/itamerikanta /bsds/3185.html.

Laine, A.O., Mattila, J., Lehikoinen, A. 2006. First record of the brackish water dreissenid bivalve *Mytilopsis leucophaeata* in the northern Baltic Sea. Aquatic Invasions 1: 38–41.

Lehtiniemi, M., Lindén, E. *Cercopagis pengoi* and *Mysis* spp. alter their feeding rate and prey selection under predation risk of herring (*Clupea harengus membras*). Marine Biology (in press).

Leppäkoski, E. 2005. The first twenty years of invasion biology in the Baltic Sea area. Biological and Hydrobiological Studies, 24(Suppl.): 1: 5–17.

Leppäkoski, E. 200x. Scientific Aspects: Ecological Effects of Ballast Water on the Seas – What is ballast water pollution? In: Fonseca de Souza Rolim MH (ed) Ballast Water – Legal Aspects (submitted, November 2005).

Leppäkoski, E., Shiganova, T., Alexandrov, B. 200x. European enclosed and semi-enclosed seas. In: Rilov G, Crooks J (eds) Marine Bioinvasions - Ecology, Conservation and Management Perspectives (submitted, December 2005).

Leppäkosk, E., Väinölä, R., Korpimäki, E., Jormalainen, V. 2006. Biodiversity of the Baltic Sea. Vesitalous 2/2006 (in Finnish).

Leppäkoski, E., Gollasch, S. 2006. Risk Assessment of Ballast Water Mediated Species Introductions – a Baltic Sea Approach (submitted to HELCOM, January 2006).

Paavola (née Pienimäki), M. 2005. Aquatic Bioinvasions: Risk Assessment of Alien Species and Their Vectors in Fresh and Brackish Northern Waters. LicPhil Thesis, Environmental and Marine Biology, Åbo Akademi University, 28 pp.

Paavola, M., Olenin, S., Leppäkoski, E. 2005. Are invasive species most successful in habitats of low native species richness across European brackish water seas? Estuarine, Coastal and Shelf Science, 64: 738–750.

Pennanen, J. and Urho, L. 2006. Invasion of the Prussian carp. Metsästys ja Kalastus 11/2005: p. 24. (In Finnish).

Pertola, S. 2006. Diffusive and ship-mediated spread of dinoflagellates in the Baltic Sea with *Prorocentrum minimum* as a special case. PhD Thesis, Environmental and Biological Sciences, University of Helsinki (in pre-examination).

Pertola, S., Kuosa, H. 200x. On the observing of phytoplankton introductions and species change in the Baltic Sea (submitted to Boreal Environment Research, February 2006).

Pertola, S., Kuosa, H., Olsonen, R. 2005. Is the invasion of *Prorocentrum minimum* (Dinophyceae) related to the nitrogen enrichment of the Baltic Sea? Harmful Algae, 4: 481–492.

Pertola, S., Faust, M.A., Kuosa, H. 2006. Survey on germination and species composition of dinoflagellates from ballast tanks and recent sediments in ports on the South Coast of Finland, North-Eastern Baltic Sea. Marine Pollution Bulletin (in press).

Sassi, J., Viitasalo, S., Rytkönen, J., Leppäkoski, E. 2005. Experiments with ultraviolet light, ultrasound and ozone technologies for onboard ballast water treatment. VTT Research report BTUO34-041277, 58 pp. http://www.vtt.fi/inf/pdf/tiedotteet/2005/T2313.pdf.

Viitasalo, S., Sassi, J., Rytkönen, J., Leppäkoski, E. 2005. Ozone, ultraviolet light, ultrasound and hydrogen peroxide as ballast water treatments - experiments with mesozooplankton in low-saline brackish water. Journal of Marine Environmental Engineering, 8: 35–55.

# National report France, 2005

Prepared by Laurence Miossec with support from

Patrick Le Mao, Ifremer St Malo; Jean-François Bouget, Ifremer La Trinité sur mer; and Philippe Goulletquer, Daniel Masson, JP Joly Ifremer La Tremblade.

## Highlights

- A 3 year research program, PROGIG, is starting in 2006 in order to better understand the *Crassostrea gigas* proliferation mechanisms and impacts on marine ecosystem. Economical consequences on human activities will be evaluated as measures for management and restoration to limit this expansion and identify decision-making.
- Few data on accidental introduction of exotic species in the marine environment have been recorded this year, concerning mainly invertebrates. Only one *Rapana venosa* was recorded in 2005 in the bay of Quiberon where this species was previously observed. A Japanese prawn *Penaeus (Marsupenaeus) japonicus* was caught in the same area. Presence of these two species in this area is probably linked to shellfish transfer for the first one and to aquaculture escaping for the second.
- An International Scientific Conference « Biodiversity: Science and Governance » took place in January 2005 in Paris in order to assess current knowledge and needs for research and scientific expertise and to examine public and private approaches to biodiversity preservation and management.

## 1.0 Laws and regulations

A Council regulation is currently in preparation setting rules governing the use of alien species in aquaculture. This Regulation aims to propose management rules on the introduction of alien species in aquaculture. A guideline will be developed, using on an EU framework to ensure adequate protection of the aquatic environment from the risks associated with the use of alien species in aquaculture which be based on the existing voluntary International Council for the Exploration of the Sea (ICES) and European Inland Fisheries Advisory Commission (EIFAC) Codes.

## 2.0 Deliberate releases and planned introductions

### 2.2 Invertebrates

A research program, called PROGIG, funded by the French Ministry of the Environment, is just starting at the beginning of 2006 for a three year period to better understand the *Crassostrea gigas* proliferation mechanisms and the impacts on marine environment. This species has been introduced in the seventy's to replace cultivation of Portuguese oyster (*Crassostrea angulata*) affected by a viral disease. This introduction resulted in a natural setting of this species on the southwest Atlantic coast from Le Rochelle to the Arcachon bay, including the Bay of Marennes-Oleron and the Gironde estuary. However, over the last 10 years, natural reproduction and setting occurred successfully along the Atlantic coast and up north in the English Channel. Wild population have been settled near cultivated stocks. This program aims to assess stock, distribution and remediation options considering the species proliferation along the French Atlantic and English Channel coastlines. The causes of this new situation will be studied (climate change or/and genetic adaptation). Impact on marine ecosystems and economical consequences on human activities will also be evaluated. According to the results, adapted measures for management and restoration will be investigated to limit this expansion and facilitate decision-making.

In the same topic, a European project called Rispect (Risks of *Crassostrea gigas* species invasion for native bivalves in North sea and Atlantic coast), coordinated by Katja Broeg from the Alfred Wegener Institute for Polar and Marine research from Bremerhaven in Germany, was submitted to an EU call for proposal in 2005. This project aimed to assess and simulate the potential risk for native bivalve species of being displayed by *Crassostrea gigas* and to elucidate the underlying mechanisms of successful bio invasion. French scientists from Ifremer were contacted to take part of this project, especially on shellfish genetic and disease purposes. Although favourably evaluated by the Commission services, the project was not financed due to EU budget limits.

### 2.3 Algae and higher Plants

Kraan and Barrington reported in a recent publication (2005) that a commercial seaweed farm of *Asparogopsis armata* was set in the mid 1990s on the Island of Ouessant, Brittany, north west of France, which in the mid 2000s encompassed 2 ha with 14 km cultivation ropes. The annual yield was estimated to 8 metric tons (ww). Wild plants are used as seed stocks and gametophytes propagated vegetatively.

## 3.0 Accidental introductions and transfers

### 3.2 Invertebrates

In 2005 one veined whelk adult *Rapana venosa,* weighed 682 g was caught in an area called Anse du Pô in the bay of Quiberon (South Brittany) where other Rapana's were previously collected. This species, observed annually in this area over the last few years, was likely introduced with clam commercial transfers originating from Italy. The small number of captured animals probably indicates limited consequences of this introduction.

A Japanese prawn *Penaeus (Marsupenaeus) japonicus* (Bate, 1888) was caught in the bay of Quiberon (South Brittany) in May 2005. This male adult was 19 cm long. This species was introduced for farming in France in 1969 and is cultured until now in Mediterranean lagoons and in natural salt water ponds along the French Atlantic coast. A farm located in Plouharnel (Southern Brittany), at the near vicinity of the bay of Quiberon, was commonly producing this prawn semi-extensively in the ninety's. The production was stopped in 2003. Individuals, probably escaped from farming ponds, have been occasionally captured since the beginning of the ninety's in the Gulf of Biscay and in the English Channel. This species can survive at temperatures above 12°C, but needs 20°C to reproduce. There is no conclusion until now about a permanent establishment of a *P. japonicus* population since reproduction is unlikely at this temperature range characterizing those areas.

The expansion of *Crepidula fornicata* was monitored from 12 to 19 May 2005 in the Bay of St Brieuc (North Brittany) using acoustic imaging system (side scan sonar), divers and underwater video. This survey is part of a scientific program initiated 4 years ago to exploit the crepidula stock for agro-food purposes. The first results showed an increase in the settlement of this species, therefore inducing new harvesting measures.

*Ocinebrellus inornatus* was recorded in 2003 for the first time in the bay of Mont St Michel (North Brittany), but this information was only available in 2005. This species was probably introduced with oysters' transfers.

### 3.3 Algae and higher plants

The Dinoflagellate, *Ceratium candelabrum* (Ehrenberg) Stein 1883, has been recorded in the bay of Concarneau (south west coast of Brittany) for a few weeks at the end of November. It is the first time that this species which is currently observed in warm temperate and tropical water, is identified up north in France. This is likely correlated to the climate change.

### 3.4 Parasites, pathogens, and other disease agents

A zoosanitary surveillance program (REPAMO) on cultured and wild populations of shellfish, demonstrated the presence of *Perkinsus olseni* in wild clams *Ruditapes philippinarum* collected in the English Channel (in Blainville and Agon Coutainville in Normandy) in 2005. This parasite was first recorded in 1987 in Portugal. Since then, it has been frequently detected in the Mediterranean Sea and in the Atlantic Ocean. It was previously observed in a cultivated area of clams in the Normand- Britain Gulf. However, it is the first record of this parasite in wild clams in the English Channel.

## 4.0 Live imports

Only 2004 data are available.

### 4.1 Fish

Detailed tables on fish imports and exports are available in French at the following address: http://www.ofimer.fr/Pages/marche/Marche_AccueilDyna.html#Anchor-Le-47857, section "Bilans annuels de l'Ofimer" (Annual results of Ofimer), then "Bilan annuel commerce extérieur 2004" (annual external trade) http://www.ofimer.fr/99_up99load/2_actudoc/1010d1_01.pdf.

### 4.2 Invertebrates

Mollusc imports (2004)

| Species | Origin | Weight (MT) |
|---|---|---|
| *Ostrea edulis* | Ireland | 36 |
| | UK | 23 |
| | Spain | 6 |
| | | |
| *Crassostrea gigas* | Ireland | 1472 |
| | UK | 514 |
| | Spain | 434 |
| | Portugal | 224 |
| | Denmark | 59 |
| | Netherlands | 82 |
| | | |
| *Mytilus sp.* | Netherlands | 15999 |
| | Spain | 9330 |
| | Ireland | 8601 |
| | UK | 3345 |
| | Greece | 3925 |
| | Italy | 2659 |
| | Norway | 1195 |
| | Belgium | 284 |
| | Denmark | 486 |

## 5.0 Live exports

Only 2004 data are available.

### 5.1 Fish

Detailed tables on fish imports and exports are available in French at the following address: http://www.ofimer.fr/Pages/marche/Marche_AccueilDyna.html#Anchor-Le-47857, section "Bilans annuels de l'Ofimer" (Annual results of Ofimer), then "Bilan annuel commerce extérieur 2004" (annual external trade) http://www.ofimer.fr/99_up99load/2_actudoc/1010d1_01.pdf.

## 5.2 Invertebrates

Mollusc imports (2004)

| SPECIES | COUNTRY | WEIGHT (MT) |
|---|---|---|
| *Ostrea edulis* | Spain | 127 |
| | Italy | 87 |
| | Kuwait | 9 |
| | Germany | 8 |
| | Belgium | 11 |
| | | |
| *Crassostrea gigas* | Italy | 4169 |
| | Belgium | 640 |
| | Germany | 386 |
| | Spain | 245 |
| | Switzerland | 233 |
| | Russia | 133 |
| | Ireland | 35 |
| | Luxembourg | 85 |
| | Netherlands | 76 |
| | | |
| *Mytilus sp.* | Spain | 2581 |
| | Switzerland | 290 |
| | Italy | 538 |
| | Germany | 328 |
| | Belgium | 228 |
| | Luxembourg | 61 |
| | Netherlands | 48 |

# 6.0 Meetings, conferences, symposia or workshops on introductions and transfers

## 6.1 Past meetings for year being reported

Quelle stratégie pour les aires marines protégées? Journée Mondiale des Océans, Nausicaa – 8 juin 2005, Boulogne sur mer, France, Comité français UICN Union Mondiale pour la Nature.

An International Scientific Conference « Biodiversity: Science and Governance » took place from January 24 to 28, 2005 at the Paris Headquarters of UNESCO with a double objective: to assess current knowledge and needs for research and scientific expertise and to examine public and private approaches to biodiversity preservation and management. Four plenary sessions and fifteen workshops were held during this conference. The workshop 10 was focused on "Biodiversity and challenges for fisheries management".

A summary of the discussions is available at the following address: http://www.iisd.ca/download/pdf/sd/sdvol100num5e.pdf

Following this International conference, the French Institute on Biodiversity (IFB) organised a meeting in La Rochelle on December 12-13 and 14 (2005) between scientists, policy makers, NGO's and stakeholders on the following subject "Biodiversity: Science and Governance in provinces and territories". Three workshops were held on:

- Sustainable management of living resources and biodiversity

- Land use modification and biodiversity
- Invasive species control

Although mainly focused on terrestrial species, several example of remediation were proposed including communication and pro-active approaches and public awareness to limit side-effects of exotic species. Proceedings will be available in 2006.

### 6.2 Upcoming meetings

Exotics, should non-indigenous species be used in aquaculture? 5th Annual SABS/AAC Workshop, St Andrews, New Brunswick. This workshop will explore the current knowledge and contemporary research on the benefits and the hazards of introduced species. Existing guidelines for incorporating exotics into the aquaculture product will be reviewed in order to determine if with current knowledge and reasonable care exotics species can be utilized in aquaculture without incurring unacceptable risk.

The European project DIPNET organizes a workshop on April 3–4 (2006) in Prague. The main objectives are to provide a scientific overview of pathogen transmission between wild and farmed fish and shellfish and to review the evidence for disease interactions and population impacts. The first draft of this bibliographic review will be presented and commented for improvement (http://www.dipnet.info/).

### 6.3 Program in progress

The program REBENT is underway. The objective is to monitor the macro benthic ecosystem in order to evaluate its development following introduction of exotic species, global changes, eutrophication or accidental pollution. This program provides relevant data in compliance with the EU Water Framework Directive and the Directive 92/43/EEC on the conservation on natural habitat and of wild fauna and flora. Until now, this surveillance network is not uniformly developed along the French littoral, working on the coasts of Brittany and starting in 2006 in Mediterranean Sea but only in 2007 along the Atlantic coast and in the English Channel.

## 7.0 Bibliography

Capiomont, A., Breugnot, E., den Haan, M., Meinesz, A. 2005. Phenology of a deep-water population of *Caulerpa racemosa* var. cylindracea in the northwestern Mediterranean Sea. Bot. Mar., 48(1): 80–83.

Daguin, C., Voisin, M., Engel, C., Viard, F. 2005. Microsatellite isolation and polymorphism in introduced populations of the cultivated seaweed *Undaria pinnatifida* (Phaeophyceae, Laminariales). Conservation Genetics, 6: 647–650.

Garcia, C., Arzul, I., Chollet, B., Ferrand, S., François, C., Joly, J-P, Miossec, L., Robert, M. 2006. Bilan 2005 du réseau Repamo, Réseau national de surveillance zoosanitaire des mollusques marins, sous presse.

Girard, S., Pérez Agundez, J.A., Miossec, L., Czerwinski, N. 2005. Recensement de la conchyliculture 2001. Agreste Cahiers, N°1, 89 pp.

Kraan, S. and Barrington, K..A. 2005. Commercial farming of *Asparagopsis armata* (Bonnemaisoniceae, Rhodophyta) in Ireland, maintenance of an introduced species? J. Applied Phycology, 17: 103–110.

Longepierre, S., Robert, A., Levi, F., Francour, P. 2005. How invasive alga species (*Caulerpa taxifolia)* induces changes in foraging strategies of the benthivorous fish *Mullus surmulutus* in coastal Mediterranean ecosystems. Biodiv. Conserv., 14: 365–376.

Masson, D., Piquet, J.-C., Courtois, O. 2005 Survival of bacteria and phytoplancton in ship's ballasts. Communication in ENSUS 2005, 3rd International Conference on Marine Science and Technology for Environmental Sustainability, 13–15 April 2005, in Newcastle.

Merle, D., Filippozi, D. 2005. First record of T*runculariopsis trunculus* (Linnaeus, 1758) (Mollusca: Gastropoda) from the basin of Arcachon (Gironde): the second exotic muricid on the French Atlantic coast. Cah. Biol. Mar., 46(3): 299–303.

Pergent-Martini, C., Leoni, V., Pasqualini, V., Ardizzone, G. D., Balestri, E., Bedini, R., Belluscio, A., Belsher, T., Borg, J., Boudouresque, C. F., Boumaza, S., Bouquegneau, J.M., Buia, M. C., Calvo, S., Cebrian, J., Charbonnel, E., Cinelli, F., Cossu, A., Di Maida, G., Dural, B., Francou,r P., Gobert, S., Lepoint, G., Meinesz, A., Molenaar, H., Mansour, H. M., Panayoditis, P., Peirano, A., Pergent, G., Piazzi, L., Pirrotta, M., Relini, G., Romeo, J., Sanchez-Lizaso, J.L., Semroud, R., Shembri, P., Shili, A., Tomasello, A., Velmirov, B. 2005. Descriptors of *Posidonia oceanica* meadows: use and application. Ecol. Indicators, 5: 213–230.

Simon-Bouhet, B.**,** Daguin, C., Garcia-Meunier, P., Viard**,** F. 2005. Polymorphic microsatellites for the study of newly-established populations of the gastropod. Cyclope neritea. Molecular Ecology Notes, 5: 121–123.

Simon-Bouhet, B.**,** Garcia-Meunier, P., Viard, F. 2006 Multiple introductions promote range expansion of the mollusc *Cyclope neritea* (Nassariidae) in France: evidence from mitochondrial sequence data. Molecular Ecology. sous presse.

Thomas, F., Renaud, F., Guegan, J.-F. ed. 2005. Parasitism and Ecosystems, Oxford University Press, 221 pp.

Viard, F**.,** Ellien, C**.**, Dupont, L. 2006. Dispersal ability and invasion success of *Crepidula fornicata* in a single gulf: insights from genetic markers and larval-dispersal models. Helgoländer Marine Research (sous presse).

# National report Germany, 2005

Prepared by Stephan Gollasch and Harald Rosenthal

## Highlights of National Report

- In summer 2005 the macroalga *Gracilaria vermiculophylla* (vegetative) was found for the first time in the Kiel Fjord near the port (marina) of Schilksee. The algae was formerly found in Sweden (2003), Sylt (2004?) and also along the North- and Baltic Sea coasts of Denmark.
- The previously introduced non-indigenous oyster *Crassostrea gigas* continues to spread in the Wadden Sea. Activities on aquaculture and restocking focussed in 2005 on eels, sturgeon and salmon. Ornamental trade is continuing to be popular. The opening of new public aquariums may prompt this trend further. For direct human consumption, various crustaceans, blue mussels, common carp, and *Tilapia* species are imported. Live exports to ICES Member Countries focus on *Mytilus edulis* predominantly for the Belgium and Dutch markets.
- Together with Vadim Panov (Russia), Stephan Gollasch is the editor of *Aquatic Invasions* – the new European journal of applied research on biological invasions in aquatic ecosystems.
- Several aspects of this journal relate to WGITMO Terms of Reference, e.g. announcement of new findings of biological invaders and also an early warning due to timely release of journal issues. The journal is free and more information including the first issue released early 2006 may be found at http://www.zin.ru/rbic/AquaticInvasions/ or http://www.aquaticinvasions.ru/.
- Stephan Gollasch is also a contributing partner of the new EU project Delivering Alien Invasive Species Inventories for Europe (DAISIE). One of the key objectives of this initiative is to prepare a European-wide list of biological invasions (including terrestrial habitats) which will eventually be made available via the Internet. Another objectives is to create European Alien Species Expertise Registry. The expertise registry has recently been set up and contains already details of more than 580 experts from 64 countries. Now there is an opportunity to register yourself at the DAISIE European Alien Species Expertise Registry. The registration process is only a matter of minutes and in return you may get new contacts with experts from European Countries as well as from overseas. This registry is open to the public, for governmental bodies and for stakeholders, searching for a given expertise. Thus, it may become rewarding, to be included there. Please take time to register at http://daisie.ckff.si/.
- Ballast water issues become more and more into focus. Germany continues to be active in the Ballast Water Working Group of the International Maritime Organization. Onboard tests of two ballast water treatment systems developed by German vendors will be undertaken later in 2006.

## 3 Accidental introductions and transfers

As already pointed out in last year's report, it is assumed that the Asian shore crab ***Hemigrapsus penicillatus*** will invade German waters in the very near future as records are known from Belgium and the Netherlands, indicating its eastward directed spread into the German Bight. The Ponto-Caspian fish ***Neogobius melanostomus***, known from the German Baltic coasts, was recently recorded in the Netherlands – the first record from the North Sea. The species seems to be well established with several records form the Netherlands in 2005. Is is assumed that the species may also be recorded from the German North Sea coast in the near future. It is of further concern that ***Rapana venosa*** was found in the south eastern North Sea. Records from Germany are not reported (yet). This predatory snail may have an impact on bivalves including those used for aquaculture purposes.

In summer 2005 the macroalga ***Gracilaria vermiculophylla*** (vegetative) was found for the first time in the Kiel Fjord near the port (marina) of Schilksee. The algae was formerly found in Sweden (2003), Sylt (2004?) and also along the North- and Baltic Sea coasts of Denmark.

Status report of earlier introduced species:

***Crassostrea gigas***

Culturing the Pacific Oysters resulted also in oyster settlement outside the farm. As there is not much hard substrate in the German Wadden Sea to settle mussel beds of *Mytilus edulis* became the first foothold for oyster spat. *Crassostrea gigas* continues to spread southwards and competes with native *Mytilus edulis* for habitat and food. It was documented at certain sites that the oysters have overgrown mussel beds with an increasing tendency.

***Eriocheir sinensis***

The Chinese Mitten Crab population declines further in density after its mass occurrence in the 1990s.

# 4 Live imports

## 4.1 Fish

**Aquaculture** (no major changes to last years National Report)

Several culture facilities are in operation – some of them use warm water effluents of powerplants. Species are cultured for the aquarium industry (**koi carp**, **gold fish** and **sterlett**), human consumption (**Asian carp, *Tilapia*** species) and restocking (**glass eels**). **Glass eels** are imported from various countries (e.g. France, Italy, Ireland, Netherlands, and Sweden) according to the ICES Code of Practice.

Several **Sturgeon** species are still imported from Russia by local farmers for small-scale culture, among them is the Siberian sturgeon ***Acipenser baerii***. Records of escapees continue and numbers recorded increase annually. There are also German sturgeon hatcheries producing *A. baerii* juveniles for stocking of other farms inside Germany and abroad. The number of exported juveniles is not known. Several sturgeon species (even from the Far East) are in the aquarium trade for petfish garden ponds. Judging from the sale advertisements on the Internet, the number must be in the thousands. ***A. oxyrhynchus*** (egg, larvae and juveniles) were imported from Canada.

Imports of **salmonid species** continued in the year 2005 at a comparable level to previous years. It is extremely difficult to trace the routings and quantities of life fish trade in several regions as there is no mechanism to collect these data. As in previous years, rainbow trouts were imported mainly from Denmark, the Netherlands, Poland, and the Czech Republic. The tonnage of trouts imported overall varied, but is usually above 10 000 tonnes annually. Live **Atlantic Salmon** were imported from Sweden for human consumption in an unknown quantity.

**Common carp** is regularly imported alive since decades. Imports source countries are Poland, Hungary, Czech Republic. The present amount being imported is approx. 5000 tonnes.

**Arctic charr** eggs were imported from Canada and Finland.

## 4.2 Invertebrates

***Crassostrea gigas*** and ***Ostrea edulis*** were imported from France and ***Mytilus*** sp. from Sweden.

**Ornamental trade**

Large quantities of marine, brackish water and freshwater organisms were imported from South America, South-East Asia and other regions (inner-European trade) to serve the aquarium and hobby industry. Several million fish are imported annually predominantly from the Philippines, Indonesia, Thailand, Singapore and Hawaii. Of particular importance seems to be the trade with koi carp. Although the varieties imported are exclusively placed into freshwater garden ponds and home aquaria, the trade and the associated spread of the Koi Herpes Virus over the past few years can serve as an excellent example of unintentional spread of pathogens of epidemiological importance as this virus apparently affects also common carp and its conventional pond culture. Apparently, the spread of the virus is also occurring in other European countries. Detailed information is available from the European Association of Fish Pathologists (EAFP) and publications of its members.

### 4.2 Invertebrates

Live **Blue Mussels** (*Mytilus edulis*) were imported from Denmark for human consumption in an unknown quantity.

Live crustaceans (***Nephrops norvegicus***, ***Homarus gammarus***, ***H. americanus***, ***Callinectes sapidus*** and ***Cancer pagurus***) have been imported for human consumption from various countries in an unknown dimension.

### 4.3 Plants

Macroalgae for human consumption become an increasing business. Currently test cultures are underway growing the brown-alga *Laminaria saccharina* and red-alga *Palmaria palmata*.

## 5 Live exports to ICES member countries

The live **Blue Mussel** (*Mytilus edulis*) production is predominantly exported to the Belgium and Dutch markets.

**Rainbow trouts** were exported to Finland and **Carp** to Sweden.

## 7 Meetings, conferences, symposia or workshops on introductions and transfers

### 7.1 Meetings

**NEOBIOTA group.** This German group on biological invasions (established in 1999) is an effort to co-ordinate responses to the ever increasing problems caused by the invasion of non-native organisms. The group considers all species introductions, including invasions in terrestrial habitats. The next meeting is planned for September 2006 in Vienna (back-to-back with the next meeting of the EU DAISIE Programme).

### 7.2 New journal – Aquatic Invasions

Together with Vadim Panov (Russia), Stephan Gollasch is the editor of *Aquatic Invasions* – the new European journal of applied research on biological invasions in aquatic ecosystems. *Aquatic Invasions* is focussed on biological invasions of the inland and coastal waters of geographic Europe. It is our intention to also provide an opportunity to publish relevant technical reports and other accounts not publishable in regular scientific journals, including large datasets of aquatic invasive species records from monitoring and biological surveys. Several aspects of this journal relate to WGITMO Terms of Reference, e.g. announcement of new findings of biological invaders and also an early warning due to timely release of journal issues. The journal is free and more information including the first issue released early 2006 may be found at http://www.zin.ru/rbic/AquaticInvasions/ or http://www.aquaticinvasions.ru/. Contributions to the journal from WGITMO members are more than welcome. Manuscripts related to inland waters may be submitted to Vadim Panov at rbic@zin.ru and accounts on coastal invaders to Stephan Gollasch SGollasch@aol.com.

### 7.3 Ballast water treatment

Ballast water issues become more and more into focus. Germany continues to be active in the relevant working group of the International Maritime Organization (IMO), the United Nations body which deals with shipping. Onboard tests of two ballast water treatment systems developed by German vendors will be undertaken later in 2006 and test results will be communicated to IMO.

### 7.4 Invasive alien species in Germany: report on situation and activities

This summary was compiled for the 6th meeting of the Group of Experts on Invasive Alien Species of the Bern Convention, Palma de Mallorca, Spain, 9–11 June 2005. The annotated checklists of alien plant and animal species have been conduced. In total 1149 alien animal species and 1233 alien higher plants were found Germany (data include terrestrial habitats). For further details, pelase contact Frank Klingenstein, Federal Agency for Nature Conservation, Konstantinstr. 110, 53179 Bonn, Germany, frank.klingenstein@bfn.de.

## 8 Bibliography

Relevant publications of the authors since last years WGITMO meeting:

Minchin, D., Gollasch, S. and Wallentinus. 2005. Vector pathways and the spread of exotic species in the sea. ICES Cooperative Research Report, 271.

Gollasch, S. 2005. Die Nordsee – exotischer denn je. Waterkant 2/05, 8–11

Dragsund, E., Andersen, A.B., Gollasch, S., ten Hallers-Tjabbes, C.C. and Skogen, K. 2005. Scoping Study on Ballast Water Management for North Western Europe. DNV Report No. 2005–0638. 131 pp.

Gollasch, S. 2005. Sampling protocol for tests of ballast water treatment systems according to relevant IMO guidelines with an emphasis of onboard tests. prepared for Det Norske Veritas, Hövik, Norway.

Gollasch, S., Carlberg, S. and Kenchington, E. 2005. ICES Code of Practice on the Introductions and Transfers of Marine Organisms. 30 pp.

Gollasch, S. (ed.). 2005. Recommendations on ballast water risk assessment exemptions relevant to Guidelines (G7) and regulation A-4 of the Ballast Water Management Convention. Document submitted by ICES in behalf of the ICES/IOC/IMO Working Group on Ballast Water and other Ship Vectors (WGBOSV). 8 pp. MEPC 53/2/10.

# Update from Ireland, 2005

Prepared by Dan Minchin Rosenthal

## Non-native range expansions to and within Ireland in 2005

There are three notable species range expansions within Ireland and two new introductions during 2005. The amphipod *Caprella mutica*, first recorded in July 2003 on the west coast of Ireland has been found in abundance in Dublin Bay on the east coast of Ireland in April 2005 however a recent January survey failed to find any. The brown alga *Sargassum mutica* was found in Carlingford Lough, north-east coast of Ireland for the first time. There were also many detached specimens stranded on the upper shore. The tunicate *Styela clava* has extended its range and occurs in low abundance in Dublin Bay and on the south-west coast in Dingle and Tralee bays (Martin Davis pers. comm.). *S. clava* has been known only from Cork Harbour since 1972.

In an estuary north of Dublin in October 2005 a growth form of *Didemnum* sp. was found to overgrow fouling on marina pontoons and heavily fouled leisure craft. Sheet like growth overgrew mussels and may have smothered some. Long prolonged growths hang from both the hulls of craft and pontoons with extensions of up to ~60cms. The tunicate bears a strong resemblance to populations in the Rade de Brest and Le Havre and in Dutch waters. *Didemnum* sp. with a similar growth form are known from the east and west coasts of North America and from New Zealand.

The southern hemisphere tunicate *Corella eumyota* was found for the first time in Ireland at Cork Harbour in 2005 (Christine Woods of the Marine Biological Association, Plymouth pers. comm.).

# National report, Italy (Guest status), 2005

Prepared by Anna Occhipinti-Ambrogi
(for supporters see end of report)

## Summary

New findings of alien species in Italian marine waters are reported for the year 2005. No new information has been made available for legal matters and for deliberate introductions. Eleven new invertebrates species have been added to the list of NIS found in Italian waters. Many species are enlarging their distribution in Italian waters and data have been gathered on the biology of some of the most important ones.

**Note:** This report is the outcome of a special working group of the Italian Marine Biology Society (SIBM) on a voluntary basis. It does not reflect an official position or knowledge of the relevant Italian Government bodies.

It has been prepared according to the guidelines for ICES WGITMO National Reports; it updates the Italian status sent by correspondence in March 2005.

## 3.0 Accidental introductions and transfers

### 3.1 Fish

New information was made available for the following species that have been already reported in the previous years.

*Fistularia commersonii* continues to be found in numerous groups in the Sicily Straits; it was also caught along the SW shore of Sicily (Milazzo *et al.*, in press) and other localities in the Tyrrhenian sea (Micarelli *et al.*, in press).

For *Siganus luridus,* that had been found in the Linosa island in 2000, the genetic variability of the early phase of invasion and the genetic variation within and between colonist and source populations (Red Sea) were tested (Azzurro *et al.*, in press). A lowering of the genetic diversity of the invading population has been found. Within the Mediterranean populations of Israel, Greece and Italy, there was no pattern of regional separation and mitochondrial diversity appeared to be preserved during the Linosa colonization, with no traces of founder events. *Siganus luridus* has been found also near Capo d'Orlando, along the Northern coast of Sicily (Castriota and Andaloro, 2005).

The finding of a juvenile specimen of the sandbar shark *Carcharhinus plumbeus* was erroneously inserted in the Italian N.R. 2004, in fact the species was known (Tortonese, 1956) from different locations along the Italian coasts since 19$^{th}$ century.

### 3.2 Invertebrates

The following species have been added to the list of NIS for Italian coasts.

The Bryozoan *Pherusella brevituba* has been collected at Ustica Island in 1996. It was known only from California; several colonies were growing on Posidonia leaves (Chimenz Gusso and d'Hondt, 2005). Together with other species of Bryozoa, that had been recorded before in Italian waters, it must be considered a cryptic species, being surely unconspicuous and having a difficult taxonomic status. The two other species are:

*Bugula serrata* is an indopacific species, was described in the beginning of 1900 from Corsica and was found again in the small Tyrrhenian islands of Vulcano and Ponza (1992) and Ustica (1994) (Chimenz Gusso *et al.*, 2004).

*Arachnoidea protecta* is known from Celebes and had been found in the island of Vulcano near Sicily in 1994 (Chimenz Gusso *et al.*, 1998).

Four species of Polychaetes had been recorded in the Italian seas in previous years, but were not registered into the list of Italian alien species.

*Epidiopatra hupferiana hupferiana* had been recorded for the first time in 1991 in the Mediterranean Sea at Augusta (Sicily). It belongs to the Onuphidae and it is known from the Atlantic and Eastern Pacific, South Africa and the Antarctic (Cantone *et al.,* 1991).

*Lumbrinerides acutiformis,* an indopacific species, was recorded for the first time in the Mediterranean Sea in the islands of the Sicily Straits (Albertelli *et al.,* 1995).

*Hyboscolex longiseta* had been recorded for the first time in the Mediterranean Sea in Tunisia and later on in the Latium region in Italy. It belongs to the Scalibregmatidae and is cosmopolitan; since it is known from the Red Sea and Suez, it might be an Erithrean alien (Cantone *et al.*, 1978).

*Loimia medusa*, a Terebellid indopacific species, was recorded for the first time in the Mediterranean Sea in the islands of the Sicily Straits (Albertelli *et al.,* 1995).

Among the molluscs, the indopacific bivalve, *Theora lubrica*, was found in Leghorn in 2001 (Balena *et al.*, 2002), and since then it is colonizing a few stations inside the harbour, forming a large population (Campani *et al.*, 2004).

An Isopod species belonging to the genus *Mesanthura,* known from tropical areas and new for the Mediterranean, was found in the harbour of Salerno (Tyrrhenian Sea, southern Italy): it is probably *M. romulea* (Lorenti *et al.*, submitted).

A single adult male individual of *Eriocheir sinensis* (Crustacea, Decapoda Grapsidae) has been collected by catch in the lagoon of Venice in May 2005 and sent alive to the Venice Fish Market Veterinary Service. Passive transport of larvae in ballast water is one of the way of introduction but in this case the import of live material is most likely: in 2003 living individuals of this species coming from U.K. had been sold in the local fish market (Mizzan, 2005).

The non-indigenous ascidian, *Distaplia bermudensis*, from the western Atlantic Ocean was found for the first time in the year 2000 in the Taranto Seas (Ionian Sea, southern Italy), where an abundant population of colonies is present (Mastrototaro and Brunetti, 2006).

New information was made available for the following species that have been already reported in the previous years.

*Clytia hummelinckii* : this hydroid species was recorded for the first time from the Mediterranean (Ionian coasts of Calabria and Apulia) by Boero et al. in 1997 and, since then, from both the Adriatic and the Tyrrhenian seas (albeit unpublished). The species is expanding rapidly. It forms dense carpets at 1–2 m depth, in full light, on rocks covered by encrusting coralline algae, especially those intensively grazed by sea urchins. The species is present in the summer, but the whole cycle is still unknown. Being present both in the Atlantic and in the Pacific, it is not clear if it entered the Mediterranean either from Suez Canal or from Gibraltar. The rapid expansion of this species of hydroid witnesses a great success of the medusa stage, since dispersal is mainly obtained by displacement with currents. Unfortunately, Clytia medusae are very similar to each other and are invariably identified as Clytia hemisphaerica by plankton ecologists, so the diversity of species is undetected (Boero *et al.,* 2005).

*Aplysia dactylomela* had been found in 2002 in Lampedusa Island (Chemello, in press).

*Cerithium scabridum* is expanding in the western shores of Sicily, it builds up large populations in some locations, but they disappear after an year or so.

*Musculista senhousia* has built up a large population inside the harbour of Leghorn, enlarging its Tyrrhenian distribution (Campani *et al.*, 2004).

The distribution of *Branchiomma luctuosum*, *Microcosmus squamiger* (= *M. exasperatus*) and *Musculista senhousia* has been described in the sea inlets facing the town of Taranto (Mastrototaro *et al.*, 2004). *Microcosmus squamiger* was also fond in the harbour of Salerno (Tyrrhenian Sea) (Mastrototaro and Dappiano, 2005).

*Caprella scaura,* an Asian Amphipod collected for the first time in 1994 in the Lagoon of Venice, was recently reported as very abundant also in the harbour of Ravenna (Sconfietti *et al.*, 2005).

In 2002, during a survey for control and detection of NIS in the lagoon of Venice (Mizzan *et al.*, 2005), the crustacean decapod *Rhithropanopeus harrisii* was found in two inner areas of the lagoon characterized by mean annual salinity lower than 24 PSU (Mizzan, 2005). It was previously known from a basin used for rearing *Penaeus japonicus* in the Po river delta.

The invasive crab *Percnon gibbesi* has reached the Central Tyrrhenian (Russo and Villani, 2005). The success of this species has been related to reproductive characteristics (Puccio *et al.*, 2003) and to its strictly herbivorous feeding habits (Puccio *et al.*, 2006).

## 3.3 Algae and higher plants

The following algal species have been added to the list of NIS for Italian coasts:

The planktonic centric diatom *Skeletonema tropicum* was found for the first time in the Gulf of Naples, and in the Mediterranean Sea, in autumn 2002 (Sarno *et al.*, 2005). This species is considered tropical and subtropical, with a distribution not beyond 30° North in the western Atlantic Ocean. Since the first finding, it regularly occurred in late summer and autumn in the Gulf.

A green alga belonging to the genus *Prasiola,* known from polar and cold-temperate regions, has been recorded in 2002 in the Lagoon of Venice (Miotti *et al.*, 2005) in three different occasions, with few and small specimens; it is the first finding in Italy, while it has been reported from the Black and Azov Sea, and doubtfully from the Aegean.

New information was made available for the following species that have been already reported in the previous years.

Besides the detailed information on all the Italian localities where *Caulerpa racemosa* has been found (Piazzi *et al.*, 2005), the expansion of *Caulerpa racemosa,* starting from a small initial point near Taranto in 1996, has been monitored till 2004, encompassing 70 km of the coast (Cecere *et al.*, 2005). The distribution of *Womersleyella setacea* is now extended to three localities in the Apulian region (Cecere *et al.*, 2005). Other algal species have also expanded in the same area of the Gulf of Taranto (Cecere and Petrocelli, 2004; Mastrototaro *et al.*, 2004).

The study on the interactions of *Caulerpa* species with native algae has been continued. In an area near Leghorn, where *Caulerpa racemosa* and *C. taxifolia* co-occur, macroalgal communities were more different from reference areas when invaded by *C. racemosa*; the structure of invaded communities was related to the invader also in terms of growth habit (Piazzi *et al.*, 2003; Balata *et al.*, 2004). In habitats where four introduced macroalgae are present with very high percentages of macroalgal abundance, the native community was deeply affected (Piazzi and Cinelli, 2003). The effect of the increase in sediment deposition on the spread of *Caulerpa racemosa var. cylindracea* and the interactive effects of sedimentation and *C. racemosa* on native macroalgal assemblages have been evaluated by means of field experiments near Leghorn (Piazzi *et al.*, 2005). Results showed that *C. racemosa* was not affected by an increase of sedimentation rate. Synergistic mechanisms between sediment deposition and *C. racemosa* colonization resulted in a strong decrease in percent cover of the main algal species in areas where the two disturbances co-occurred.

As an output of the European project ALIEN, in depth studies involving macroalgae in the Italian waters have been continued, including the effect of temperature on growth and photosynthesis of *Caulerpa racemosa* var. *cylindracea* (Flagella *et al.*, 2005a; Raniello *et al.*, 2005, Raniello *et al.*, in press), molecular aspects of *Caulerpa* ecology (Patti, 2004, Varela-Alvarez *et al.*, in press), and the ecology of *Asparagopsis taxiformis* (Flagella *et al.*, 2005b).

The distribution and dynamics of the introduced green alga, *Codium fragile* ssp. *tomentosoides*, was investigated on breakwaters in the north Adriatic Sea, and the mechanisms underlying its establishment have been investigated. The artificial structures provide suitable habitats for non-indigenous marine species and function as corridors for their expansion (Bulleri and Airoldi, 2005).

## 7.0 Meetings, conferences, symposia or workshops on introductions and transfers

During the meeting "Physical and Chemical Impacts on Marine Organisms, a Bilateral Seminar Italy-Japan" held in November 2004 in Genoa, a paper has been presented on methods for ballast water treatment (Faimali *et al.*, in press). The screening of a promising molecule derived from alkylated naphtoquinones on a battery of ballast water model organisms showed that this new molecule is very effective in the absence of light and is extremely photodegradable. It can thus be easily degraded when released in the environment.

The project (IMSAT) on the monitoring of alien species in the Taranto inlets, funded by the Ministy of Education and Research, has been concluded in November 2005. The distribution of the algae *Caulerpa racemosa*, *Undaria pinnatifida*, and of the fishes *Sparisoma cretense* and *Balistes caroliniensis* has been assessed, while new alien species have been found (the red alga *Hypnea cornuta*, and the nudibranch *Melibe fimbriata* (= *Melibe viridis*)). Moreover, studies on the hulls, on the ballast water and sediments have been performed, concluding that this is the main vector for the introductions in the area.

In the framework of the UNEP Mediterranean Action Plan, an Expert Workshop on "Non-indigenous species" has taken place in Rome, 6–7.12.2005. The Regional Activity Centre for Specially Protected Areas (RAC/SPA) convened the meeting in order to prepare Guidelines for controlling the vectors of introduction into the Mediterranean of non-indigenous species and invasive marine species (UNEP, 2005).

The Italian Ministry for the Environment has consulted an expert group coordinated by Pietro Genovesi, before issuing a decree on species reintroductions and repopulation of animal and plant species, including marine ones. A guideline document has been produced (INFS 2005).

## 8.0 Bibliography

Albertelli, G., Chiantore, M., Drago, N. 1995. Macrobenthic assemblages in Pelagie Islands and Pantelleria (Ionian Sea, Mediterranean). Oebalia, 21: 115–123.

Azzurro, E., Golani, D., Bucciarelli, G., Bernardi, G. In press. Genetics of the early stages of invasion of the Lessepsian rabbitfish *Siganus luridus*. Journal of Experimental Marine Biology and Ecology.

Balata, D., Piazzi, L., Cinelli, F. 2004. A comparison among assemblages in areas invaded by *Caulerpa taxifolia* and *C. racemosa* in a subtidal Mediterranean rocky bottom. P.S.Z.N.: Marine Ecology, 25: 1–13.

Balena, G., Campani, E., Coppini, M., Margelli, A., 2002. Segnalazione dell'immigrante *Theora (Endopleura) lubrica* Gould, 1861 (Semelidae Stoliczka, 1870), con osservazioni sui rappresentanti Mediterranei della famiglia. La Conchiglia, 302: 11–20.

Boero, F., Di Camillo, C., Gravili, C., 2005. Phantom aliens in Mediterranean waters. Marine Biodiversity and Ecosystem Functioning, MarBEF Newsletter, 3: 21–22.

Boero, F., Gravili, C., Denitto, F., Miglietta, M.P., Bouillon, J. 1997. The rediscovery of *Codonorchis octaedrus* (Hydroidomedusae, Anthomedusae, Pandeidae), with an update of the Mediterranean hydroidomedusan biodiversity. Ital. J. Zool., 64: 359–365.

Bulleri, F., Airoldi, L. 2005. Artificial marine structures facilitate the spread of a nonindigenous green alga, *Codium fragile* ssp. *tomentosoides*, in the north Adriatic Sea. J. Applied Ecology, 42: 1063–1072.

Campani, E., Coppini, M., Cuneo, F., Margelli, A., 2004. Bivalvi «alieni» nelle acque del porto di Livorno: *Theora (Endopleura) lubrica* Gould, 1861 e Musculista senhousia (Benson in Cantor, 1842). Atti Società toscana Scienze nat., Mem., Serie B.,111: 1–5.

Cantone, G. , Fassari, G., Brigandì, S. 1978. Ricerche sui Policheti della Tunisia. Animalia 5 (1/3): 51–78.

Cantone, G., Fassari, G., Mollica, E. 1991. Analisi della struttura trofica del popolamento polichetologico della rada di Augusta, Sicilia orientale. Animalia, 18: 103–114.

Castriota, L., Andaloro, F. 2005. First record of the lessepsian fish *Siganus luridus* (Osteichthyes: Siganidae) in the Tyrrhenian Sea. JMBA2 – Biodiversity Records, Published online.

Cecere, E., Petrocelli, A. 2004. Floristic and biogeographic considerations about the benthic macroalgal flora in the Gulf of Taranto. Biogeographia, 25: 7–18.

Cecere, E., Petrocelli, A., Saracino, O.D. 2005. Biodiversity of phytobenthic communities in the marine reserve of Porto Cesareo. Biol. Mar. Medit., 12(1): 78–87.

Chimenz Gusso, C., Boccia, P., Giovannini, N. 2004. Importance of faunistic and taxonomical studies for a correct analysis of the zoogeography of Mediterranean Bryozoa. Biogeographia, 25: 93–108.

Chimenz, Gusso C., d'Hondt, J.-L. 2005. Finding of *Pherusella brevituba* Soule, 1951 (Bryozoa Ctenostomatida, Pherusellidae) in the Mediterranean Sea. Boll. Museo Civico di Storia Naturale di Verona, 29 : 85–88.

Chimenz Gusso, C., d'Hondt, J.-L., Nicoletti, L., Galluzzo, G. 1998. Finding of *Arachnoidea (Arachnoidella) protecta* (Bryozoa, Ctenostomatida, Arachnidiidae) in the Mediterranean Sea. Italian J. Zool., 65: 235–238.

Faimali, M., Garaventa, F., Chelossi, E., Piazza, V., Saracino, O.D., Rubino, F., Mariottini, G.L., Pane, L. 2006.. A new photodegradable molecule as a low impact ballast water biocide: efficacy screening on marine organisms from different trophic levels. Mar. Biol,(on line) DOI 0-1007/500227-005-0207-y.

Flagella, M.M., Lorenti, M., Buia, M.C. 2005a. Effect of temperature on growth and photosynthesis of the invasive *Caulerpa racemosa* var. *cylindracea.* Phycologia, 44(4), Suppl.: 15.

Flagella, M.M., Lorenti, M., Buia, M.C. 2005b. Assessment of the potential success of *Asparagopsis taxiformis*. In: Proceedings of The Seventh International Conference on the Mediterranean Coastal Environment, MEDCOAST 05, 25–29 October 2005, Kuşadasi (Turkey) (E. Özhan ed): 611–619.

INFS. 2005. Linee guida per la reintroduzione e il ripopolamento di specie animali e vegetali di interesse comunitario. Istituto Nazionale per la Fauna Selvatica "Alessandro Ghigi", 18 maggio 2005, 24 pp.

Lorenti, M., Dappiano, M., Gambi, M.C. Presence of the genus *Mesanthura* (Crustacea, Isopoda, Anthuridea) in the Mediterranean Sea: a probable introduction to two Italian harbours. (submitted to Scientia Marina).

Mastrototaro, F., Dappiano, M. 2005. New record of the non indigenous species *Microcosmus squamiger* Michaelsen, 1927 (Ascidiacea, Stolidobranchia) in the harbour of Salerno (Tyrrhenian Sea, Italy). JMBA2 – Biodiversity Records. Published online.

Mastrototaro, F., Brunetti, R. 2006. The non-indigenous aplosobranch ascidian *Distaplia bermudensis* in the Mediterranean: comparison with the native species *Distaplia magnilarva* and *Distaplia lucillae* n. sp. J. Mar. Biol. Ass. U. K., 86: 181–185.

Micarelli, P., Barlettani, M., Ceccarelli, R. In press. Note sul ritrovamento di un esemplare di *Fistularia commersonii* (Fistularidae, Pisces) nelle acque del Tirreno centrale. Atti Congr. Soc. Ital. Biol. Mar., Trieste, 9–13 may 2005.

Milazzo, A., Barraco, B., Beltrame, A.M., Cannizzaro, L., Puleo, M., Rizzo, P., Salvo, G., Vitale, S. In press. Catturata *Fistularia commersonii* (Fistularidae) (Ruppel, 1835) nelle acque costiere di Selinunte. Atti Congr. Soc. Ital. Biol. Mar., Trieste, 9–13 may 2005.

Miotti, C., Curiel, D., Rismondo, A., Bellemo, G., Dri, C., Checchin, E., Marzocchi, M.. 2005. First report of a species of *Prasiola* (Chlorophyta, Prasiolaceae) from the Mediterranean Sea (Lagoon of Venice). Scientia Marina, 69(3): 343–346.

*Rhithropanopeus harrisii* (Gould, 1841) (Crustacea, Decapoda Panopeidae) ed *Eriocheir sinensis* H.Milne Edwards, 1854 (Crustacea, Decapoda Grapsidae): due nuovi granchi esotici in laguna di Venezia. Boll. Mus. Civ. St. nat.Venezia, 56: 89–95.

Mizzan, L., Trabucco, R., Tagliapietra, G. 2005. Nuovi dati sulla presenza e distribuzione di specie alloctone del macrozoobenthos della Laguna di Venezia. Boll. Mus. Civ. St. nat. Venezia, 56: 69–88.

Patti, F.P. 2004. The success of invasive species in the Mediterranean basin: molecular tools to identify non indigenous benthic species. Biogeographia, 25: 74–79.

Piazzi, L., Balata, D., Cecchi, E., Cinelli, F. 2003. Co-occurrence of *Caulerpa taxifolia* and *C. racemosa* in the Mediterranean Sea: interspecific interactions and influence on native macroalgal assemblages. Cryptogamie, Algol, 24: 233–243.

Piazzi, L., Cinelli F. 2003. Evaluation of benthic macroalgal invasion in a harbour area of the western Mediterranean Sea. Eur. J. Phycol., 38: 223–231.

Piazzi, L., Balata, D., Ceccherelli, G., Cinelli, F. 2005. Interactive effect of sedimentation and *Caulerpa racemosa* var. *cylindracea* invasion on macroalgal assemblages in the Mediterranean Sea. Estuarine Coastal Shelf Science, 64: 467–474.

Puccio, V., Relini, M., Azzurro, E. 2003. Osservazioni sulla riproduziuone di *Percnon gibbesi* (H. Milne Edwards, 1853) a Linosa. Biol. Mar. Medit., 10: 267–272.

Puccio V., Relini M., Azzurro E., Orsi Relini L., 2006. Feeding habits of *Percnon gibbesi* (H. Milne Edwards, 1853) in the Sicily Strait. Hydrobiologia, 557: 79–84.

Raniello, R., Mollo E., Lorenti M., Brunet C., Gavagnin M., Buia M.C., 2005. *Caulerpa racemosa* versus *Cymodocea nodosa*: photosynthetic adaptation and chemical interaction. Phycologia, 44 (4), Suppl.: 15.

Raniello, R., Lorenti, M., Brunet, C., Buia, M. C. In press. Photoacclimation of the invasive alga *Caulerpa racemosa* var. *cylindracea* to depth and daylight patterns and a putative new role for siphonaxanthin. Marine Ecology.

Sarno, D., Kooistra, W.C.H.F., Medlin, L.K., Percopo, I., Zingone, A. 2005. Diversity in the genus *Skeletonema* (Bacillariophyceae). II. An assessment of the taxonomy *S. costatum*-like species, with the description of four new species. J. Phycol., 41: 151–176.

Sconfietti, R., Mangili, F. Savini, D., Occhipinti Ambrogi, A. 2005 Diffusion of the alien species *Caprella scaura* Templeton, 1836 (Amphipoda: Caprellidae) in the Northern Adriatic Sea. Biol. Mar. Medit., 12 (1): 335–337

Tortonese, E. 1956. Fauna d'Italia vol.II Leptocardia, Ciclostomata, Selachii. Caldeini Bologna, 334pp.

UNEP-MAP-RAC/SPA. 2005. Action Plan concerning species introductions and invasive species in he Mediterranean Sea. Ed. RAC/SPA Tunis, 30 pp.

Varela-Álvarez, E., Andreakis, N., Lago-Lestón, A., Pearson, AG., Serrão, AE., Procaccini, G., Duarte, MC. and Marbá, N. In press. Genomic DNA isolation in green and brown Algae (Caulerpales and Fucales) for microsatellite library construction. Journal of Phycology.

***Papers quoted "in press" in the previous National Reports for Italy, that have appeared during 2005***

Andaloro, F., Falautano, M., Sinopoli, M., Passarelli, F.M., Pipitone, C., Addis, P., Cau, A., Castriota, L. 2005. The lesser amberjack *Seriola fasciata* (Bloch, 1793) (Perciformes: Carangidae) in the Mediterranean: a recent colonist? Cybium, 29(2) : 141–145.

Ceccherelli, G., Piazzi, L. 2005. Exploring the success of manual eradication of *Caulerpa racemosa* var. *cylindracea* (Caulerpales, Chlorophyta): the effect of the habitat. Cryptogamie Algologie, 26: 319–328.

Mastrototaro, F., Matarrese, A., D'Onghia, G., 2004. Observations on the recruitment of *Musculista senhousia* (Mollusca, Bivalvia) in the Taranto seas (Eastern-Central Mediterranean Sea). Biogeographia, 25: 55–63.

Mastrototaro, F., Petrocelli, A., Cecere, E., Matarrese, A. 2004. Non indigenous species settle down in the Taranto seas. Biogeographia 25: 47–54.

Piazzi, L., Meinesz, A., Verlaque, M., Akçali, B., Antoli, B., Argyrou, M., Balata, D., Ballesteros, E., Calvo, S., Cinelli, F., Cirik, S., Cossu, A., D'Archino, R., Djellouli, A.S., Javel, F., Lanfranco, E., Mifsud, C., Pala, D., Panayotidis, P., Peirano, A., Pergent, G., Petrocelli, A., Ruitton, S., Zuljevic, A., Ceccherelli, G. 2005. Invasion of *Caulerpa racemosa* var. *cylindracea* (Caulerpales, Chlorophyta) in the Mediterranean Sea: an assessment of the spread. Cryptogamie Algologie, 26(2): 189–202

Russo, G.F., Villani, G. 2005. Diffusione nel Tirreno centrale della specie alloctona *Percnon gibbesi* (Decapoda, Grapsidae). Biol. Mar. Medit., 12(1): 329–330.

Scuderi, D., Russo, G.F. 2005. Prima segnalazione di *Aplysia dactylomela* Rang, 1828 e probabile presenza di *Syphonota geographica* (Adams e Reeve,1850) (Gastropoda:Opisthobranchia: Anaspidea) per le acque del Mediterraneo. Biol. Mar. Medit., 12(1): 338–341.

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# National report, The Netherlands, 2005

Prepared by Deniz Haydar

## 1.0 Laws and regulations

There are no national laws and regulations in The Netherlands that specifically adress introduced species. However, in 2005 the Ministry of Agriculture, Nature and Food Quality appointed the EXOBEL working group to start designing laws and regulations, as The Netherlands have ratified the "Convention of Biological Diversity" and the "Convention on the conservation of European wildlife and natural habitats". Van der Weijden *et al.* (2005) made an inventory of aspects of exotic species that (might) affect the Netherlands. This report was presented to the Minister in July 2005. The conclusions of this report will be used in designing laws and regulations for the prevention of introduction of invasive exotic species, and the elimination and/or management of highly invasive species.

## 3.0 Accidental introductions and transfers

(Wolff, 2005) presents an overview of non-indigenous marine and estuarine plant and animal species recorded from The Netherlands. Exotic species from outside NW Europe and non-indigenous species from elsewhere in NW Europe are listed. Species that have been suggested to be non-indigenous in The Netherlands but for which insufficient evidence could be found are discussed shortly as well. The list is based mainly on literature data supplemented by observations of the author. At least 99 plant and animal species have been introduced from elsewhere in the world. Another 13 species have been introduced from other parts of NW Europe. The list is preceded by an introduction describing the history of Dutch research on introduced species, the origin of the marine and estuarine flora and fauna of The Netherlands, natural and human-induced dispersal processes, and a summary of the geographic patterns of introduced species.

In 2005 three species were added to the list of introduced species in The Netherlands: *Palaemon macrodactylus*, *Rapana venosa* and *Neogobius melanostomus* were recorded for the first time in Dutch waters.

*Didemnum* sp. ("*lahillei*" in Dutch literature) has been present in the Dutch Oosterschelde estuary since 1991. It remained rare until 1998, after which it dramatically expanded its population size and overgrew almost all hard substrata present, including organisms like algae, plants, bivalves, hydroids, sponges, sea anemones and other ascidians. It is hypothesized that *Didemnum* sp. could not expand its populations earlier than 1998 because of the minimum water temperature of –2 degrees Celsius in 1996 and 1997. After 1997, for eight years now, the minimum temperature has remained about 4 degrees Celsius, which might be just warm enough for the didemnid to survive.

The Pacific oyster *Crassostrea gigas* is still spreading in the Wadden Sea. At this moment it is the dominant invader in Dutch waters. Its spread and interaction with native shellfish species are being studied by Wageningen IMARES Yerseke, the University of Groningen and the Royal NIOZ at Texel.

## 4.0 Live imports and transfers, and 5.0 Live exports to other countries

Data for 2005 were not available at the time of writing this report, data of 2004 are presented instead. The available data (from Statistics Netherlands, see www.cbs.nl) are grouped as "live or fresh fish; other than fish fillets and other fish meats" and "shellfish" , which includes both live and dead animals. Detailed information on international trade in live organisms could not be obtained on short notice. Imports and exports to and from European countries are almost an order of magnitude larger than values for other countries, and are therefore presented in separate graphs.

1a 1b

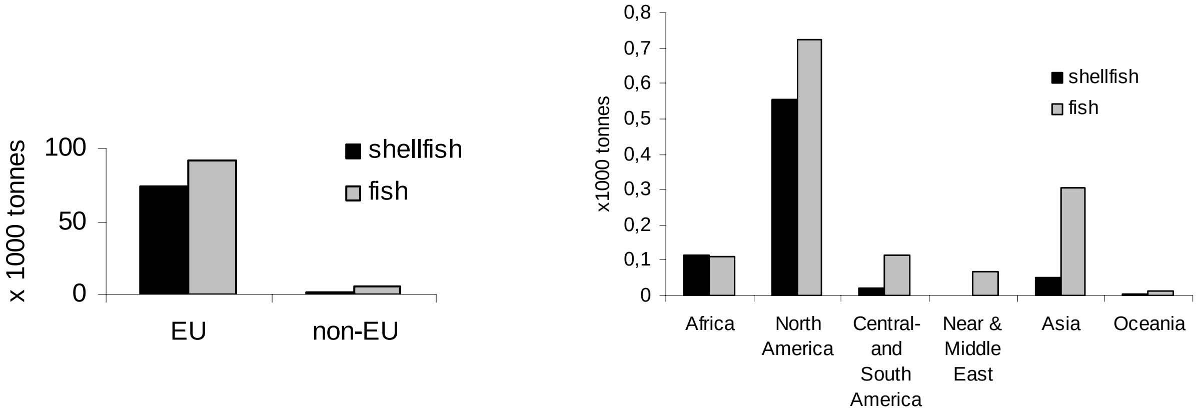



**Figure 1. Imports of fish and shellfish to The Netherlands, 1a: from European countries, 1b: from other countries.**

2a 2b

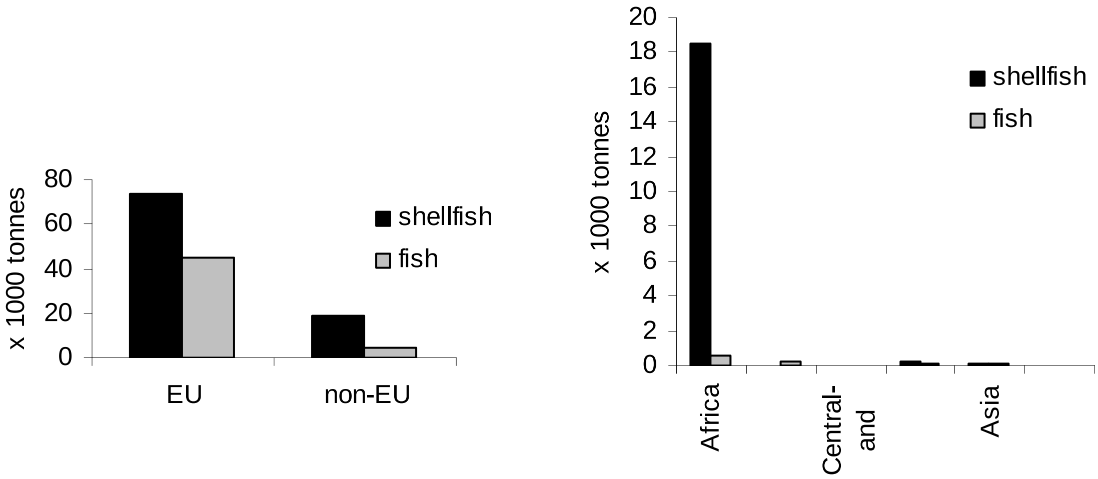



**Figure 2. Exports of fish and shellfish from The Netherlands, 2a: to European countries, 2b: to other countries.**

## 7.0 Bibliography

Van der Weijden, W.J., Bol, P. and Leewis, R. 2005 Biologische globalisering. Omvang, oorzaken, gevolgen, handelingsperspectieven. Achtergronddocument voor de beleidsnota Invasieve Soorten van het ministerie van Landbouw, Natuur en Voedselkwaliteit. CLM Culemborg. 92 pp.

Wolff,W.J. 2005. Exotic marine and estuarine species introduced into the Netherlands. Zoologische Mededelingen, 79: 1–120.

# National report, Norway, 2005

prepared by Anders Jelmert

## Summary

No new laws or bylaws have been enacted in 2005, but a law on biodiversity (NOU 2004:28) has been on hearing. The biodiversity law is put on hold for a harmonization with a EU directive before being enacted, likely in 2007.

Some 14 lobsters with suspect habitus-characteristics were collected in southern Norway. Eight were confirmed to be the American lobster and two of the specimens were females carrying fertilized eggs. Intensive capturing efforts were initiated at a "hot spot" outside Bergen (N60 19, E05 10) where the majority of specimens were found, but no additional specimens were recovered.

The Red King crab *Paralithodes camtschaticus* has continued its south- and westward migrationand several individuals have been caught outside Tromsø (N70, E19 30). The southernmost individual caught at Folla, (N64 40, E 11), well south of the Lofoten Archipelago (N68, E15). A free fishery W. of 26 deg E. yielded 22 tons, but the fishery was abandoned when not profitable.

The snow crab *Cionoecetes opilio* has increased considerably in numbers, and increasing numbers of smaller, young individuals are being reported. The stock on the Goose Bank have been estimated to approximately 500 000 individuals.

The red algae *Heterosiphonia japonica* has continued to expand its range, and have now been found in significant numbers in the "Oslofjord" area (N59, E 10).

A new cross-sectorial databank for biodiversity-data has been established (www.artsdatabanken.no). In addition to a thorough review of the "Red list" of endangered species, the databank will establish and maintain a searchable list of alien species in Norway (both terrestrial, limnic and marine).

## 1.0 Laws and regulations

The law on biological diversity (NOU 2004:28) has been on hearing, and the hearing responses are still beeing evaluated. The law will likely be enacted in 2007.

The report #21(2004–2005) to the parliament on The Environmental Status and Policy sat forth goals to stop the loss of biodiversity by 2010.

A species databank ("Artsdatabanken") has been established. Its scope is to establish a cross-institutional searchable database for biodiversity: www.artsdatabanken.no

1 ) Norwegian species and habitats
2 ) Norwegian endangered species (review of "The red List")
3 ) A Norwegian "Alien list"

The databank is for terrestrial, limnic and marine environments.

## 2.0 Deliberate releases and planned introductions

No attempts to import species for deliberate releases have been reported for 2005.

# 3.0 Accidental introductions and transfers

## 3.2 Invertebrates

The red king crab *Paralithodes camtchaticus* has continued its west and southwards migration as well as indications of a northward migration towards Spitzbergen. One specimen has been collected at “Folla” (N64 40, E 11), substantially south of the Lofoten archipelago (N68, E15), but this is believed to be a released individual. Suspected migrating individuals, have been caught close to Tromsø (N70, E19 30).

The snow crab *Cionoecetes opilio* has become fairly common in bottom trawls east in the Barents Sea / Goose Bank, and an increasing number of young individuals/juveniles is reported. The stock have been estimated to some 500 000 individuals on the Goose Bank (N 70–75, E35–45) in the Russian EZ.

During the pot fishery for lobster, some 14 lobsters with suspect habitus-characteristics were collected several places in Southern Norway. Eight were confirmed to be the American lobster, and two of these were females carrying fertilized eggs. Intensive capturing efforts were initiated at the “hot spot” outside Bergen (N60 19, E05 10) where the majority of specimens were found, but no additional specimens were captured. Several of the American lobsters had rubber band on their claws.

## 3.3 Algae and higher plants

The red alga *Heterosiphonia japonica* has continued to expand its range both northward and south-/eastward. It is now easily found and well established in the “Oslofjord” area (N59, E 10).

Japanese driftweed, *Sargassum muticum* continues to increase in biomass in areas where established (sheltered to semi-sheltered localities from the Swedish border (N59 03, E 11 08) to North of the “Sognefjord” (N61 14, E4 56)

# 4.0 Live imports

## 4.1 Fish

Ornamental fish for aquaria (species not specified):

3 shipment of total 339 specimens. Origin: South America and Russia

Cyprinus Carpio: 4 shipments totaling 332 specimens from Japan

Fish imported for scientific studies:

Cyprinodon variegates: 7 shipments totaling 3300 specimen.

## 4.2 Invertebrates

*Homarus americanus*: 156 shipments totaling 57 tons from Canada.

# 5.0 Live exports

None reported

# 6.0 Meetings, conferences, symposia or workshops on introductions and transfers

- A Norwegian – Russian workshop on the red king crab was held in Tromsoe in june 2005. A report to the Norwegian – Russian Fisheries commission was prepared after the meeting.

- A workshop to develop a strategy to deal with introduced species was held in Oslo 22–23 September 2005
- A national conference on biodiversity will be held in Oslo, May 9th 2006.

## 7.0 Bibliography


Alvsvåg, J., Agnalt, A.L., Jørstad, K.E. 2005. Snow crab (*Chionoecetes opilio*) introduction to the Barents Sea -present distribution and future perspectives. 6th International Crustacean Congress, Glasgow July 2005. Poster.

Husa, V., Sjøtun, K., Brattenborg, N. and Lein, T.E. 2005 Will establishment of an introduced red algae (*Heterosiphonia japonica*) result in local algal biodiversity changes? Oral presentation on the British Phycological Society Annual Meeting, Plymoth January 2006.

Jørgensen, L.L. Manushin, I. Sundet, J.H. and Birkely, S.-R. 2005. The intentional introduction of the marine red king crab *Paralithodes camtchaticus* into the Southern Barents Sea. ICES Cooperative Research Report, 277. 18 pp.

Jørstad, K.E., Prodohl, P.A., Agnalt, A.L., Hughes, M., Farestveit, E., Ferguson, A. 2005. American lobster (*Homarus americanus*) in Norwegian waters – an evaluation of genetic and biological methods to detect hybrids with European lobster (*Homarus americanus*). 6th International Crustacean Congress, Glasgow, 18–20 July 2005

Jørstad, K.E., Seeb, L. 2005. Microsatellite DNA analyses of introduced Red king crab (*Paralithodes camchatica*) in the Barents Sea and comparison with samples from the Bering Sea and Kamchatka region. 6th International Crustacean Congress, Glasgow, 18–22 July 2005.

Van der Meeren, G.I**.** and Jelmert, A. 2005. Invasive Crustaceans, Invasive Intruders and Efficient Emigrants, a review. Oral presentasjon ved 6th International Crustacean Congress, Glasgow 18–22 juli, 2005.

# Update from Spain, 2005

Prepared by Jesus Cabal

Studies on non native species in Spanish coast are very scarce. In this sense more of the studies are related to macro-organisms as benthos macroalgae, terrestrial plants, crabs and fishes. A few studies have focused in the ecological impact of the alien species. In the last years, the number the non native species has been increased, but at the moment there is not an institution or agency that coordinates the work on this topic.

## Ongoing projects

Project: Programme for the Prevention and Control of Non Native Species of the Port of Barcelona.

Host Institute: The Port Authority of Barcelona, Coordinator: A. Palau, Project duration: 1999– ??

Key Objetives:

- Identification and evaluation of pathways of introductions.
- The application of preventive measures.
- Implementation of campaign to detect any non-native species that have been introduced.

Planning of new research project: Plankton no native species of the Port of Gijón (Biscay Bay). OVAL.

Host Institute: Instituto Español de Oceanografía. Centro Oceanográfico de Gijón, Coordinator: Jesús Cabal, Project duration: 2006–2009

Key Objetives:

- Identification on zooplankton species in the coastal area at the Port of Gijón. The main goal is generate a baseline dataset on the zooplankton species in the study area
- Zooplankton species in the ballast water by cargo´s ship at the Gijón Port. Sampling the ballast water of the ship´s . Port of Gijon is located in the south of Bay of Biscay, a temperate sea, and more of the ship traffic is also with port located in temperate seas, so the risk of introduction of species with similar ecological characterised is high.

Project: Algal Introductions to European shores (ALIENS).

Host Institute (in Spain): University of Oviedo, Coordinator (in Spain): Rico, J.M.; Flagella, M., Mineur, F., Buia, C. and Soria, A., Project duration: 2004–2007

Key Objetives: ALIENS is a multidisciplinary project with several objectives:

- Explain the underlying ecological causes of the introduction, establishment and development of seaweed invasions on European shores.
- To generate a baseline dataset on the present status of seaweed introductions to European shores, and of future susceptibility to further introductions/invasions.
- To elucidate the genetic structure of various populations of selected invasive seaweeds in Atlantic and Mediterranean Europe, with a view to determining whether there have been multiple cryptic European introductions.
- To evaluate the economic impact of existing seaweed invasions on a European scale, comparing losses cost associated with prevention and eradication.

- To carry out the risk assessment and propose for invasive macro algae to be used in coastal zone management.

Project: Delivery Alien Invasive Species Inventories for Europe (DAISIE).

Host Institute (in Spain): CREAF, Coordinator (in Spain): M.Vila., Project duration: 2005–2008

Key Objetives:

- To create an inventory of invasive species in Europe.
- To structure the inventory to provide the basis for prevention and control of biological invasions.
- To assess and summarise the ecological economic and health risks and impact of the widespread and/or noxious invasive species in Europe.
- To use distribution data and the experience of the individual Member States as a framework for considering indicators for early warning.

## Management and control of invasive species

There are local programmes to control *Sargassum muticum* in the swimming areas of the beaches (i.e. Gijón municipality).

## Occurrence of Non Native Species

The study reported here was undertaken to collect records and review information about the introduction of marine fauna and flora to Spain. In order to obtain a list of non native marine species a questionnaire has been distributed to marine biologists including targeted marine specialists with knowledge of particular taxonomic groups. Besides, information was also drawn from an extensive literature search about alien species in the Spanish coast. At the moment, fifty three species of marine organisms have been identified as non-native. The majority of these 53 species are crustacean (13 species), molluscs (10) and macroalgae (20). Spanish coast is distributed along three biogeographical region: Mediterranean, Atlantic and Macaronesian bioregions, some of these species have been founded in one or two regions of the coast. Very often there was a delay between a species was introduced and its establishment was confirmed. Difficulties in identifying some species, or the fact that they were not recognized as alien, have led to inaccurate records.

Table 1. List of amrine fauna and flora in Spain. * = new record of species.

| Taxon | Year of first record | Location of first record | Possible introduction vector | Invasion Status | References |
|---|---|---|---|---|---|
| *PHYTOPLANKTON* | | | | | |
| *Alexandrium taylori* | | Cataluña coast | | | Garcés *et al.*, 1999 |
| *Alexandrium catenella* | 1987 | Cataluña Coast | Ballast water | Established | Margalef and Estrada 1987.<br>Gomis *et al.* 1996<br>Vila *et al.*, 2001 |
| *PROTOZOA* | | | | | |
| *Marteilia refringens* | 1975 | Galicia | Aquaculture | Spreading | Figueras and Montes,1988<br>Riera *et al.*, 1993.<br>Lama *et al.*, 1993 |
| *Bonamia ostrea* | 1982 | Galicia | Aquaculture | Spreading | Polanco, 1984.<br>Montes y Lama, 1993.<br>Durfort, 1995 |

| TAXON | YEAR OF FIRST RECORD | LOCATION OF FIRST RECORD | POSSIBLE INTRODUCTION VECTOR | INVASION STATUS | REFERENCES |
|---|---|---|---|---|---|
| *Perkinsus atlanticus* | 1983 | Galicia | Aquaculture | Spreading | Gonzalez *et al.*, 1987.<br>Riera *et al.*, 1995.<br>Santmartí *et al.* 1995.<br>Sagrista *et al.*, 1996 |
| *PHYTOBENTOS* | | | | | |
| *Caulerpa taxifolia* | | Mediterranean coastal area | Aquariums | | Meinesz *et al.*, 1998<br>Aranda *et al.*, 1999 |
| *Caulerpa racemosa* | 1998 | Mallorca | Aquariums | | Ballesteros *et al.*, 2000 |
| *Acrothamniun preissii* | | Mallorca | | | Ferrer *et al.*, 1994 |
| *Antithamnion amphigenium* | | Mallorca | | Spreading | Ribera and Soto 1992.<br>Ballesteros *et al.*, 1997<br>Aranda and Solano 1999 |
| *Lophocladia lallemandii* | | South Mediterranean | | Spreading | Soto y Conde 1988.<br>Conde *et al.*, 1996.<br>Patzner, 1999 |
| *Womersleyella setacea* | | Balearic Islands | | | Ballesteros 1993.<br>Ballesteros *et al.*, 1997.<br>Rindi and Cinelli, 1995. |
| *Laminaria japonica* | | Mediterranean Sea | | | |
| *Demarestia viridis* | 1984 | Málaga | | | |
| *Undaria pinnatifida* | 1990 | NW Spain and Biscay Bay | | Spreading | Caamaño *et al.* 1990. |
| *Sargassum muticum* | 1985 | Biscay Bay | Aquaculture | Spreading | Fernández *et al.* 1990 |
| *Asparagopsis armata-Falkembergia rufolanosa* | 1930 | Medierranean Sea | | | |
| *Asparagopsis armata-Falkembergia rufolanosa* | 2003 | Asturias (Biscay Bay) | | | |
| *Grateolupia filicina* | | Mediterranean Sea | | | |
| *Grateolupia filicina* | 2003 | Asturias (Biscay Bay) | | | |
| *Bryopsis plumosa* | | Mediterranean Sea | | | |
| *Polysiphonia elongata* | | Mediterranean Sea | | | |
| *Codium fragile* | | Mediterranean Sea | | | |
| *Codium fragile* | 2005 | Asturias (Biscay Bay) | | | J. Rico (com. pers.,2005). |
| *Colpomenia peregrina* | | Mediterranean Sea | | | |
| *Colpomenia peregrina* | | Asturias (Biscay Bay) | | | |
| *Bonnemaisonia* | | Asturias (Biscay | | | |

| Taxon | Year of first record | Location of first record | Possible introduction vector | Invasion Status | References |
|---|---|---|---|---|---|
| *hamifera* | | Bay) | | | |
| *Chrysymenia whrightii* | | Mediterranean Sea | | | |
| *Mastocarpus stellatus* | | Mediterranean Sea | | | |
| *Hypnea musciformis* | | Mediterranean Sea | | | |
| *PLANTS* | | | | | |
| *Spartina densiflora* | 1950? | Gulf of Cadiz | | | Nieva *et al.* (2001, 2003, 2005).<br>Castillo *et al.* (2005) |
| *Spartina versicolor* | 1997 | Asturias (Biscay Bay) | | | Bueno Sanchez, 1997.<br>Torre Fernández, 2003 |
| *ECHINODERMATA* | | | | | |
| *Diadema antillarum* | | Canarias Islands | | | |
| *Coccinasterias tenuispina* | 2000 | Asturias (Biscay Bay) | | Spreading | N. Anadón (com. pers.) |
| *MOLLUSCA* | | | | | |
| *Ruditapes philippinarum* | | | Aquaculture | | |
| *Crassotrea gigas* | | Atlanctic and mediterranean coast | Aquaculture | | Zenetos *et al.*, 2003 and references therein |
| *Gibbula albida* | 1981–1984 | Galicia | Aquaculture | | Rolán *et al.*, 1985 |
| *Gibbula adansoni* | | Galicia | Aquaculture | | Rolán, 1992 |
| *Cyclope neritea* | | Galicia<br>Asturias | | | Sauriau, 1991.<br>Rolán ,1992 |
| *Crepidula aculeata* | 1973 | Alicante harbour | | | Zibrowius, 1992 |
| *Crepidula fornicarta* | 1990–2000 | Galicia<br>Asturias | | | Blanchard, 1997<br>N. Anadón (com. pers., 2005) |
| *Fulvia fragilis* | | Mediterranean Sea | | unfrequent | Zenetos *et al.*, 2003 |
| *Chlamys lischkey* | 1985 | Alborán Sea | | | Zenetos *et al.*, 2003 |
| *Dreissena polimorpha (Zebra Mussels)* | 2001 | Ebro estuary | Unknown | | C. Altaba (ICES/IOC/IMO SGBOSV, 2002) |
| *CRUSTACEA* | | | | | |
| *Balanus improvisus* | 1900 | Galicia | | | Waldford, L. and R. Wicklund, 1973 |
| *Megabalanus tulipiformis* | | Bay of Biscay | | | Kish, 1958 |
| *Elminius modestus* | | Ria Eo, Villaviciosa and Ribadesella (Asturias) | | Rare | J. Arrontes (com. pers.) |
| *Rhitropanopeus harisii* | 2001 | Guadalquivir Estuary | | | |
| *Eriocheir sinensis* | 2001 | Guadalquivir estuary<br>Cataluña coast | Ballast water<br>Hull fouling | | Galil *et al.* 2002 |
| *Callinectes sapidus** | 2005 | Guadalquivir Estuary<br>Gijón (Port of Musel) | | | L. González and P. Millán (com. pers.) |

| TAXON | YEAR OF FIRST RECORD | LOCATION OF FIRST RECORD | POSSIBLE INTRODUCTION VECTOR | INVASION STATUS | REFERENCES |
|---|---|---|---|---|---|
| *Percnon gibbesi* | 1999 | Balearic Islands | | | Galil *et al.* 2002 and references therein. |
| *Processa macrodactyla* | 1980 | Alborán Sea | | | Galil *et al.* 2002 |
| *Scyllarus posteli* | 1982 | Málaga | | | Galil *et al.* 2002 |
| *Cryptosoma cristatum* | 1987 | Alboran Sea | | | Galil *et al.* 2002 |
| *Calappa pelii* | 1991 | Chafarinas Islands | | | Galil *et al.* 2002 |
| *Merhippolyte ancistrota* | 1980 | Alboran Sea | | | Galil *et al.* 2002 |
| *Hemigrapsus penicillatus* | 1994 | Laredo (Bay of Biscay) | | | Goulletquer *et al.* 2003. |
| *FISH* | | | | | |
| *Fundulus heteroclitus* | 1973–1976 | Gulf of Cadiz | | | Bernardi *et al.*, 1995.<br>Gutierrez-Estrada *et al.*, 1998. |

## References


Aranda, A. and Solano, L.. 1999. Algunas algas interesantes procedentes del litoral del SE Ibérico (Mediterráneo occidental). Actas XIII Simposio Botánica Criptogámica, Madrid:55.

Aranda, A., Mallol, J. and Solano, L.. 1999. Presencia del alga *Caulerpa racemosa* (Forsskäl) J. Agardh (Chlorophyta, Caulerpales) en el Mediterráneo Ibérico. Actas XIII Simposio Botánica Criptogámica, Madrid:53.

Ballesteros, E. 1993. Algues bentòniques i fanerògames marines. In: J.A. Alcover, E. Ballesteros and J.J. Fornos (eds). Historia Natural de l'Archipèlag de Cabrera. CSIC; Ed. Moll, Palma de Mallorca :503–530.

Ballesteros, E.,. Grau, A.M and Riera, F. 2000. *Caulerpa racemosa* (Forsskäl) J.Agardh (Caulerpales, Chlorophyta) a Mallorca. Bol. Soc. Hist. Nat. Balears, 42: 65–68.

Ballesteros, E., Pinedo, S. and Rodríguez-Prieto, C.. 1997. Contribució al coneixement algològic de la Mediterrània espanyola-X. Acta. Bot. Barc., 44: 29–37.

Bernardi, G., C. Fernández-Delgado, M. Gómez-Chavarri and Powers, D.A. 1995. Origin of a Spanish population of *Fundulus heteroclitus* inferred by cytochrome *b* sequence analysis. J. Fish Biol., 47: 737–740

Bueno Sanchéz, A. 1997. Flora y vegetación de los estuarios asturianos. Cuadernos de Medio Ambiente,3. Serv. Public. Principado de Asturias,Oviedo. 352 pp.

Caamaño, S., Duran, J., Neira, C. and Acuña Castroveijo, R. 1990. Aparición de *Undaria pinnatifida* en las costas de Galicia (España). Un nuevo caso en la problemática de introducción de especies foráneas. Informes Centro Investigaciones Submarinas, 3: 44 pp.

Castillo *et al.* 2005. Biological Invasions, 7: 29–35.

Conde, F., Flores-Moya, A., Soto, J., Altamiro, M. and Sánchez, A. 1996. Check-list of Andalusia (S. Spain) seaweeds. III. Rhodophycea. Acta Botanica Malacitana, 21: 7–33.

Durfort, M. 1995. Revision de las parasitosis más frecuentes en los moluscos bivalvos de interés comercial del mar Catalán (Mediterráneo). Actas V Congreso Nac. Acuicult.: 52–73.

Fernández, C., Gutiérrez, L.M. and Rico, J.M. 1990. Ecology of Sargassum muticum on the north coast of Spain. Preliminary observations. Botanica Marina, 33: 423–428.

Ferrer, E. Ribera, M.A. and Gómez Garreta, A. 1994. The spread of *Acrothamnion preissii* (Sonder) Wollaston (Rhodophyta, Ceramiaceae) in the Mediterranean Sea: new record from the Balearic islands. Flora Mediterranea, 4: 163–166.

Galil, B., Froglia, C. and Noël, P. 2002. CIESM Atlas of exotic species in the mediterranean. Vol. 2 Crustaceans: decapods and stomatops. (F. Briand, Ed.) 192 pp. CIESM Publishers, Monaco.

Garcés, E., Masó, M and Camp, J. 1999. A recurrent and localized dinoflagellate bloom in a Mediterranean beach. J. Plankton Res, 21: 2373–2391.

Gomis, C., Alcober, J. and Bernabeu, A. 1996. Seguimiento de las poblaciones fitoplanctónicas en las bateas mejilloneras del Puerto de Valencia 1991–1994. IV reunión Ibérica de fitoplancton tóxico y biotóxinas. ( Ed. E. Matamoros and M. Delgado), pp 29–38. Depart. Agricultura, Ramaderia I Pesca.

Gutiérrez-Estrada, J.C., Prenda, J. Oliva, F. and Fernández-Delgado, C. 1998. Distribution and habitat preferences of the introduced mummichog *Fundulus heteroclitus* (Linnaeus) in south-western Spain. Est. Coast. Shelf Sci., 46: 827–835.

Goulletquer, P. Bachelet, G. Sauriau, P.G. and Noel, P. 2003. Open Atlantic coast of Europe : A century of introduced species into French waters. In Invasive Aquatic species of Europe: Distribution, impacts and Management. E.Leppäkoski, S. Gollasch and S. Olenin (eds.). Kluwer Academic Publishers. 583 pp.

Kish, B.S. 1958. *Balanus tulipiformis* Ellis on the Atlantic coast of France and an unusual situation for *B. amphitrite* Darwin. Nature, 158: 206–207.

Margalef, R and Estrada, M. 1987. Synoptic distribution of summer microplankton (Algae and protozoa) across the principal front in the Western Mediterranea. Investigaciones Pesqueras, 51: 121–140.

Mosquera, E.R. 1984. Moluscos de la Ría de Vigo: I. Gasterópodos. Velagraf (ed.). Santiago de Compostela. 202 pp.

Meinesz, A., Cottalorda, J.M., Chiaverini D., Cassar, N. and De Vaugelas (eds) J. 1998. Suivi de l'invasion de l'algue tropicale *Caulerpa taxifolia* en Méditerrnée: situation au 31 décembre 1997. LEMI-UNSA publ.:1–238.

Nieva *et al.* 2001. Estuarine Coastal and shelf Science, 52: 515–527.

Nieva *et al.* 2003. Estuarine Coastal and shelf Science, 57: 909–910

Nieva *et al.* 2005. Wetlands, 25: 122–129

Patzner, R.A. 1999. The invasion of *Lophocladia* (Rhodomelaceae, Lophotaliae) at the northern coast of Ibiza (western Mediterranean Sea). Boll. Soc. Hist. Nat. Balears 41: 75–80.

Polanco, E., Montes, J.,Outon, M.J. and Meléndez, M.I. 1984. Haliotis, 14: 91–95

Ribera Siguan, M.A. and Soto Moreno, J. 1992. Presencia de *Antithamnion algeriense* (Rhodophyta, Ceramiales) en las costas españolas. Cryptogamie, Algol., 13: 25–30.

Rico, J.M. and Fernández, C. 1997. Ecology of *Sargassum muticum* on the north coast of Spain II. Physiological differences between *Sargassum muticum* and *Cystoseira nodicaulis*. Botanica Marina, 40: 405–410.

Riera, V., Santmartí, M. and Durfort, M. 1993. Presencia de *Marteilia refringens* en los cultivos de moluscos bivalvos del litoral catalán. Actas IV Congreso Nac. Acuicult.: 539–544.

Riera, V., Bigas, M., Santmartí, M. and Durfort, M. 1995. Prevalencia del protozoo parásito *Marteilia refringens* en las poblaciones de ostra plana (*Ostrea edulis* L.) del Maresme (NE Barcelona). Actas V Congreso Nac. Acuicult.: 242–247.

Rindi, F. and Cinelli, F. 1995. Contribution to the knowledge of the benthic algal flora of the isle of Alboran, with notes on some little-known species in the Mediterranean. Cryptogamie, Algol., 16: 103–114.

Rolán, E. 1992. Dos especies más de moluscos mediterráneos introducidas en la bahía de O Grove (Galícia, Spain). Thalassas, 10: 135.

Rolán, E., Trigo, J., Otero-Schmitt, J. and Rolán-Álvarez, E. 1985. Especies implantadas lejos de su área de distribución natural. Thalassas, 3: 29–36.

Sagristà, E., Durfort, M. and Azevedo, C.. 1996. Ultrastuctutral data on the life cycle of the parasite *Perkinsus atlanticus* (Apicomplexa) on the clam *Ruditapes philippinarum* in the Mediterranean. Sci. Mar, 60: 283–288.

Santmartí, M.M., Garcia Valero, J., Montes, J., Pech, A. and Durfort, M. 1995. Seguimiento del protozoo *Perkinsus* sp. en las poblaciones de *Tapes decussatus* y *Tapes semidecussatus* del delta del Ebro.

Sauriau P.-G. 1991. Spread of *Cyclope neritea* (Mollusca: Gastropoda) along the north-eastern Atlantic coasts in relation to oyster culture and to climatic fluctuations. Mar. Biol., 109: 299–399.

Soto, J. and Conde, F. 1988. Algunas consideraciones sobre la flora algal de Murcia (sureste de España). Bentos, 6: 15–21.

Torre Fernández, F. 2003. Las Plantas Invasoras de Asturias. Naturalia Cantabricae, 2: 33–43.

Vila, M., Garces, E., Maso, M. and Camp, J. 2001. Is the distribution of the toxic dinoflagellate Alexandrium catenella expanding along the NW Mediterranean coast ?. Marine Ecology Progress Series, 222: 73–83.

Walford, L. and Wicklund, R.. 1973. Contribution to a worldwide inventory of exoic marine and anadromous organisms. FAO Fisheries Technical Paper, 121: 1–49.

Zenetos, A., Gofas, S., Russo, G. and Templado, J. 2003. CIESM Atlas of exotic species in the mediterranean. 3 Mollucs. (F. Briand, Ed.) 376 pp. CIESM Publishers, Monaco.

Zibrowius, H. 1992. Ongoing modifications of the Mediterranean marine fauna and flora by the establishment of exotic species. Mésogée, 51: 83–107.

# National report, Sweden, 2005

Prepared by Inger Wallentinus and Fredrik Nordwall

## 1 Laws and regulations

The 16th Environmental Quality Objectives on Biodiversity were adopted by the Swedish parliament in November 2005, with a partial goal on introduced species. This environmental quality goal is being developed in response to how Sweden will implement the Convention on Biological Diversity's decisions on Guiding Principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species.

## 2 Deliberate releases

### 2.1 Finfish

In 2004 (no figures available for 2005) 2.0 million individuals of Baltic salmon (*Salmo salar*) smolt and 0.6 million individuals of smolt of sea-trout (*Salmo trutta*) were released in rivers and coastal areas (both probably mainly of Swedish origin). In 2005, 30,000 individuals of pike-perch (*Sander lucioperca;* young of the year) were released in the province of Stockholm (probably of Swedish origin; and since not all county councils have replied the figure might be higher). About 0.5 millions of glass eels (*Anguilla anguilla*) from England were released in coastal areas of the Baltic Sea and around 10 tonnes of small adult eels were transferred from the Swedish west coast into the Baltic Sea.

## 3 Accidental introductions and transfers

### 3.1 Finfish

There are still NO reports of the round goby *Neogobius melanostomus* from Swedish coastal waters, despite its common occurrence in Gdansk Bay, Poland, at some sites in northern Germany, Estonia, Lithuania and a record from the Turku archipelago, Finland, in February 2004.

There are ongoing studies, in co-operation with Polish scientists, of the behaviour, life history traits and ecology of the invasive *N. melanostomus*, in Gdansk Bay, in relation to habitat variations, structure as well as size and age at sexual maturity (Gustaf Almqvist, Stockholm univ., pers. comm.; for more see WGITMO 2005).

### 3.2 Invertebrates

One very large (>20 cm), live individual of *Crassostera gigas* was found in northern Bohuslän in 2004 and brought to the closeby Tjärnö Marine Biological Station for examination (H-G Hansson, Göteborg univ., pers. comm.). In the early 1970s a few specimens of Pacific oysters were introduced and cultivated in Sweden, just south of the town Strömstad in the province of Bohuslän, close to this area (J. Haamer, pers. comm.). It is assumed that this is a surviving specimen from the original batch, indicating that it may live longer than 30 years and according to R. Mann (Virginia Inst. Mar. Sci., USA, pers. comm.) this is quite likely. However, it did not survive long in the aquarium, where it was placed. No surveys of oysters have been performed in Sweden, but there is concern, if this oyster should establish on the Swedish west coast (see separate entry in this report).

During 2005 the following studies (Elena Gorokhova, Stockholm univ., pers. comm.) have been made on *Cercopagis pengoi*, an invasive predatory cladoceran, which has become a permanent member of the Baltic Sea pelagic ecosystem. Earlier studies (e.g. Gorokhova *et al.* 2005) have focused on the contribution of *Cercopagis* to fish diet and found that this species is an important prey for fish during summer. In the latest study (summer 2005) a different question was asked – how does fish predation affect *Cercopagis* growth and development?

Field and experimental studies were conducted to assess changes in body size, fecundity (including also embryos carried by parthenogenetic females and their subsequent growth), and individual growth rate of *Cercopagis* during the season. Indications of direct selective predation on *Cercopagis* were found. These changes were observed within two-three generations and they cannot be attributed to temperature fluctuations; however, it remains unclear to what extent availability of prey (i.e. herbivorous zooplankton) for *Cercopagis* contributes to the observed patterns of growth and fecundity. These results suggest that the fish predation may have a strong impact on *Cercopagis* abundance and population structure, and possibly cause cascading effects of *Cercopagis* predation on herbivorous zooplankton, thus mediating the effects of this newcomer on the ecosystem.

The polychaete *Marenzelleria*, still refered to as *M*. cf. *viridis*, is found in several of the monitoring programmes along the Swedish east and south coasts, and in the Öresund and Skälderviken. However, it has not been recorded in monitoring samples from the Swedish west coast (Stefan Agrenius, Göteborg univ., pers. comm.). It is not known if the findings from the Öresund area belong to the true *M. viridis*, which has been introduced to the European Atlantic coasts, or should be named *M. neglecta*, following a revision of this genus (Sikorski and Bick, 2004). In 2005, *Marenzelleria* was recorded only from one single site in the Helsingborg area in relatively low abundances (Hellfalk *et al.*, 2005), while it the previous year was found in four different areas. In the S Bothnian Sea, outside the nuclear power plant at Forsmark, the province of Uppland, *Marenzelleria* was first recorded in 1997, and in 2004 it comprised 55% of the total number of individuals at a station 16 m deep, and 77% at a station 41 m deep, where it also comprised 32 % of the biomasses (Abrahamsson *et al.*, 2005). It is not known to which species they do belong, following the revision quoted above. For details on previous development of abundances of *Marenzelleria* in the Gulf of Bothnia, see WGITMO 2004 and 2005.

Every year single specimens of the Chinese mitten crab, *Eriocheir sinensis*, are reported to have been caught by fishermen (e.g. in the Södertälje city, Lake Mälaren, in June 2005, and one specimen as far north as in the Gulf Norrfällsviken, the Bothnian Sea). There are NO reports of mass occurrences. However, it has been told that commercial fishermen in Lake Mälaren during the fishing season catch 20–30 mitten crabs each day in their nets.

## 3.3 Algae and Higher Plants

### *Macroalgae*

Details on the large Asiatic red alga *Gracilaria vermiculophylla,* first recorded during August-September 2003 in the Göteborg archipelago, have been given in the WGITMO-reports 2004 and 2005. In 2005 it was recorded much further south than previously, in Bua and Treslövsläge, in the middle of the province of Halland. Thus, from the first site of record, its distribution now has been extended around 72 km to the north and 80 km to the south.

Grazing experiments (Gustafsson, 2005) were performed in spring 2005, to see if any native grazer (six different species tested) would eat of *G. vermiculophylla* with *Ulva lactuca* used as a control alga (in closed systems, autoclaving *Gracilaria* and water after each experiment was finished). The results indicated that the invading alga, *G. vermiculophylla*, can be grazed by some of the frequently occurring herbivores on the Swedish west coast; in the tests they were: *Aplysia punctata*, *Idotea granulosa*, *Littorina littorea* and nereid polychaetes. Survival of thalli through the digestion system of the herbivores did not seem to be possible. Thus herbivores that do graze on *G. vermiculophylla* will not participate in the dispersal of the alga.

The first Swedish records of the red alga *Aglaothamnion halliae*, common in harbour areas on the south coast of Norway since at least 1980, was in 2003 (in harbour areas in Strömstad, Grebbestad and Rönnäng, the northern and middle parts of the province of Bohuslän;

WGITMO, 2004). In 2005, it was recorded in the marina at Bua, in the middle-northern part of the province of Halland, which is an extension of around 100 km to the south. It is quite likely that it is more frequent than reported, since the size and shape, similar to many closely related native species, makes it easily overlooked.

In late summer 2005, two attached plants of the Japanese brown alga *Sargassum muticum* were found in the northern part of the city of Helsingborg, northern Öresund (Hellfalk *et al.*, 2005), and drifting specimens were seen in several areas around Helsingborg. For a long number of years only drifting specimens have been seen along the coasts south of Treslövsläge, in the middle part of the province of Halland. The southern border for attached plants thus has moved around 120 km to the south.

The Japanese red alga *Heterosiphonia japonica* (i.e. "*Dasysiphonia* sp." in WGITMO reports until 2003) was during 2005 very common on both sides of the Kosterfjord, N Bohuslän. During late autumn (November–December) it is a dominant component, especially in sheltered areas (1–10 m depth) with strong currents among small islands. The southernmost known locality is still the very exposed offshore "shallow" area, Persgrunden, about 20–25 km south of Koster, where it has been found down to 19 m depth, although not as a dominant alga (Jan Karlsson, Göteborg univ., pers. comm.).

A study (Hill, 2006) was made during autumn 2005, to see if the generalized theories on mechanisms behind plant invasions (the Enemy Release Hypothes, the Evolution of Increased Competitive Ability Hypothesis, and the Intrinsic Resistance Hypotheses) were applicable to macroalgae, which generally are grazed on by generalist herbivores. The introduced macroalgae *Sargassum muticum*, *Codium fragile* and *Bonnemaisonia hamifera* were tested in feeding preference experiments with two generalist mesoherbivores, and compared to several native seaweeds. Overall, the results did not support a general release from enemies. However, *Bonnemaisonia hamifera* was significantly released in comparison to the native species, while the two other macroalgae were preferred food items.

In an experiment by Nylund and coworkers (2005), crude extracts from the introduced red alga *Bonnemaisonia hamifera* were tested for their ability to inhibit bacterial growth and attachment (11 strains of bacteria, representing 5 different taxonomic groups). The extracts inhibited growth of 9 bacteria at concentrations volumetrically equivalent to whole algal tissue, or lower. Extracts from four other, native red algae had weak growth-inhibiting effects on only a few bacterial strains. Surface extracts of *B. hamifera* tested on bacteria showed that metabolites are naturally present at sufficiently high concentrations in order to inhibit bacterial growth on the surface of the alga. *In situ* quantification of bacteria on *B. hamifera* also showed that this alga had significantly fewer bacteria on its surface compared to a coexisting alga. These findings suggested that *B. hamifera* naturally reduces its epibacterial abundance by production of broad-spectrum growth-inhibiting secondary metabolites. This is one of a few examples where ecologically relevant effects of algal metabolites on bacterial colonization have been shown.

### *Phytoplankton*

For several years we have reported of the raphidophyte *Chattonella* aff. *verruculosa* as a potentially introduced species in Scandinavian waters. Last year (WGITMO, 2005) we provided information on a new name and affinity, however, most reports still use the name *C.* aff. *verruculosa*. In April 2005, small populations were noted on the Swedish west coast, and again in November. In 2006, it was present in abundances up to ca 30 000 cells per litre, both on the Swedish west coast and in S Norway. In February 2006, numbers over 200 000 cells per litre were recorded on the Swedish west coast, while Danish samples had up to 1–4 million cells per litre (Skejvik 2005–2006). In March 2006, slightly lower numbers (145 000 cells per litre) were found on the Swedish west coast, while they were still 2.6 millions in Århus, Denmark, and it is assumed that it caused the death of 18 tonnes of farmed fish in the northern part of the Great Belt area (Kalundborg Fjord; Skjevik 2006). Thus, since the species can cause fish kills, there is concern of bloom events.

### 3.4 Parasites, pathogens and other disease agents

The parasite *Gyrodactylus salaris* was found at a fish farm, on the Swedish west coast and in a small river (Himleån).

IPN-V (infectious pancreatic necrosis) was recorded in a fish farm on the west coast.

Dead perch in the lake Norrviken (just north of the city of Stockholm) was found to have died from attacks of the freshwater fungus *Branchiomyces denigrans*, which previously has not been recorded from Sweden. The species, which also can infect pike and other fish, but not salmonoids or carp, is well-known from e.g. Germany and Poland, having caused death in many fish farms by penetrating the gills of fish. The fungus is believed to have come to Sweden with contaminated fish, but dormant spores, from earlier introductions, cannot be ruled out for causing the fish kill. High temperatures favour the growth of the fungus, and spores may be dormant for many years. Spores are relased from the gills into the water, from where they infect new fish; secondary diseases are common and may also cause fish death. (National Veterinary Institute of Sweden 2005)

## 4.0 Live imports during 2005 (for EU countries amounts may be underestimated)

### 4.1 Fish

**For consumption/processing** (Metric tonnes)

| | Eel from: | Carp from: | | Eel from: |
|---|---|---|---|---|
| Denmark | 21 | 1 | | |
| Norway | 52 | | Germany | 19 |
| The Netherlands | 40 | | U.K. | 1 |

**Ornamental fish (not specified for marine and freshwater spp.)** (Metric tonnes)

| | | | |
|---|---|---|---|
| The Czech Republic | 14 | Indonesia | 6 |
| Denmark | 5 | Singapore | 4 |
| Germany | 1 | Thailand | 2 |
| The Netherlands | 1 | Sri Lanka | 1 |
| Israel | 1 | Brasil | 1 |

**Live invertebrates for consumption/processing (Metric tonnes)**

| | *Mytilus* from: | Scallops from: | Oysters from: |
|---|---|---|---|
| Norway | 844 | 372 | |
| The Netherlands | 22 | 4 | 33 |
| Denmark | 26 | 9 | 3 |
| USA | | 11 | |
| U.K. | | 5 | |
| France | | 1 | 79 |
| Ireland | | | 7 |

| | Lobsters from: | "Crabs" from: |
|---|---|---|
| Canada | 166 | |
| USA | 22 | |
| Norway | 13 | 135 |
| Ireland | 4 | 259 |
| Denmark | 3 | 1 |

# 5.0 Live exports during 2005 (for EU countries amounts may be underestimated)

## 5.1 Fish

**For consumption/processing** (Metric tonnes)

| | Eel to: | | Eel to: | Rainbow trout and trout to: |
|---|---|---|---|---|
| Denmark | 222 | Italy | 16 | |
| The Netherlands | 145 | Finland | 8 | |
| Germany | 124 | Poland | 6 | |
| Belgium | 42 | Norway | | 4 |

**Ornamental fish (not specified for marine & freshwater spp.)** (Metric tonnes)

| | | | |
|---|---|---|---|
| Norway | 71 | Finland | 1 |
| Denmark | 2 | Russia | 1 |

## 5.2 Live invertebrates for consumption/processing (Metric tonnes)

| | *Mytilus* to: | Scallops to: | | *Mytilus* to: | Scallops to: |
|---|---|---|---|---|---|
| France | 600 | 6 | Ireland | 17 | |
| Germany | 105 | 35 | Poland | 17 | |
| The Netherlands | 21 | 80 | UK | | 1 |
| Belgium | 12 | 40 | Spain | 1 | 72 |
| Denmark | 20 | 59 | Italy | | 70 |
| Finland | 40 | | Luxemburg | | 1 |
| Norway | 19 | 1 | | | |

# 6 Others on introductions and transfers of marine organisms

A topical session " Non-indigenous Aquatic Species – An Integrated Approach" has been arranged for the ALSO Summer Meeting, June 4–9, 2006, Victoria; British Columbia, Canada.

In September 2005, a new web site was set up (http://www.frammandearter.se) — "Främmande arter i svenska hav" (Alien species in Swedish seas). It compiles current knowledge on alien species in Swedish sea and archipelago areas, including the Skagerrak/ Kattegatt and the whole of the Baltic Sea. It addresses all those who want to know more about aquatic invaders in the marine environment. This includes people who deal with alien species on a professional basis, those who encounter aquatic invaders in their private lives, and those who can influence the spread of alien species to sea areas. The site is a joint information channel for the three regional Information Offices along the Swedish coast (the Skagerrak/ Kattegatt area on the Swedish west coast, the Baltic Sea proper, and the Gulf of Bothnia). The work of the Information Offices is commissioned by the Swedish Environmental Protection Agency. The web site has been produced in close cooperation with the Swedish research programme AquAliens. The material published on the site, including the contents of the fact sheets, has been reviewed by marine scientists and by experts at the Information Offices. The site is divided into eleven sections, with a choice of links to on-line sources of information (Swedish and international sites or documents) available on most pages. At present, most material on the site is available in Swedish only, but an English version of the site, hopefully, will be set up and running in 2006.

There is interest also among students outside the area of natural science to study, within their graduation thesis, the risk alien species may pose. Schantz (2005) summarized the legal situation in Sweden and concluded that there is a need of a more explicit and standardized legislation for both intentional and unintentional introductions. It is especially hard to create a system that covers liability, if someone is not complying with the law, and how compensation claims should be dealt with, since it is almost impossible to prove that someone has released a specific organism, unless it is a planned one needing a permit.

In summer 2005 a pilot study was made, comparing introduced hard bottom species in eight marinas and at eight, closeby, natural habitats on the Swedish west coast (Alsterberg and Wallentinus in prep.). The aim was to elucidate the question if marinas have more introduced species than other coastal areas, due to secondary dispersal, and if some species are more common on either type of locality. Monitoring was restricted to document 15 selected, already introduced or potential candidates of hard bottom organisms on natural and artificial substrates. No new introduced species was found – all eight species recorded (7 macroalgae and 1 barnacle) are already known from the Swedish west coast. The barnacle *Balanus improvisus* was the most common, introduced species in both marinas and at coastal localities, followed by the brown alga *Sargassum muticum*. Totally, both these species were more frequent in marinas than at the coastal localities. For three marinas and one coastal locality, all monitoring sites had at least one introduced species. On the other hand, one marina and three coastal localities had no introduced hard bottom species at all.

In 2005–2006, the plankton group at Stockholm university participates in a development of the water treatment system conducted by the Swedish industrial companies Alfa Laval and Benrad Marine. To assess efficiency of the equipment for water treatment, methods were developed for evaluating viability in phyto- and zooplankton organisms and apply them in the laboratory and field tests (Elena Gorokhova, Stockholm univ., pers. comm.).

# 7 Bibliography


Abrahamssson, I., Karås, P., Mo, K. 2005. Biologisk recipientkontroll vid Forsmarks kärnkraftverk. Fiskeriverkets Kustlaboratorium, Öregrund, 13 pp (In Swedish)

Ahlgren, H. 2005. On the Gracilariaceae found in Sweden. M.Sc. Thesis, Dept Marine ecology, Göteborg univ., Contrib., 266: 1–9.

Gorokhova, E., Hansson, S., Höglander, H. and Andersen, C.M. 2005. Stable isotopes show food web changes after invasion by the predatory cladoceran *Cercopagis pengo*i in a Baltic Sea bay. Oecologia, 143(2): 251–259

Gustafsson, T. 2005. Can native herbivores, of the Swedish west coast, graze the introduced red alga *Gracilaria vermiculophylla*? M.Sc. Thesis, Dept Marine ecology, Göteborg univ., Contrib., 288: 1–34

Hellfalk, M., Johansson, L., Melin, M., Lundgren, V. 2005. Inventering av grunda bottnar i Helsingborgs kommun sommaren 2005. Miljönämnden i Helsingborg, Helsingborg, 69 pp (In Swedish)

Hill, K.E. 2006. Success in establishment of invasive algal species: an evaluation of the importance of grazing. M.Sc. Thesis, Dept Marine ecology, Göteborg univ., Contrib., 300: 1–21.

Minchin, D., Gollasch, S. and Wallentinus, I. (eds). 2005. Vector pathways and the spread of exotic species in the sea. ICES Cooperative Research Report, 271: 1–29

National Veterinary Institute of Sweden. 2005. http://www.sva.se/dok/1068.html?searchstring=Branchiomyces&visaarkiv=1 (In Swedish)

Nyberg, C.D. and Wallentinus, I. 2005. Can species traits be used to predict marine macroalgal introductions? Biological Invasions, 7: 265–279

Nylund GM, Cervin G, Hermansson M, Pavia H (2005) Chemical inhibition of bacterial colonization by the red alga *Bonnemaisonia hamifera*. Marine Ecology Progress Series 302: 27–36

Schantz, R. 2005. Främmande arter i marin miljö – Mål och möjligheter (Alien species in marine environments – Goals and oppotunities). School of Business Economics and Law, Göteborg univ. 54 pp (In Swedish)

Sikorski, A.V. and Bick, A. 2004. Revision of *Marenzelleria* Mesnil, 1896 (Spionidae, Polychaeta). Sarsia, 89: 253–275

Skjevik, A.-T. 2005-6. Algsituationen: In Månadsbladet 2005:4, 2005:11, 2006:1, 2006:2, 2006:3. SMHI för Bohuskustens Vattenvårdsförbund (In Swedish).

# Introduction, transfer and farming of live oysters

Prepared by Fredrik Nordwall

Around the world, there is a large demand for oysters for human consumption. This demand is to a large extent supplied by farmed oysters. Actually, one of the largest production reported for an individual species in worldwide aquaculture is the Pacific oyster (*Crassostrea gigas*) – 4.2 million tonnes out of a world production of 40 million tonnes.

In Europe, many attempts have been made to restore exploited stocks of European oysters (*Ostrea edulis*) with Pacific oysters. The majority of introductions of the Pacific oyster have been undertaken as a replacement or alternative for collapsed fisheries and farming of native species, especially the European oyster In the Netherlands and Germany, Pacific oysters were introduced for aquaculture purposes in the 1960s and 1970s. In Denmark, Pacific oysters from German aquaculture experiments were planted in the Little Belt of the Baltic Sea in 1979. In 1975 and 1976, natural *spatfalls* occurred during warm summers resulting in potential overseeding of larvae outside aquaculture facilities in the Netherlands. The Dutch Pacific oyster has developed explosively afterwards and since 1980 a rapid spreading in Dutch estuaries has been observed. In 1986 commercial aquaculture activities was established in the northern areas of the German Wadden Sea. Some years after farming of oysters in the German Wadden Sea, natural spatfalls occurred and in 1991 the first wild Pacific oyster were found outside the cultured areas. Since then a substantial dispersal have taken place in the area. In Denmark, also Pacific oysters from England, the Netherlands and France were imported in the 1980s but the species was never established in areas of imports. However, in the Danish Wadden Sea wild individuals were first observed in 1999. Recent reports indicate extensive dispersal of the species in Danish waters. Assessments indicate that the Pacific oyster not yet has reached its potential distribution in Europe but the coastal waters of Northern Europe are probably too cold.

Imports and introductions of live Pacific oysters may therefore cause a threat to remaining populations of European oysters. The Pacific oyster is known to aggregate in dense stocks where established, resulting in a limitation of available space and food constraints for other bentic species. The coexistence of two oyster species, one native and one alien, in European water raises the possibility of hybridization and introgression between the two species. Moreover, it has been suggested that the parasite *Bonamia ostreae* was introduced to Europe (i.e. France) with infected oysters from the east coast of North America. This indicates potential spreading of diseases through transfer of living oysters. Pacific oysters may be infected by parasites and diseases without being affected and may therefore be regarded as a potential vector for transmission. For instance, all imports of Pacific oysters from France to the Netherlands were banned in 1981 because of the risks for spreading *Bonamia*. In all areas where the two blood parasites *Bonamia ostreae* and *Marteilia refringens* have been introduced it has been practically impossible to farm European oysters and natural banks of European oysters have been wiped out.

The natural distribution of the European oyster covers the eastern Atlantic coast from Norway to Morocco, into the Mediterranean Sea and Black Sea. Genetical assessments of oyster stocks using microsatellites indicate a low structural heterogeneity among stocks studied. However, oysters may tentatively be grouped into three different stocks – one Atlantic stock and two Mediterranean stocks. It has also been suggested that Norwegian stocks of oysters may be genetically different from other Atlantic stocks. A low but observable genetic structure among European oysters may call for precautionary actions such as limited transfer and importation of live oysters between areas in order to preserve genetic structure within the species. Moreover, further studies on genetic structure of oysters are required.

In the early 1970s a few specimens of Pacific oysters were introduced and cultivated in Sweden, just south of the town Strömstad in the county of Bohuslän (J. Haamer, pers.comm.). In the summer of 2005 one live individual from this area was brought for examination to the Tjärnö Marine Biological Station (H-G Hansson, pers. comm.). It is not known if this could have been a surviving specimen from the original batch indicating that it may live longer than 30 years. It did not survive long, however, in the aquarium where it was placed. No survey of oysters have been performed in Sweden.

In Sweden there is a growing interest for farming of European oysters. The species is on its margin of distribution in Swedish waters mainly owing to low summer temperatures. Therefore, the Swedish stocks show limited recruitment which also to a large extent varies annually. This is one of the main reasons for the lack of hatcheries within Swedish boarders. To cover the demand for juveniles, imports from hatcheries in Norway and Denmark have been done during 2002 and 2003. These actions open for potentially genetic contamination and also risks for spreading of notifiable diseases among Swedish stocks.

To reduce the risk of spreading diseases and unwanted species and strains stricter regulations of live imports of seafood and aquaculture animals are necessary. However, there is a potential conflict with regulations on free trading of goods.

# National report, United Kingdom, 2005

Prepared by Ian Laing, Gordon Copp and Tracy Edwards

## 1 Laws and regulations

The list of countries from which imports of live molluscs can be imported for relaying has been further restricted to parts of the USA only (Commission Decision 2005/409/EC).

## 2 Deliberate introductions and transfers

### 2.1 Fish

A recent review of past introductions of non-native fish in 17 countries of Europe and North America (Copp *et al.*, 2005b) found that the USA (93) and France (35) are at the top of the list of intentional fish introductions, followed by the Czech Republic, Russia, Romania, Austria and Spain (27 to 21), with the other countries (including England & Wales) having <20 intentional introductions but only Germany had <10 such introductions.

In relation to genetically modified fish, the Environment Agency initiated field studies on the movements and interactions of diploid and triploid brown trout with wild brown trout as part of R&D work to inform its Trout & Grayling Strategy (D. Longley, pers. comm.). Equal numbers of wild, diploid and triploid brown trout have been tagged to assess their migratory behaviour and interactions.

The deliberate release of unwanted pet fish and associated plants by the general public is a problem identified long ago but only recently subjected to scientific study. Wheeler's (1998) suggestion on ponds close to roads and to fairgrounds has been tested and corroborated in a recent study of ponds in the greater London area (Copp *et al.*, 2005c). This same study revealed an increase in the proportion of non-native species in pond fish assemblages during the 1990s.

A dead specimen of porcupinefish *Diodon hystrix* Linnaeus, 1758 (50 cm standard length) was found on Winterton Beach (Norfolk) in September 2005. Porcupinefish occur in tropical and subtropical waters of the Atlantic, and have been reported from European seas. However, following media coverage, Cefas were informed that the specimen was a release from a tropical collection. Porcupinefish are popular in the marine aquarium trade, and whereas most species grow to maximum sizes of about 30–50 cm length, *D. hystrix* can grow to more than 90 cm (Tortonese, 1984). As such, porcupinefish are capable of outgrowing home aquaria, and this increases the risk that the species may be released to the wild.

### 2.2 Invertebrates

Deliberate releases of Pacific oysters for cultivation continue at a similar level to that in previous years. Annual production of market-sized oysters is just over 1000 tonnes. The valuable Manila clam fishery in Poole Harbour produced around 400 tonnes. Jensen *et al.* (2005) have published a review of this species at this location. There were reports of a few Manila clams found in Langstone Harbour and larger numbers along the North Kent coast, where there is a hatchery rearing this species. It is not known if either population is self-sustaining. The Langstone record can probably be related to residual animals from previous farming activity. There are also reports of the species being present in Southampton Water, possibly from spawning of the Poole Harbour population.

# 3 Accidental introductions and transfers

## 3.1 Fish

Topmouth gudgeon *Pseudorasbora parva*, which originally entered the UK in the mid-1980s as a contaminant of an ornamental fish consignment from Continental Europe, continues to spread via accidental transfers (Pinder *et al.*, 2005), increasing the concern over the potential impact of this highly invasive species, which was discovered in 2005 to be the healthy host of a rosette-like agent (Gozlan *et al.*, 2005). However, an attempt to eradicate topmouth gudgeon from a small lake in Cumbria, using rotenone, appears to have succeeded (M. Brazier, personal communication). Also, data on the species' presence in a pond of Epping Forest (Greater London) suggests that removal of the species (i.e. Copp *et al.*, 2005c), when initially found in small numbers (i.e. Wheeler, 1998), may result in the species extirpation (G.H. Copp, unpublished data).

## 3.2 Invertebrates

***Marine***

A student at the Marine Biological association, Plymouth, with the assistance of the Cefas and FRS Fish Health Inspectorates, has been reviewing the current status of *Styela clava* (leathery sea squirt) in the UK. The study is on-going until later in 2006 but so far there has been no apparent extension to the range of this introduced species and the perception of fish and shellfish farmers is that it is not a major problem for them.

Dr. David Horne of Queen Mary College, University of London has confirmed identification of *Sarsiella* (*Eusarsiella*?) *zostericola*, an alien ostracod species predating on copepods. The UK Environment Agency found seven individuals in a JNCC Day grab sample at Mucking Flats on the Thames tideway. Four remaining samples are still to be processed. Anecdotally, the species was recorded previously at Kingsnorth Power station in 1984 (Bamber, 1987). It was first recorded in the UK in 1975 (Kornicker, 1975). It is quite a distinctive looking species, and is large enough to be retained on the 0.5 and 1 mm meshes commonly used. The UK EA are keen to determine its geographic distribution and monitor whether its range may be increasing in UK waters.

SAMS (Scottish Association of Marine Science) have reported *Caprella mutica* identifications with date of reporting, site description (if known) and the possible mechanism of introduction. These reports are as follows: England (Southampton Harbour, 2003) less than 10 km from the port, by shipping (L. Baldock and M. Marley, pers. comm.). England (Harwich Harbour, 2004) within 10 km of port, by shipping, (Ashelby, in press). Scotland (Shetland Is, 2003) on mussel lines, probably by aquaculture or hull fouling, noted within 30 km of port (G. Duncan, pers. comm.). Wales (Anglesey, 2003) on mooring lines, probably by hull fouling/recreational boats, within 20 km of port (T. Stoker, pers. comm.). Although this represents some pre-2005 data, this is the first time we understand the reports to have been noted. Richard Shucksmith (CASE NERC PhD at SAMS in association with Scottish Natural Heritage has shown *Caprella mutica* to displace the native caprellids, *Caprella linearis* and *Pseudoprotella* spp. from artificial structures at relatively low densities in aquarium trials. These trials will be repeated in the field in 2006 using a variety of potential native competitors.

Chinese mitten crabs have anecdotally been reported on the intake screens of Shoreham Power Station, situated on the River Adur, Sussex (Southern England).

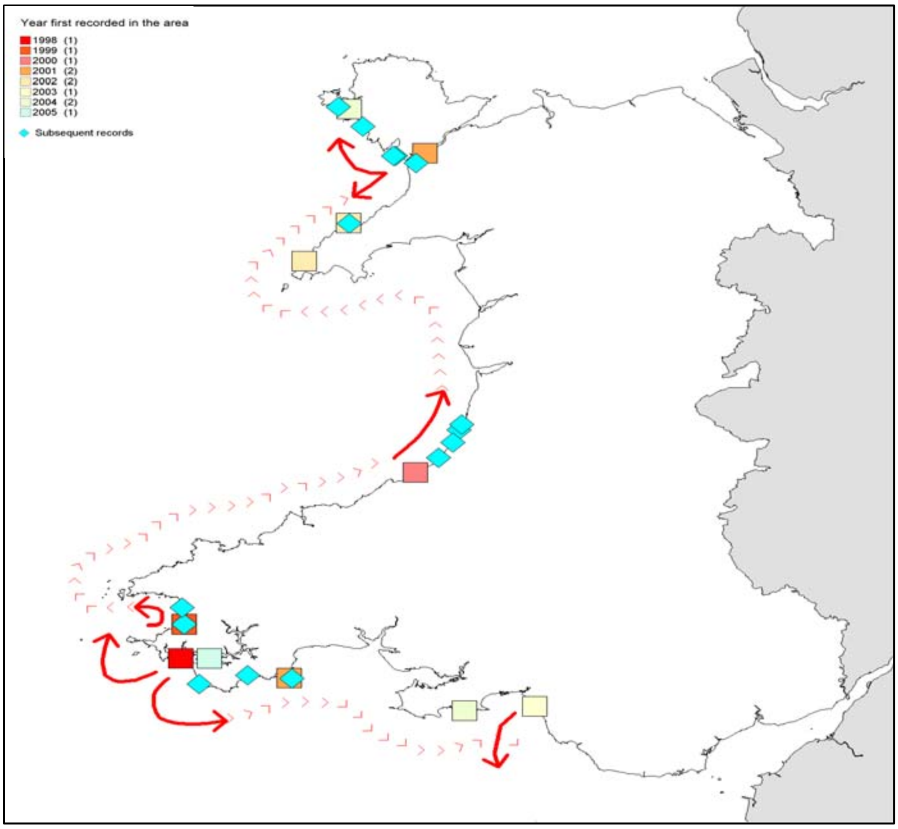
***Freshwater:***

A paper has been published (Elliot *et al.*, 2005) documenting current problems associated with zebra mussels in English waterworks. Questionnaires and manual surveys conducted between 2001 and 2003 have revealed that over 30 water treatment works in England suffer problems associated with zebra mussels. Hundreds of tonnes of mussels are being removed each year from raw water intakes, pipelines and reservoirs. Problems have increased in the last five years, due to a spread in the range of zebra mussels around England and the cessation of chemical treatment at the intakes of many treatment facilities during the 1990s.

The range of Signal crayfish (*Pacifastacus leniusculus*) continues to expand. There was one outbreak of crayfish plague in native crayfish in 2005. This was in the River Dove, Derbyshire.

## 3.3 Algae and Higher Plants

*Sargassum muticum* has continued to spread in Wales (see figure).




Sediment cores were collected under and outside canopies of *S. muticum* in Strangford Lough (*S. muticum* first recorded in 1995) and Langstone Harbour, English Channel (*S. muticum* first found in 1974) to investigate modification of the infaunal assemblages. At both study sites, community analyses highlighted significant differences between the assemblages under the canopies and those in adjacent unvegetated areas. In Strangford Lough, the invertebrate community under the canopy contained a higher abundance of smaller, opportunistic, *r*-selected species than outside the canopy. By contrast, the communities under and outside the canopy at Langstone Harbour were similar in species composition, diversity and dominance, but overall faunal abundance was greater under the canopy. Sediment characteristics were not affected by *S. muticum* canopies, but the infaunal changes may be related to environmental modification; shading, flow suppression and temperature stratification were also investigated. The differences between these two sites indicate that localized conditions and/or the duration of colonization of *S. muticum* are important in determining the nature of habitat modification (Strong, *et al.*, 2006).

*Caulacanthus okamurae*, has crossed the Channel to Devon and Cornwall where it was found at Plymouth in 2004 and at Looe in 2005 (Mineur *et al.*, 2006).

*Heterosiphonia japonica* is now widespread along the south coast from Devon to the Isle of Wight.

Molecular investigations have revealed a likely Australian provenance for Mediterranean invasions of both *Caulerpa taxifolia* and *Caulerpa prolifera* var. *cylindracea*. Multiple cryptic invasions of *Codium fragile* subsp. *tomentosoides*, originally from Japan, include stepping stone introductions. As yet, however, very little research has been directed towards examining the genetic consequences of seaweed invasions. An overview (Booth *et al.*, 2006) of seaweed invasions from a genetic perspective, focusing on invader species for which the greatest amount of information is available will be published shortly.

# 4 Live imports and transfers

## 4.1 Fish

Imports of rainbow trout eggs into the UK were 53.7 million in 2004 (20.8 million into England and Wales, 32.9 million into Scotland). This represents an increase of 16.5% on the total number of eggs imported in 2003 (46.1 million). In England and Wales, these eggs came mainly from the USA, as well as from disease-free sources within ICES boundaries including Denmark, Northern Ireland, and the Isle of Man. No eggs were imported into Scotland from the USA in 2004. The other countries listed above supplied some eggs but the majority came from other EU member states. Over 178 tonnes of live eels were imported from Holland (168 tonnes), France (10.1 tonnes) and Spain (0.6 tonnes).

Imports of Atlantic salmon eggs into Scotland were 17 million. This represents a 20% decrease from the previous year (21.2 million in 2003). These eggs came mainly from Norway, Iceland and other EU member states, with small quantities from Australia and the USA. Scotland also received 820 000 salmon parr and smolts from other EU member states. This is a considerable reduction from the 2.6 million imported in 2003.

As part of a study of propagule pressure and fish introduction pathways, the annual mean number of freshwater fishes imported to England (2000–2004 values) has been estimated at 374.8 million fish (including eggs) per year, with the incidence of (controlled) non-native species being correlated with the intensity of non-native fish imports (G.H. Copp and R.E. Gozlan, unpublished data).

Within England, various species are introduced to open (fisheries) waters (including fish farms). The main ones are: rainbow trout *Oncorhynchus mykiss* (31.9 % of the total), sterlet & sturgeons *Acipenser spp.* (8.2 %), common carp & varieties *Cyprinus carpio* (6.4 %), ide (orfe) & varieties *Leuciscus idus* (4.2 %), bighead carp *Aristichthys nobilis* & silver carp *Hypophthalmichthys molitrix* (0.6 %), and European catfish *Silurus glanis* (0.4 %).

## 4.2 Invertebrates

The hatchery on Guernsey sent 2.5 million pacific oyster seed to shellfish farm sites in England.

Imports of non-native species of live bivalve molluscs and crustaceans for human consumption continues. There are strict controls to prevent them being deposited into the wild, through both disease control and wildlife legislation. About two thousand tonnes of live molluscs were imported in 2003, with two thirds of this total from other EU Member States. In addition, about 900 tonnes of live Canadian/American lobsters were bought in to the UK.

There was one report of a large American lobster, caught by a fisherman in the English Channel near Bournemouth, Dorset. The fisherman told us that this was the first he had caught for over 30 years.

# 5 Live exports to ICES member countries

## 5.1 Fish

In 2004, a total of 5.9 million Atlantic salmon ova were exported from Scotland. This halts a declining trend since the year 2000, with trade at a level that is now just 17% of the exports in that year. Trade to Chile resumed in 2004, following a year in which there had been no exports. All the other ova exported went to other EU member states.

## 5.2 Invertebrates

Specific information on seed shellfish for relaying is only available where exports are to EU Approved Zones. Pacific oyster seed produced in UK hatcheries were exported to Eire, Jersey and Guernsey (64 consignments) and seed *Mytilus edulis* were sent to Guernsey and Jersey (32 consignments). The UK is a net exporter of live shellfish for human consumption and almost all of the trade (28 000 tonnes of bivalve molluscs and 1400 tonnes of lobsters) goes elsewhere in Europe.

# 6 Meetings etc.

## 6.1. Research initiatives

### *6.1.1*

An informal group of European invertebrate zoologists form a loose affiliation known as the European Invertebrate Survey. One of the members, Pierre Noel of the Natural History Museum in Paris (pnoel@mnhn.fr), studies crustaceans and is about to start work on an Atlas of invasive (= introduced) aquatic invertebrates, including marine species.

### *6.1.2*

In 2004, JNCC undertook an inventory of non-native species in UK Overseas Territories. Given the scope of the review, very few marine/aquatic non-natives were noted and it is suspected that this is an under-representation of baseline information. The information is available from JNCC publications

### *6.1.3*

The Marine Aliens Project is an independent project reporting primarily on 7 species of marine invaders. It is run by SAMS and Marlin (http://www.marlin.ac.uk/marine_aliens/marine_aliens.htm) in conjunction with JNCC. Updated leaflets on the project have been produced recently.

### *6.1.4*

Supported by the NATO Science Programme, a Collaborative Linkage on *Life-history traits as predictors in assessing risks of non-native fishes*, coordinated by Cefas Lowestoft was completed in June 2005. Bringing together researchers from Canada, Portugal, Slovakia, Slovenia, Spain and the UK, this network initiated a number of collaborative studies (see papers in Copp, Kováč, Ojaveer and Rosenthal 2005) that are still on-going and have become incorporated (in part) in subsequent research initatives, such as the '*Invasions*' pillar of the EC Integrated Project '*ALARM*', which is led by Phil Hulme (CEH-Banchory).

## 6.2 Policy initiatives

### *6.2.1*

An English Nature contract to carry out an audit of non-native species in England (including freshwater, coastal and marine species) was completed by a consortium led by CEH that includes CEFAS, CSL and NBN. The database includes reference to ICES marine zones for marine and coastal species (Hill *et al.*, 2005). This can be downloaded from http://www.english-nature.org.uk/pubslink.htm.

### *6.2.2*

The Biodiversity Research Action Group (BRAG) has a sub-group for non-native species. (BRAG NNS Subgroup). They feed to BRAG in the UK, which in turn feeds to the European Platform. It has developed:

*Non-Native Objectives:*

- Raise profile of problems caused by non-native species, especially invasive forms, for biodiversity
- Identify the strategic research needs and opportunities in support of the UKBAP
- Facilitate networking in both the national and international research community, including research activities, research needs and dissemination of results
- Formulate an outline strategy for research, including prioritisation of key issues and a delivery plan
- Encourage effective knowledge transfer among scientists, stakeholders and the general public

*POSITION STATEMENT Non-native species research priorities*

The Non-Native Species Sub-Group of UK BRAG has identified the following broad themes as priorities for research coordination and action. These will form the basis of further, more detailed consideration by the Sub-Group, for the development of a Research Strategy;

- An audit of status and trends, comparable across the UK, of terrestrial, freshwater, and marine non-native species
- Identification, quantification and characterisation of key pathways and vectors for the introduction of non-native species
- Autecological and demographic studies of key non-native taxa to develop and validate models of population dynamics, impacts and management
- Assessment of environmental, economic and social risks and impacts
- Appraisal of the true economic costs of non-native species, e.g. on provision of ecosystem services, trade and tourism
- Social perceptions, awareness and resolution of non-native species conflicts
- Efficient monitoring of the spatio-temporal trends in introduction, establishment, spread and impact of non-native species
- Novel approaches to management including improved control strategies and ecosystem consequences of non-native removal
- Prediction of the vulnerability of habitats, species and ecosystems
- Interactions between species invasion and environmental change

The detailed Research Strategy has been released and is available at http://www.ukbap.org.uk/BAPGroupPage.aspx?id=11. This deals with each of the themes raised above in the position statement in more detail.

#### *6.2.3*

The All-Irish Review has now been released and encompasses Ireland and Northern Ireland (hence the UK interest in this project). The document is very comprehensive. Further details are available at http://www.quercus.ac.uk/pages/invasive.htm. See also Stokes *et al.* (2006).

#### *6.2.4*

Defra (UK Department of Environment, Food and Rural Affairs) is hoping to conduct an audit of what non-natives work is already done in the UK regarding (all) non-natives. This should highlight research on impacts, databases and rapid assessments etc. A non-native species risk identification and assessment was published by Defra early in 2005, consisting of modules to assess species, pathways, receptors and economic impacts. (see: www.defra.gov.uk/wildlife-countryside/resprog/findings/non-native-risks/index.htm). This scheme includes taxonomic-based protocols for identifying potentially invasive species, currently for terrestrial and aquatic plants, amphibians, freshwater fishes as well as marine fishes and invertebrates. Defra are expecting further validation studies in 2006.

The Defra Programme Board has been set up at Director level attendance for UK government Departments/advisors, with a national strategy working group for how non-native species in general will be dealt with in the UK. There will be a national strategy group as well as a stakeholder group and various technical working groups (TWGs). However, the TWGs are not split by ecosystem, but by invasion 'process', hence marine issues will not be dealt with as a separate issue but will be considered alongside terrestrial and aquatic systems under specific themes (e.g. control and management, surveillance & monitoring). It is anticipated that the secretariat will not be fully functional until some time in the 2006/7 financial year. Task developments are expected to follow once the secretariat has been established

#### *6.2.5*

JNCC publication "Non-native marine species in British waters: a review and directory" details the introduction of marine fauna and flora to Great Britain (Eno *et al.*, 1995) and is still the most recent for the UK as a whole. However, in line with these recent initiatives, it is anticipated that an update to the JNCC publication for all UK species will be possible. JNCC are investigating pulling together all UK/GB work on audit of at least marine non-native species to update this work.

## 6.3 Meetings

#### *6.3.1*

In the UK, The Water Framework Alien Species Group meets on an ad hoc basis to support the work of the TAG (Technical Advisory Group). At the moment, it is being asked to consider the type of guidance required to take on board the alien species issue when using classification tools. Although alien species do not come under the 'normative definitions', the ASG feel that there is the potential for the presence of a high impact non-native to compromise meeting good ecological status under the Water Framework Directive (WFD). The group has also already presented guidance in terms of a risk assessment for whether water bodies are at risk of not meeting good ecological status (available from the TAG website).

A workshop is being held on 8–9$^{th}$ March in Brussels to gather other EU country approaches of WFD and how alien species may impact the work progressing for implementation.

#### *6.3.2*

The next Defra Non-natives meeting is scheduled for April/May at the London Wetlands Centre.

*6.3.3*

A number of conferences and symposia held in 2005 focused on, or had special sessions addressing, non-native species:

- The International Workshop on '*Biological Invasions in Inland Waters*'. 5–6 May 2005, Florence, Italy.
- The 6th Conference on Fish Telemetry held in Europe, 5–11 June 2005. Sesimbra, Portugal.
- Symposium for European Freshwater Sciences (SEFS-4), 22–26 August 2005. Krakow, Poland.
- Session on '*Freshwater diversity: ecosystem function, invasive species and conservation*', Annual meeting of the British Ecological Society, Hatfield 5–7 September 2005.

Amongst the most notable of forthcoming symposia are:

- The 14th International Conference Aquatic Invasive Species, which will be held in Key Biscayne, Florida, on 14 to 19 May 2006.
- The Annual Conference of the Fisheries Society of the British Isles '*Integrated Biology of the Establishment Success and Dispersal of Non-Native Fishes*', which will be held 23-27 July 2007 in Exeter.

# 7 Bibliography

A dedicated issue of the *Journal of Applied Ichthyology* was published in August 2005, with the editing lead taken by Cefas (Copp *et al*., 2005a). This special volume contains accepted papers from the Alien Fishes sessions (convened by G.H. Copp and H. Ojaveer) from the European Ichthyological Congress held in Tallinn, Estonia, in September 2004.

There will be a Hydrobiologia Special Issue entitled 'Invasive Crustacea' produced this year, following on from the session (of the same name) at the 6th International Crustacean Congress, Glasgow in July 2005 with E. Cook and P. Clark as co-editors. Two papers from SAMS (Ashton *et al.* and Cook *et al.*, see below) are due to be published in this special issue.

Ashton, G.V., K.J. Willis and Cook, E.J. (in press). Global Distribution of the Japanese Skeleton Shrimp, *Caprella mutica* (Crustacea, Amphipoda, Caprellidae) with a detailed account of the distribution in Scotland, U.K. Hydrobiologia.

Bamber, R. 1987. Some aspects of the biology of the North American ostracod *Sarsiella zostericola* Cushman in the vicinity of a British power station. J.Micropaleontol., 6; 57–62.

Booth, D., Provan, J. and Maggs, C.A. 2006. The genetic consequences of invasion. Botanica marina (invited submission).

Cook, E.J., Willis, K.J. and Lozano-Fernandez, M. (in press). Survivorship, Growth and Reproduction of the Invasive *Caprella mutica* Schurin (Crustacea: Amphipoda). Hydrobiologia.

Copp, G.H., Kováč, V., Ojaveer, H. and Rosenthal, H. (eds.). 2005a. The introduction, establishment, dispersal and impact of introduced non-native fishes. Selected papers from the 11th European Congress of Ichthyology, Tallin, Estonia, 6–10 September 2004. Journal of Applied Ichthyology, Vol. 21.

Copp, G.H., Bianco, P.G., Bogutskaya, N., Erős, T., Falka, I., Ferreira, M.T., Fox, M.G., Freyhof, J., Gozlan, R.E., Grabowska, J., Kováč, V., Moreno-Amich, R., Naseka, A.M., Peňáz, M., Povž, M., Przybylski, M., Robillard, M., Russell, I.C., Stakėnas, S., Šumer, S., Vila-Gispert, A. and Wiesner, C. 2005b. To be, or not to be, a non-native freshwater fish? J. Appl. Ichthyol., 21: 242–262.

Copp, G.H., Wesley, K.J. and Vilizzi, L. 2005c. Pathways of ornamental and aquarium fish introductions into urban ponds of Epping Forest (London, England): the human vector. J. Appl. Ichthyol., 21: 263–274.

Elliott, P., Aldridge, D.C., Moggridge, G.D. and Chipps, M. 2005. The increasing effects of zebra mussels on water installations in England. Wa. Environ. J., 19 : 367–375.

Gozlan, R.E., St-Hilaire, S., Feist, S.W., Martin, P. and Kents, M.L. 2005. Disease threat to European fish. Nature, 435: 1046.

Hill, M., Baker, R., Broad, G., Chandler, P.J., Copp, G.H., Ellis, J., Jones D., Hoyland, C., Laing, I., Longshaw, M., Moore, N., Parrott, D., Pearman, D., Preston, C., Smith, R.M. and Waters, R. 2005. Audit of non-native species in England, English Nature Research Reports No. 662, 82 pp.

Jensen, A., Humphreys, J., Caldow, R. and Cesar, C. 2005. The Manila clam in Poole Harbour. In: Humphreys, J and May, V. (editors), The Ecology of Poole Harbour. Proceedings in Marine Science 7, Elsevier, pp 163–173.

Kornicker, L.S. 1975. Spread of ostracods to exotic environs on transplanted American oysters. Bull. Amer. Paleont., 65 : 129–139.

Mineur, F., Maggs, C. A. and Verlaque, M. 2006. Molecular survey of the genera *Gelidium* and *Caulacanthus* on European shores: Update on alien introductions. Poster presented at 54th British Phycological Society meeting, Plymouth, Jan, 2006.

Pinder, A.C., Gozlan, R.E. and Britton, J.R. 2005. Dispersal of the invasive topmouth gudgeon, *Pseudorasbora parva* in the UK: a vector for an emergent infectious disease. Fish. Manag. Ecol., 12: 411–414.

Stokes, K.E., O'Neill, K.P., Montgomery, W.I., Dick, J.T.A., Maggs, C.A. & McDonald, R.A. 2006. The importance of stakeholder engagement in invasive species management: a cross-jurisdictional perspective in Ireland. Biodiv. Conserv. (in press).

Strong, J.A., Dring, M.J and Maggs, C.A. 2006. Colonization and modification of soft substratum habitats by the invasive macroalga *Sargassum muticum.* Mar. Ecol. Prog. Ser. (in press).

Tortonese, E. 1984. Diodontidae. In *Fishes of the North-eastern Atlantic and the Mediterranean* (P.J.P. Whitehead, M.L. Bauchot. J.-C. Hureau, J. Nielsen & E. Tortonese, Eds.), Volume 3. UNESCO, Paris, 1346–1347.

Wheeler, A.C. 1998. Ponds and fishes in Epping Forest, Essex. London Nat. 77: 107–146.

# National report, United States of America, 2005

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## Highlights of 2005 United States National Report

- No new nonindigenous species legislation was passed at the national level even though several bills are before Congress. For the past two years *Crassostrea ariakensis* triploids have been introduced to the Chesapeake Bay area and work on the Environmental Impact Statement continues. The state of Virginia passed its own legislation allowing transplantation to move forward, but its relationship to the federal regulations is unclear.
- Most of the introduced fish and invertebrate species reported here are range expansions from earlier reported introductions, although some species were reported earlier in the literature but not in previous National reports. Some species are of unknown status. Two new species of *Porphyra, P. katadae* and *P. yezoensis* were recently identified by molecular analysis. *P. yezoensis* was introduced several years ago, but the strain that has been found throughout New England is not the same as the mariculture species.
- We do not have good data on fish, invertebrate, and seaweed imports as live organisms.

## 1.0 Laws and regulations

Similar to 2004, the U.S. Congress has not passed new legislation on aquatic invasions since the reauthorization of the Nonindigenous Species Act (NISA) of 1996 which expired in 2002 1. However, several new bills are before Congress, a few of which are receiving attention. One relates directly to ballast water (Senate Bill 363), which was placed on the legislative calendar in November 2005, but is not yet enacted. Two complementary proposed bills that address ballast water management and more broadly aquatic (and marine) nonindigenous species issues have been introduced by the Senate (S. 770) and the House of Representatives (H.R. 1592). These bills (S. 770 and H.R. 1592) were referred to respective legislative committees.

The Ballast Water Management Act of 2005 (S.B. 363) focuses on managing ballast water and proposes standards for ballast water discharge that are more strict than those proposed by the International Maritime Organization (IMO). The legislation would amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 to establish a new, national approach to addressing invasive species in ballast water. The bill was passed by the Senate but a similar bill is not yet reported out of committee by the House. Both the Senate and House would need to pass the bill before it could go to a joint committee for reconciliation and sent to the President for enactment.

The Ballast Water Management Act would have the following provisions: (a) funds for the US Coast Guard and Federal Ballast Water Demonstration Project, (b) requirement for exchange of ballast with exceptions, (c) inclusion of environmentally sound standards for ballast water

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1 The structure of legislation in the USA is that bills are prepared by Committees of both the Senate and the House of Congress. Once approved by the Committees the bills are passed to the respective bodies and voted on by those bodies (Senate Committee to Senate, House Committee to House). There is no prerequisite that these bills be the same. In fact it is often the case that they differ, and the differences may be resolved between the two bodies in conference after their individual passage. The product from conference then goes to the President for signing into law.

treatment technologies (more stringent than the IMO), and (d) phased adoption of technologies in over a 10-year period.

A similar bill is still under discussion by the House committee. A draft exists but it is not final for the committee to vote on. Passage through committee and a vote by the full House in 2006 are not assured in 2006. This must occur before any compromise can occur.

The S. 770 and H.R. 1592 also include sections on managing ballast water but their provisions extend to address prevention from all pathways, including research into pathways, authorizing rapid response funds, creating education and outreach programs, and developing prevention and control strategies. These bills are not yet reported out of committee. In addition, several states have regulations and programs to manage ballast water that are in various stages of implementation.

A recent court ruling requires the U.S. Environmental Protection Agency to include ballast water discharge under the National Pollution Elimination Discharge System Permits. It is not clear if this ruling applies to all areas of the U.S.

## 2.0 Deliberate releases and planned introductions

Status of efforts to introduce *Crassostrea ariakensis* in the U.S.

The U.S. Army Corps of Engineers is preparing an Environmental Impact Statement for a Proposed Introduction of the Oyster Species, *Crassostrea ariakensis*, Into the Tidal Waters of Maryland and Virginia To Establish a Naturalized, Reproducing, and Self-Sustaining Population of This Oyster Species. Seven alternatives are to be considered including:

- Alternative 1. No Action, i.e., continue current native oyster (*Crassostrea virginica*) restoration programs in Maryland and Virginia.
- Alternative 2. Expand Native Oyster Restoration Program: Expand, improve, and accelerate native oyster restoration programs in Maryland and Virginia, including disease resistant brood stock enhancement.
- Alternative 3. Impose a Harvest Moratorium: Implement a temporary harvest moratorium on native oysters that includes an oyster industry compensation (buy-out) program in Maryland and Virginia.
- Alternative 4. Enhance Native Oyster Aquaculture.
- Alternative 5. Non-native Oyster Aquaculture: Establish aquaculture operations in Maryland and Virginia using suitable triploid, non-native oyster species.
- Alternative 6. Introduce and Propagate and Alternative Oyster Species: Introduce oyster restoration programs in Maryland and Virginia of a disease-resistant oyster species other than *C. ariakensis*, or an alternative strain of *C. ariakensis*, from waters outside the U.S. in accordance with the ICES 1994 Code of Practices on the Introductions and Transfers of Marine Organisms.
- Alternative 7. Combination of Alternatives.

Research in support of the Environmental Impact Statement (EIS) has been proceeding with both federal and state funds. Quarterly summaries of progress on federally funded projects are available at http://noaa.chesapeakebay.net/. In addition to the research an industry group, the Virginia Seafood Council has been pursuing very large-scale trials of the commercial feasibility of *C. ariakensis* triploid culture. The triploids are the product of tetraploid-diploid crosses (see http://www.vims.edu/vsc for discussion of these crosses).

The first trial released eight deployments of 100 000 oysters each and the second trial conducted ten deployments of 100 000 oysters each. A permit has been requested for a third trial using over 2 000 000 oysters. The focus of these trials is to grow the oyster to market size within one year and thereby minimize the possibility of spawning in the culture location. At this time the industry has managed to consistently produce market size oysters (76 mm longest dimension) in the majority (typically 75%, often higher) of their cultured oysters in less than one calendar year from deployment as 10 mm seed oysters.

The Commonwealth of Virginia revised the Code of Virginia (the law of Virginia) to specifically address permitting of the introduction of *C. ariakensis* thus under the Virginia House Bill No. 2452, effective July 1, 2005. The Bill allows the Commissioner to authorize the placement of *Crassostrea ariakensis* on state-owned bottomlands based on several requirements. The sites chosen must be delineated and not conflict with native oyster restoration programs or submerged aquatic vegetation habitats. The oysters shall originate at a certified hatchery in the Chesapeake Bay region *to be currently in compliance with applicable protocols established by the International Council for the Exploration of the Sea* and so documented.

Deployed *C. ariakensis* oysters shall be rendered incapable of reproduction; i.e. to a level of less than one diploid oyster per 1,000 and after July 1, 2007 fertile or diploid oysters may be deployed. Director of the Virginia Institute of Marine Science, may authorize the placement of diploid or fertile *C. ariakensis* oysters on state-owned bottomlands. Permits and certification are required and violators must remove oysters. The legislation ends by noting that

> *"The status of the authority designated in this bill with respect to U.S. federal law is open to debate in that the deployment of oysters in Virginia is also subject to permit under the federal Clean Water Act. This precedent has not been formally resolved."*

# 3 Accidental introductions and transfers

***(1) Negative impacts***

Several of the recent papers identify negative impacts, however, a comprehensive examination is not reported here.

***(2) Vectors if known***

Generally, vectors are not known, but the reports highlight potential and probable vectors.

## 3.1 Fish

*Pterois volitans* (Lionfish) appears to be well established from North Carolina to Florida. Experimental studies indicate that this fish tolerates temperatures as low as 10–16ºC and is capable of surviving winter conditions as far north as Cape Hatteras. Juveniles have been caught on Long Island, New York, carried north by currents and suggesting that the southern populations are breeding.

Two introductions of predatory freshwater fishes in U.S. Atlantic Coast rivers pose concerns for anadromous fish populations such as Alewife and American Shad (*Alosa* spp.) Individuals of *Channa argus*, Northern Snakehead, native to Asia, were caught in 2004 in both the Potomac and Delaware Rivers, in the vicinities of Washington and Philadelphia, respectively, and are now established in both estuaries. *Pylodictus olivaris*, the Flathead Catfish, native to the Mississippi River and other Gulf of Mexico tributaries was introduced to Atlantic watersheds in North Carolina and Virginia in the 1990s by state agencies. In 2002, this catfish was first caught in Pennsylvania tributaries of the Delaware River and in 2004, it was caught in the Susquehanna River, the largest tributary of Chesapeake Bay. The Flathead Catfish is now established in both rivers, reaching tidal fresh waters in the states of Maryland, Pennsylvania, and New Jersey. Both *C. argus* and *P. olivaris* are large, top-level predators, with maximum sizes of 0.85 and 1.4 meters, respectively. Extensive efforts are being made to restore populations of American Shad (*A. sapidissima)* in these rivers, but restoration is threatened by the introduction of these predators to their freshwater migration and spawning areas. For both species, the likeliest vector of introduction is illegal stocking by private individuals.

## 3.2 Invertebrates

### *Atlantic/Gulf Coasts*

*Tubastrea coccinea* (Orange Cup Coral) – This Indo-Pacific coral first appeared in the Caribbean in 1943, probably transported on ship fouling. It gradually expanded its range north into the Gulf of Mexico, reaching oil platforms off Texas and Louisiana by 1991. By 2002, it had invaded the Flower Garden Banks National Marine Sanctuary off Texas, an important deep-water reef, and had also been collected on shipwrecks off the East Coast of Florida.

*Hyotissa hyotis* (an Indo-Pacific Oyster) – A native Atlantic oyster, *H. mcgintyi*, had long been misidentified as *H. hyotis*. However, *H. hyotis* differs in shell coloration and reaches a much larger size. During a molecular study of *H. mcgintyi*, two oyster specimens, found near Marathon Key, Florida in 2003, proved almost identical to specimens of *H. hyotis* from Guam. Earlier records of *'H. hyotis'* in Western Atlantic waters refer to *H. mcgintyi*. Several specimens of true *H. hyotis* have been collected in Florida, but established populations have not confirmed. Hull fouling and ballast water are possible vectors for the transport of this oyster.

*Perna viridis* (Green Mussel) – This mussel continues to expand its range northward. In 2003, it was collected for the first time in Georgia waters, along the entire coast of the state, from St. Simons Island north to the Savannah River.

*Synidotea laevidorsalis* – This isopod, native to the Indo-West Pacific, was collected in New York City Harbor, at South Street Seaport in 2003, in MIT Sea Grant Surveys, and in 2002, was found on fouling plates in lower Chesapeake Bay (Elisabeth Jewett, personal communication). On the Pacific coast, it is known from San Francisco Bay (since 1897) and from Willapa Bay, Washington. It was first found on the East Coast in 1998 in Charleston, South Carolina, and in 1999 in Delaware Bay. *Synidotea laevidorsalis* is likely to be present in other East Coast estuaries, and has also been collected on the Atlantic Coasts of France and Spain.

*Charybdis helleri (*Asian Swimming Crab) – U.S. Records of this Indo-Pacific crab, now extend from Sarasota Bay, Florida, on the Gulf of Mexico (first collected in 2004) north to Core Sound, North Carolina, about 50 miles south of Cape Hatteras (also first collected in 2004).

*Didemnum* sp. (compound ascidian) – This species has been referred to as *D. vexillum* and *D. lahillei*, but neither are accepted at the definitive identification for the U.S. organisms. This represents a change from last year when *D. lahillei* was preferred nomenclature. The current accepted identification is *Didemnum* sp. New reports of the species include Cobscook Bay, Maine; Strong Island, Osterville Strong Island, and Woods Hole Iselin Dock, Massachusetts; Fort Point, New Hampshire; and Beavertail Point, Rhode Island. The species has been reported from the West Coast at several locations in California and Washington. An unsuccessful eradication effort was undertaken in the Friday Harbor, Washington area. It has been found offshore in approximately 45–65 meters of water throughout areas surveyed and may cover more than 67 sq. $m^2$, representing about a 10 fold increase in last year's report. In areas where it has been observed it may cover up to 75% of the bottom cobble area.

### *Pacific Coast*

*NOTE: There is a question about whether this is an introduced species or not, however references are given and it has been included, even though it is more properly categorized as cryptogenic until further notice.*

*Orthione griffenis- Orthione griffenis* is a bopyrid isopod which inhabits the gill chambers of the burrowing mud shrimps of the genus *Upogebia*. It is apparently native to Japan, and was first collected in U.S. waters in 1985. It now infests *U. pugettensis* from Santa Barbara, California, north to British Columbia. In Oregon estuaries, up to 80% of the shrimps are infected, and are rendered incapable of reproduction. Mud shrimps are important as a suspension-feeder and as food for a wide range of fishes and shorebirds. Impacts of this parasite on mud shrimp abundances are currently being studied by John Chapman and colleagues. Ballast water is considered to be the likeliest vector of introduction.

*Perophora japonica*- This colonial tunicate was found for the first time in Humboldt Bay, California by Gretchen Lambert in 2003. So far, it has not been reported from other U.S. waters. It has colonized European waters, where it was first collected off Brittany in 1982. In the East Pacific and East Atlantic, hull fouling is the probable mode of introduction.

## 3.3 Algae and higher plants

*Antithamnion nipponicum* – This Northwest Pacific red alga (formerly known as *A. pectinatum* in Atlantic waters and *A. hubbsi* in U.S. Pacific waters) is newly reported from Beaufort, North Carolina (2003), Baja California, Mexico (1962, as *A. hubbsi*), and Halfmoon Bay, California (2003). It has been introduced to New England waters (Buzzards Bay to Long Island Sound, first reported 1985), the Azores, and the Mediterranean, and may be also introduced in West Coast waters. Fouling, ballast water, and oysters are all possible vectors.

*Caulacanthus ustulatu s* – This mat-forming red alga is reported as a recent invader in California, where it was first reported in 1999 at Cape Fermin, near San Pedro. It has subsequently spread into Elkhorn Slough and San Francisco Bay. Earlier records have been reported from Baja California (1961), British Columbia (1974), and Prince William Sound, Alaska (1996). Molecular analyses indicate that two major lineages exist, an East Atlantic group, and an Indo-West Pacific group. Populations from British Columbia populations belonged to the Indo-West Pacific lineage, as did local introduced populations in Brittany, France. Pacific oysters (from Asia), ship fouling, and ballast water are likely vectors for this alga.

*Caulerpa taxifolia* – In the previously infested areas, Aqua Hedionda Lagoon and Huntington Harbor, eradication efforts appear to have been successful. No new plants have been seen since 2002, but monitoring continues.

*Gracilaria vermiculophylla* – This West Pacific red alga was identified by molecular methods. In 1999–2000, nuisance blooms of a fouling and drifting species of *Gracilaria* were noted in the Cape Fear River, near Wilmington, North Carolina, and in Hog Island Bay, Virginia, a coastal lagoon just north of the mouth of Chesapeake Bay. These were initially assumed to be native *Gracilaria* species, but mitochondrial DNA analyses indicate that the dominant species is the introduced G. *vermiculophylla*. This species has been found on the West Coast as well, at Elkhorn Slough, California, where specimens were collected in 1994. More extensive genetic surveys are needed to determine the range of this introduced species in U.S. waters. This alga has been reported in European waters from Spain to Sweden.

*Porphyra katadae* – This Japanese red alga was identified using molecular methods, by Arthur Matheison and associates, at unspecified locations north and south of Cape Cod in 2005. Ballast water and fouling are likely vectors of introduction,

*Porphyra yezoensis* (Nori) – Although this edible Asian red alga was cultivated in Cobscook Bay, Maine, from 1991 to 1998, and carefully monitored, no evidence of reproduction was seen. However, “wild” plants were collected near Portsmouth NH by Arthur Mathieson and associates in 1999, and identified by molecular methods. Subsequently, populations were found at several locations from Maine to Long Island. Molecular analysis indicated that at least two strains were present, but both were distinct form the cultivated form.

### 3.4 Parasites, pathogens, and other disease agents

*Bonamia* sp. – In Bogue Sound, North Carolina, transplanted Suminoe Oysters (*Crassostrea ariakensis*) suffered extensive mortality from an unknown pathogen. DNA analysis indicated that the pathogen was a species of *Bonamia*. Since this infection was not detected in *C. ariakensis* in Chesapeake Bay, or Pamlico Sound, the parasite is assumed to have a local distribution. Its native/introduced status is not known.

## 4 Live imports

It is extremely difficult to get data on the amount of live imports from the U.S. Data presented in this section is based on a National Oceanic and Atmospheric Administration web site, http://www.st.nmfs.gov/st1/trade/cumulative_data/TradeDataDistrict.html, March 28, 2006.

### 4.1 Fish

No fish were reported as being imported live, although live eels from Bangladesh have been observed in markets.

### 4.2 Invertebrates

Data are presented according to the various categories that include "live" in the export description with any species names provided in the listing. The only species reported as a live import is *Homarus* (the lobster). Species that are reported as live/fresh imports include squid (one species of which is identified as *Loligo*), sea urchins, scallops, octopus, molluscs, cuttlefish, clam, and conch. Imported mussels are also identified as live/fresh and either farmed or wild. Under the category of live/fresh/salted/brined are the rock lobster, crab and crustaceans. The oyster is described as live/fresh/frozen/ dried/salted and brined.

### 4.3 Algae

Seaweeds and algae are reported as imports, but the status is not identified.

## 5 Live exports

It is extremely difficult to get data on the amount of live imports from the U.S. Data presented in this section is based on a National Oceanic and Atmospheric Administration web site, to be cited as personal communication from NOAA Office of Science and Technology, March 28,2006 http://www.st.nmfs.gov/st1/trade/cumulative_data/TradeDataDistrict.html.

### 5.1 Fish

No fish species were identified as exported "live".

### 5.2 Invertebrates

The only exported species identified that had no description of its condition, but is presumed to be live, is oyster seed. Species exported and identified as live/fresh include clam (geoduck), clam, conch, cuttlefish, molluscs, octopus, scallops, sea urchin, and squid (with *Loligo* identified as one species). Mussels are listed as live/fresh and either farmed or wild. Under the category of live/fresh/salted/brined exports are crabs; under the category of live/fresh/dried/salted/brined exports are crustaceans, lobsters, rock lobsters, and shrimp; and under the category of live/fresh/frozen/dried/salted/brined exports are oysters.

### 5.3 Algae

Seaweeds and algae are reported as exports, but the status is not identified.

## 6.0 Meetings, conferences, symposia or workshops on introductions and transfers

None are reported.

## 7 Bibliography

**ICES Literature Search 2005 papers on nonindigenous species in U.S. waters**

**(*Late or overlooked 2004 papers)**

Anderson, Lars W. J. 2005. California's reaction to *Caulerpa taxifolia*: a model for invasive species rapid response. Biological Invasions, 7: 1003–1016.

*Bieler, Rudiger; Mikkelsen, Paula; Lee, Taehwan; O'Foighil, Diarmid. 2004. Discovery of the Indo-Pacific oyster *Hyotissa hyotis* (Linnaeus , 1758) in the Florida Keys (Bivalvia: Gyphaeidae). Molluscan Research, 24: 149–159.

Bray, T. L.; Neefus, C. D.; Mathieson, A. D. 2005. Two Asian species of *Porphyra* on the New England coast. Northeast Algal Society. Rockland ME. Abstracts: 44th Northeast Algal Symposium. Pg. 4. http://www.bigelow.org/neas2005/neas_abstracts.pdf

Brown, J. Jed; Perillo, Joseph; Kwak, Thomas J.; Horwitz, Richard J. 2005. Implications of *Pylodictis olivaris* (Flathead Catfish) introduction into the Delaware and Susquehanna drainages. Northeastern Naturalist, 12(4): 473–484.

Brousseau, Diane J.; Baglivo, Jenny A. 2005. Laboratory investigations of food selection by the Asian Shore Crab *Hemigrapsus sanguineus*: Algal *versus* animal preference. Journal of Crustacean Biology, 25(1):130–134.

*Burreson, Eugene M.; Stokes, Nancy A.; Carnegie, Ryan B. 2004. *Bonamia* sp. (Haplosporidia) found in nonnative oysters *Crassostrea ariakensis* in Bogue Sound, North Carolina. Journal of Aquatic Animal Health, 16: 1–9.

DeRivera, Catherine, and 27 authors. 2005 (draft). Broad-scale non-indigenous species monitoring along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. Report to the National Fish and Wildlife Foundation. Washington DC.

Cho, Tae Oh; Won, Boo Yeon; Fredericq, Suzanne. 2005. *Antithamnion nipponicum* (Ceramiaceae, Rhodophyta), incorrectly known as *A. pectinatum* in western Europe, is a recent introduction along the North Carolina and Pacific coasts of North America.. European Journal of Phycology, 40: 323–335.

Choi, Keun-Hyung; Kimmerer, Wim; Smith, George; Ruiz, Gregory M.; Lion, Kelly. 2005. Post-exchange zooplankton in ballast water of ships entering the San Francisco estuary. Journal of Plankton Research, 27(7): 707–714.

Cohen, A. N. and 11 authors. 2005. Rapid assessment survey for exotic organisms in southern California bays and harbors, and abundance in port and non-port areas. Biological Invasions 7:995–1002.

Dawson, Michael N.; Gupta, Alex Sen; England, Matthew N. 2005. Coupled biophysical global ocean model and molecular genetic analyses identify multiple introductions of cryptogenic species. Proceedings of the National Academy of Sciences of the U.S.A., 102(34): 11968–11973.

DeRivera, Catherine; Ruiz, Gregory M.; Hines, Anson H.; Jivoff, Paul. 2005. Biotic resistance to invasion: Native predator limits abundance and distribution of an introduced crab. Ecology, 86(12): 3364–3376.

Dobbs, Fred C.. 2005. Ridding ship's ballast water of microorganisms. Environmental Science and Technology, 39(12): 259–264A.

Drake, John; Lodge, David M. 2005. Theory and preliminary analysis of species invasions from ballast water: controlling discharge volume and location. American Midland Naturalist,154: 459–470.

Drake, Lisa A.; Jenkins, Philip T.; Dobbs, Fred C. 2005. Domestic and internal arrivals of NOBOB vessels to lower Chesapeake Bay. Marine Pollution Bulletin, 50:560–565.

*Fenner, Douglas; Banks, Kenneth. 2004. Orange cup coral *Tubastraea coccinea* invades Florida and the Flower Garden banks, Northwestern Gulf of Mexico. Coral Reefs, 23:5050–507.

Floyd, Mark; Chapman, John 2005. New invasive parasite raises concern for West Coast estuaries. http://oregonstate.edu/dept/ncs/newsarch/2005/Aug05/isopod.htm

Goddard, Jeffrey H.; Torchin, Mark E.; Kuris, Armand M.; Lafferty, Kevin D. 2005. Host specificity of *Sacculina carcinia* potential biological control agent of the introduced European green crab *Carcinus maenas* in California. Biological Invasions, 7: 895–912.

*Grabowski, Jonathan H.; Petterson, Charles H.; Powers, Sean P.; Gaskill, David; Summerson, Henry C. 2005. Growth and survivorship of non-native (*Crassostrea gigas* and *Crassostrea ariakensis* versus native eastern oysters (*Crassostrea virginica*). Journal of Shellfish Research, 23(3):781–793.

Grosholz, Edwin D. 2005. Recent biological invasion may hasten invasion meltdown by accelerating historical introductions. Proceedings of the National Academy of Sciences of the U.S.A., 102(4): 1088–1091.

Harris, Larry G.; Jones, Adam C. 2005. Temperature, herbivory and epibiont acquisition as factors controlling the distribution and ecological role of an invasive seaweed. Biological Invasions 7: 913–924.

Hunt, Carlton, D.; Tanis, Deborah C.; Stevens, Thomas G.; Frederick, Ray M.; Everett, Richard. 2005. Verifying ballast water treatment performance. Environmental Science and Technology, 39(15): 321–328A.

Jewett, E. B.; Hines, A. H.; Ruiz, G. N. 2005. Epifaunal disturbance by periodic low levels of dissolved oxygen; native vs. invasive species response. Marine Ecological Progress Series, 304: 31–44.

Johnson, Donald R.; Perry, Harriet M.; Graham, William M. 2005. Using nowcast model currents to explore transport of non-indigenous jellyfish into the Gulf of Mexico. Marine Ecological Progress Series, 305: 139–146.

*Kimball, Matthew E.; Miller, John M.; Whitfield, Paula E.; Hare, Jonathan A. 2004. Thermal tolerance and potential distribution of invasion lionfish *Pterois volitans/miles* complex on the East coast of the United States. Marine Ecology Progress Series, 283: 269–278.

Lambert, Gretchen. 2005. First North American record of the ascidian *Perophora japonica*. Journal of the Marine Biological Association of the United Kingdom, 85(4): 1011–1012.

Light, Theo; Grosholtz, Edwin; Moyle, Peter. 2005. Delta ecological survey (phase1): nonindigenous aquatic species in the Sacramento-San Joaquin Delta, a literature review. US Fish and Wildlife Service. Stockton. CA.

Ma, Xiping; Purcell, J. E. 2005. Effects of temperature, salinity and predators on mortality of and colonization by the invasive hydrozoan *Moerisia lyonsi*. Marine Biology, 147: 215–224.

Maclellan, Jane 2005. Invasive species of Long Island Sound. Connecticut Sea Grant. http://www.seagrant.uconn.edu/INVLIST.PDF

*Markham, John C. 2004. New species and records of Bopyridae (Crustacea: Decapoda) infesting species of the genus *Upogebia* (Crustacea: Decapoda: Upogebiidae): the genera *Orthione* Markham, 1988, and *Gyge* Cornalia and Panceri, 1861. Proceedings of the Biological Society of Washington, 117(2): 186–198.

Matern, Scott A.; Brown, Larry R. 2005. Invaders eating invaders: exploitation of novel alien prey by the alien shimofuri goby in the San Francisco estuary, California. Biological Invasions, 7: 497–507.

Meister, H. Scott; Wyanski, Loefer, Joshua K.; Ross, Steve W.; Quattrini, Andrea M.; Sulak, Kenneth J. 2005. Further evidence for the invasion and establishment of *Pterois volitans* (Teleostei: Scorpaenidae) along the Atlantic Coast of the United States. Southeastern Naturalist, 42(2):193–206.

Minton, Mark S.; Verling, Emma A.; Miller, A. Whitman; Ruiz, Gregory M. Reducing propagule supply and coastal invasions via ships: effects of merging strategies. 2005. Frontiers in Ecology and the Environment, 3(6): 304–308.

Neilson, Mattew E.; Wilson, Raymond R., Jr. 2005. mtDNA singletons as evidence of a post-invasion genetic bottleneck in yellowfin goby *Acanthogobius flavimanus* from San Francisco Bay, California. Marine Ecological Progress Series, 296: 197–208.

Neira, Carlos; Levin, Lisa A.; Grosholz, Edwin D. 2005. Benthic macrofaunal communities of three sites in San Francisco Bay invaded by hybrid *Spartina*, with comparison to uninvaded habitats. Marine Ecology Progress Series, 292:111–126.

Orrell, Thomas M.; Weigt, Lee. 2005. The Northern Snakehead *Channa argus*, a non-indigenous fish in the Potomac River, U.S.A. Proceedings of the Biological Society of Washington, 118(2): 407–415.

Pederson, Judith and 15 authors. 2005. Marine invaders in the Northeast. MIT Sea Grant College Program. Cambridge MA. http://www.mass.gov/envir/massbays/pdf/ras2003.pdf

Peterson, Mark S.; Slack, William T.; Woodley, Christa M. 2005. The occurrence of non-indigenous Nile Tilapia, *Oreochromis niloticus* in coastal Mississippi: ties to aquaculture and thermal effluent. Wetlands 25(1): 112–121.

Pondella, Daniel J.; Chinn, Zachary K. J. 2005. Records of chameleon goby, *Tridentiger trigonocephalus*, in San Diego Bay, California. California Fish and Game, 91(1): 57–59.

*Power, Alan J.; Walker, Randal L.; Payne, Karen; Hurley, Dorset. 2004. First occurrence of the nonindigenous green mussel, *Perna viridis* in coastal Georgia. Journal of Shellfish Research, 23: 741–744.

Ray, Gary L. 2005. Invasive animal species in marine and estuarine environments: biology and ecology. Army Corps of Engineers Environmental Laboratory, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/trel05-2.pdf

Ray, Gary L. 2005. Invasive marine and estuarine animal environments of the Gulf of Mexico. Army Corps of Engineers Environmental Laboratory, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/ansrp05-4.pdf.

Ray, Gary L. 2005. Invasive marine and estuarine animal environments of the South Atlantic and Puerto Rico. Army Corps of Engineers Environmental Laboratory, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/ansrp05-5.pdf

Ray, Gary L. 2005. Invasive marine and estuarine animal environments of the North Atlantic. Army Corps of Engineers Environmental Laboratory, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/ansrp05-1.pdf

Rudnick, Deborah; Veldhuizen, Tanya; Tullis, Richard; Culver,Carolyn; Hieb, Kathryn; Tsukimura, Brian. A life history model for the San Francisco Estuary population of the Chinese mitten crab, *Eriocheir sinensis* (Decapoda: Grapsoidea). Biological Invasions 7(2):333–350.

Rueness, Jan. 2005. Life history and molecular sequences of *Graciliaria vermiculophylla* (Gracilariales, Rhodophyta), a new introduction to European waters. Phycologia, 44(1): 120–128.

Ruesink, Jennifer L. and 6 authors. 2005. Introduction of non-native oysters: Ecosystem effects and restoration implications. Annual Review of Ecology and Systematics, 36: 643–689.

Sammarco, Paul W.; Atchison, Amy D.; Boland, Gregory S. 2005. Expansion of coral communities within the northern Gulf of Mexico via offshore oil and gas platforms. Marine Ecological Progress Series, 280: 129–143.

Sano, Larissa L.; Bartell, Steven M.; Landrum, Peter F. 2005. Decay model for biocide treatment of unballasted vessels: application for the Laurentian Great Lakes. Marine Pollution Bulletin, 50:1050–1060.

Sano, Larrissa L.; Moll, Russell A.; Landrum, Peter F. 2005. Assessing the potential efficacy of glutaraldehyde for biocide treatment of un-ballasted transoceanic vessels. Journal of Great Lakes Research, 29(4): 545–557.

Thomsen, Mads S.; Gurgel, Carlos F.D.; Frederiq, Suzanne; McGlathery, Karen J. 2005. *Gracilaria vermiculophylla* (Rhodophyta, Gracilariales) in Hog Island Bay, Virginia: a cryptic alien and invasive macroalga and taxonomic correction. Journal of Phycology, 42: 139–141.

Torchin, Mark E.; Byers , James E.; Huspeni, Todd C. 2005. Differential parasitism of native and introduced snails: replacement of a parasite fauna. Biological Invasions, 7: 885–894.

Valentine, Page 2006. Marine nuisance species, genus *Didemnum*, colonial tunicate, ascidian, sea squirt. http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/.

Vasquesz, Edward A.; Glenn, Edward P.; Brown, Jed.; Guntenspergen, Glenn R.; Nelson, Stephen G. 2005. Salt tolerance underlies the cryptic invasion of North American salt marshes by an introduced haplotype of the common reed *Phragmites australis* (Poaceae). Marine Ecological Progress Series, 298: 1–8.

Verling, Emma; Ruiz, Gregory M.; Smith, David; Galil, Bella; Miller, A. Whitman; Murphy, Kathleen R. 2005. Supply-side invasion ecology: characterizing propagule pressure in coastal ecosystems. Proceedings of the Royal Society of London. Series B., 272: 1249–1257.

Wasson, Kerstin; Fenn, Katherine; Pearse, John S. 2005. Habitat differences in marine invasions of central California. Biological Invasions, 7: 935–946.

Weigle, Shannon M.; Smith, David; Carlton, Pederson, Judith. 2005. Assessing the risk of introducing exotic species via the live marine species trade. Conservation Biology, 19(1): 213–223.

*Whiteside, K. E.; Murray, S. N. 2004. Spatial and temporal patterns of abundance in southern California populations of *Caulacanthus ustulatus* (Rhodophyta). Journal of Phycology, 40(8):14.

Williams, S.L.; Ebert, T. A.; Allen, B.J. 2005. Does the recruitment of a non-native mussel in native eelgrass habitat explain their disjunct adult distributions? Diversity and Distributions, 11: 409–416.

Wonham, Marjorie J.; Carlton, James T. 2005. Trends in marine biological invasions at local and regional scales: the Northeast Pacific Ocean as a model system. Biological Invasions, 7: 369–392.

Yamada, Sylvia Brehrens; Dumbauld, Brett R.; Kalin, Alex; Hunt, Christopher E.; Figlar-Barnes, Ron; Randall. 2005. Growth and persistence of a recent invader *Carcinus maenas* in estuaries of the northeastern Pacific. Biological Invasions, 7: 309-321.

# Annex 5: PICES Working Group 21: Aquatic non-indigenous species

**Darlene Smith**

The North Pacific Marine Science Organization (PICES), is an intergovernmental scientific organization, established in 1992 to promote and coordinate marine research in the northern North Pacific and adjacent seas. Its present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America.

PICES is composed of several comities including the Marine Environmental Quality (MEQ) Committee. The MEQ Committee's area of responsibility is to promote and coordinate marine environmental quality and interdisciplinary research in the northern North Pacific. This includes understanding the sources and fates of contaminants found in the marine environment, the ecology of harmful algal blooms, marine environmental quality aspects of mariculture, and the transport and introduction of non-indigenous species and stocks. The MEQ Committee recommended that a working group on aquatic non-indigenous species be created.

The PICES governing council approved the creation of Working Group 21: Aquatic Non-indigenous Species at PICES XIV held in Valadivostok, Russia, October 2005.

**WG-21 has a three year mandate ending 2008 with the following Terms of Reference**

1 ) Complete an inventory of all aquatic non-indigenous species in all PICES member countries together with compilation and definitions of terms and recommendations on use of terms. Summarize the situation on bioinvasions in the Pacific and compare and contrast to other regions (*e.g.*, Atlantic, Australia, *etc.*);
2 ) Complete an inventory of scientific experts, in all PICES member countries, on aquatic non-indigenous species subject areas and of the relevant national research programs/projects underway;
3 ) Review and evaluate initiatives on mitigation measures (*e.g.*, ICES Code of Practice for the Introduction and Transfer of Marine Organisms; IMO Ballast Water Management Convention and others such as the Canadian Introductions and Transfers Code);
4 ) Summarize research related to best practices for ballast water management;
5 ) Coordinate activities of the PICES WG on aquatic non-indigenous species with related WGs in ICES through a joint back to back meeting of the PICES and ICES Working Groups on invasive species in 2007/8;
6 ) Develop and recommend an approach for formal linkages between PICES and ICES on aquatic non-indigenous species;
7 ) Publish final report summarizing results and recommendations.

Additional information on PICES and WG-21 can be found at www.PICES.int

**The PICES WG-21 membership list includes:**

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# Annex 6: WGITMO Input to REGNS

WGITMO input to REGNS - Introduced aquatic species of the North Sea coasts and adjacent brackish waters

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Considerable new literature is available on introduced (aquatic) species in north-western Europe because such species are of increasing concern in the regulatory and scientific community. One of the first summaries of aquatic invaders in the region was made by Gollasch (1996), with a focus on the German North- and Baltic Sea coasts. In 1997 Eno *et al.* published a summary of aquatic alien species in the United Kingdom. In 1999 Nehring and Leuchs published an overview of "neobiota" of the German coast. In the same year Reise *et al.* published an overall summary of invaders in the North Sea region. Nehring (2005) updated the inventory of introduced aquatic species in Germany, Jensen and Knudsen (2005) published an inventory of introduced species in Denmark. A comprehensive inventory of alien species in Dutch coastal waters was also published in 2005 by Wolff. An update of the 1999 summary of introduced species in the North Sea is in press (Gollasch *et al.*, in press). It forms the basis of this overview.

In total 219 non-native taxa (including cryptogenic species) were reported in the North Sea. 95 % of these taxa are introduced by man, predominantly with shipping and intentional introductions for stocking or aquaculture purposes (Table 1), 16 % of these taxa are cryptogenic species and 6 % have most likely reached the North Sea by their own means: drifting with currents, swimming, or by other ways of natural range expansion. The most recently recorded species are *Rapana venosa* and *Neogobius melanostomus*, which were both recorded for the first time in the North Sea in 2005 (Kerckhof *et al.*, 2006, van Beek, 2006).

More than half of the invaders known have established self-sustaining populations. For the rest of the recorded introduced species the population status is unknown. Some species were only recorded for a certain time period and became locally extinct thereafter With 193 species (88%) marine taxa are dominating . However, the share of marine vs. brackish water invaders varies by country - but marine species are dominating in each country. The dominating vectors of introduction are the shipping-associated vectors hull fouling and ballast water release, and species introductions for aquaculture purposes and their associated biota (thus target and non-target species) (Figure 1).

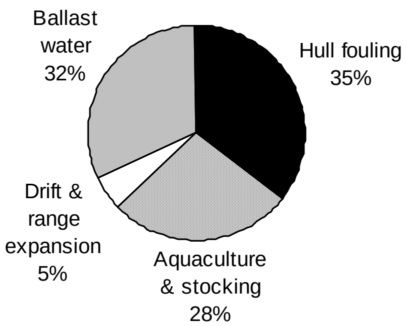


**Figure 1. Key vectors of introduction for nonindigenous species found in the North Sea.**

## Resume

It is interesting to note that 13 species have reached the North Sea by drift or range expansion – a possible indication of a changing climate regime as several of these species are known from warmer climate regions and have now been found in colder waters. Wiltshire (pers. comm.) and Franke and Gutow (2004) stated that several nonindigenous species were newly recorded in the North Sea near Helgoland which were previously known to have an eastwards distribution limit in the English Channel or were known only from the Mediterranean Sea. It is assumed that the increasing number of records of species from warmer waters might be a consequence of increasing water temperatures.

Reise *et al.* (1999) concluded that in the North Sea introduced species in most cases are more "additive" without causing major unwanted impacts. However, the introduced Pacific oyster *Crassostrea gigas* has recently spread in the coastal waters of the North Sea (Reise *et al.*, 2005) with competitive impact on mussel beds of the native blue mussel *Mytilus edulis.* The spread is likely promoted due to (a) the recent warm summers which support the recruitment of the Pacific oyster (Diederich *et al.*, 2005) and also (b) due to the lack of cold winters which are required for good recruitment of *M. edulis.* It is assumed that the current success of *C. gigas* may reverse in case water temperatures change (Diederich, 2005). In other European regions devastating effects of introduced species are known [e.g. the comb jelly *Mnemiopsis leidyi* in the Black Sea (GESAMP, 1997) or the green alga *Caulerpa taxifolia* in the Mediterranean Sea (Boudouresque *et al.*, 1992)]. However, negative impacts of the above mentioned species may be temporary only and are also subject of controversy. In general terms, biological and habitat impacts of introduced species are difficult to assess and monetary impact calculations are not available. It should also be noted that impacts of recently introduced species are often not immediately apparent

The rate of invasions has increased in the North Sea, as it has increased worldwide, and it will probably continue to increase due to the effects of climate change. There is a need for biological and monetary impact assessments and knowledge of the invasion process is essential in designing management plans to cope with the potential detrimental effects of invasive species, and to attempt to prevent their large-scale spread

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## References

Anger, K. 1990. Der Lebenszyklus der Chinesischen Wollhandkrabbe (*Eriocheir sinensis*) in Norddeutschland: Gegenwärtiger Stand des Wissens und neue Untersuchungen. Seevögel, 11 (2): 32-37 pp.

Bjærke, M.R. and Rueness J 2004. Effects of temperature and salinity on growth, reproduction and survival in the introduced red alga *Heterosiphonia japonica* (Ceramiales, Rhodophyta). Botanica Marina, 47, 373–380.

Blanchard M 1997. Spread of the slipper limpet *Crepidula fornicata* (L. 1758) in Europe. Current state and consequences. Scienta Marina, 61(Supplement 2): 109–118.

Boettger CR 1933. Die Ausbreitung der Wollhandkrabbe in Europa. Sitzungber. Ges. naturforsch. Freunde, Berlin 1933., 399–415 pp.

Campbell S and Nijland R 2004. De blaasjeskrab, *Hemigrapsus sanguineus* (De Haan, 1835) voor het eerst op het Nederlandse strand. *het Zeepaard,* 64, 40–45.

Carlton JT and Cohen AN 2003. Episodic global dispersal in shallow water marine organisms; the case history of the European shore crabs *Carcinus maenas* and *C. aestuarii*. *Journal of Biogeography,* 30, 1809–1820.

Carlton JT 1996. Biological invasions and cryptogenic species. Ecology, 77, 1653–1655.

Carlton JT 2003. Community assembly and historical biogeography in the North Atlantic Ocean: the potential role of human-mediated dispersal vectors. Hydrobiologia, 503, 1–8.

Clark PFC, Rainbow PS, Robbins RS, Smith B, Yeomans, WE, Thomas M and Dobson G 1998. The alien Chinese mitten-crab, *Eriocheir sinensis* (Crustacea: Decapoda: Brachyura), in the Thames catchment. Journal of the marine biological Association of the United Kingdom, 78: 1215–1221

Cohen AN and Carlton JT .1995. Biological study: Non-Indigenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and Delta. US Fisheries and Wildlife and National Sea Grant College Program Report PB96-166525, Springfield, Virginia, USA, 273 pp

de Blauwe H and Faasse M 2004. *Smittoidea prolifica* Osburn, 1952 (Bryozoa, Cheilostomatida), a Pacific bryozoan introduced to The Netherlands (Northeast Atlantic). Bull.Kon.Belg.Inst.Natuurwet.Biologie, 74, 33–39.

de Lafontaine Y 2005. First Record of the Chinese Mitten Crab (*Eriocheir sinensis*) in the St. Lawrence River, Canada. J. Great Lakes Res., 31: 367–370

Deslous-Paoli J-M 1985. *Crepidula fornicata* L. (Gastropode) dans la bassin de Marennes-Oleron: structure, dynamique et production d'une population. Oceanologica Acta, 8: 453–460.

Diederich, S., Nehls, G., van Beusekom, J.E.E., Reise, K. 2005. Introduced Pacific oysters (Crassostrea gigas) in the northern Wadden Sea: invasion accelerated by warm summers? Helgol. Mar. Res., 59: 97–106

Drinkwaard, A.C. 1999. Introductions and developments of oysters in the North Sea area: a review. Helgolander Meeresunters., 52: 301–308.

Eno, N.C., Clark, R.A., and Sanderson, W.G. (eds.). 1997. *Non-native marine species in British waters: a review and directory*. JNCC, Peterborough.

Fletcher, R.L. and Farrell, P. 1999. Introduced brown algae in the North East Atlantic, with particular respect to *Undaria pinnatifida* (Harvey) Suringar. Helgolander Meeresunters., 52: 259–275.

Franke, H.-D. and Gutow, L. 2004. Long-term changes in the macrozoobenthos around the rocky island of Helgoland (German Bight, North Sea). Helgol. Mar. Res., 58: 303–310

Franke, H.D., Gutow, L. and Janke, M. 1999. The recent arrival of the oceanic isopod *Idotea metallica* Bosc off Helgoland (German Bight, North Sea): an indication of a warming trend in the North Sea? Helgolander Meeresunters., 52, 347–357.

Gollasch, S. and Rosenthal, H. (in prep.) The Kiel Canal. In: Gollasch, S., Galil, B.S. and Cohen, A. (eds.) Bridging Divides. Maritime Canals as Invasion Corridors.

Gollasch, S., Haydar, D., Minchin, D., Wolff, W. and Reise, K.. Introduced aquatic species of the North Sea coasts and adjacent brackish waters. In: Rilov, G and J Crooks (eds) Marine Bioinvasions, Ecology, Conservation and Management Perspectives. Springer Academic Publishers. (in press).

Gomoiu, M.-T., Alexandrov, B., Shadrin, N. and Zaitsev, Y. 2002. The Black Sea – A recipient, donor and transit area for alien species. In: E. Leppäkoski, S. Gollasch and S. Olenin (eds.) – Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer, Dordrecht: 341–350.

Hayward, P.J. and Ryland, J.S. 1990. The Marine Fauna of the British Isles and North-West Europe. Volume 1: Introduction and Protozoans to Arthropods. Clarendon Press, Oxford.

Hoppe, K.N. 2002. *Teredo navalis* – the cryptogenic shipworm. In: E. Leppäkoski, S. Gollasch and S. Olenin (eds.) — Invasive aquatic species of Europe. Distribution, impacts and management. Kluwer, Dordrecht: 116–119.

Ichiki, M., Suzumiya, H., Hayakawa, K., Imai, J.I. and Nawa, Y. 1989. Two cases of *Paragonimiasis westermani* with pleural effusion in young girls living in the southern part of Miyazaki Prefecture, Japan. Jap. J. Parasitol., 38(6): 392–395

Jensen, K.R. and Knudsen, J. 2005. A summary of alien marine benthic invertebrates in Danish waters. Oceanological and Hydrobiological Studies, 34 Supplement 1: 137–162.

Kerckhof, F. 2002. Barnacles (Cirripedia, Balanomorpha) in Belgian waters, an overview of the species and recent evolutions, with emphasis on exotic species. Bulletin de l'Insititut Royal des Sciences Naturelles de Belgique – Biologie, 72-suppl.: 93–104.

Kerckhof, F., Vink, R.J., Nieweg, D.C. and Post, J.J.N. 2006. The veined whelk *Rapana venosa* has reached the North Sea. Aquatic Invasions, (2006) 1: 35–37

Kühl, H. 1977. *Mercierella enigmatica* (Polychaeta: Serpulidae) an der deutschen Nordseeküste. Veröff. Inst. Meeresforsch. Bremerh., 16: 99–104

Lambert, G. 2001. A global overview of ascidian introductions and their possible impact on the endemic fauna. *The biology of ascidians* (ed. by H. Sawada, H. Yokosawa, and C. C. Lambert), pp. 249–257. Springer-Verlag, Tokyo.

Luczak, C., Dewarumez, J.-M. and Essink, K. 1993. First record of the American jack knife clam *Ensis directus* on the french coast of the North Sea. J.Mar.Biol.Ass.U.K., 73: 233–235.

Maggs, C.A. and Hommersand, M.H. 1993. Seaweeds of the British Isles: Volume 1 Rhodophyta, Part 3A Ceramiales, 2 edn. Natural History Museum, London.

Maggs, C.A. and Stegenga, H. 1999. Red algal exotics on North Sea coasts. Helgolander Meeresunters., 52: 243–258.

Martinet, J.F. 1778. Katechismus der Natuur. Derde deel. — Johannes Allart, Amsterdam, 387 p.

Michaelis, H. and Reise, K. 1994. Langfristige Veränderungen des Zoobenthos im Wattenmeer. In: Lozán, J. L.; Rachor, E.; Reise, K.; Westernhagen, H. v. and Lenz, W. (eds.), Warnsignale aus dem Wattenmeer. Bd. 2, Blackwell Wissenschafts-Verlag, Berlin, 106–116 pp.

Minchin, D., McGrath, D., and Duggan, C.B. 1995. The slipper limpet *Crepidula fornicata* (L.) in Irish waters, with a review of its occurrence in the north-east Atlantic. Journal of Conchology, London. 35: 247–254.

Moll, F. 1914. Die Bohrmuschel (Genus *Teredo* Linné). — Naturwiss. Z. Forst Landwirtschaft, 12: 505–564.

Montaudoüin, X. de, Labarraque, D., Giraud, K. and Banchelet, G. 2001. Why does the introduced gastropod *Crepidula fornicata* fail to invade Arcachon Bay (France)? Journal of the Marine Biological Association of the United Kingdom, 81: 97–104.

Nehring, S. 2005. International shipping – a risk for aquatic biodiversity in Germany. In: Nentwig, W., Bacher, S., Cock, M.J.W., Dietz, H., Gigon, A. and Wittenberg, R. (eds.): Biological invasions – from ecology to control. NEOBIOTA, 6: 125–143

Nepszy, S.J. and Leach, J.H. 1973. First Records of the Chinese Mitten Crab, *Eriocheir sinensis*, (Crustacea: Brachyura) from North America. J. Fish. Res. Bd. Canada, 30(12): 1909–1910 pp.

Panning, A. 1938. The Chinese Mitten Crab. Smithsonian Rep., 361–375 pp.

Panning, A. 1952. Die chinesische Wollhandkrabbe. Die neue Brehm-Bücherei, 70: 1–46 pp.

Peters, N. 1933. B. Lebenskundlicher Teil . In: Peters, N. and Panning, A. (eds.), Die chinesische Wollhandkrabbe (*Eriocheir sinensis* H. MILNE-EDWARDS) in Deutschland. Akademische Verlagsgesellschaft mbH, Leipzig, 59–156 pp.

Petersen, K.S., Rasmussen, J.B., Heinemeier, J. and Rud, N. 1992. Clams before Columbus? Nature, 359 : 679.

Quiniou, F. and Blanchard, M. 1987. Etat de la proliferation de la crepidule (*Crepidula fornicata* L.) dans le secteur de Granville (Golfe Normano-Breton – 1985). Haliotus, 16: 513–526.

Reise, K. 1991. Ökologische Erforschung des Wattenmeeres. Biologie der Meere. Spektrum Akad. Verl., Heidelberg, 68–79 pp.

Reise, K., Dankers, N., Essink, K. 2005. Introduced species. In: Essink K *et al.* (eds) Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No.19. Common Wadden Sea Secretariat, Wilhelmshaven, Germany: 155–161

Reise, K., Gollasch, S. and Wolff, W.F. 1999. Introduced marine species of the North Sea coasts. Helgoländer Meeresunters., 52: 219–234

Rudnick, D.A., Halat, K.M. and Resh, V.H. 2000. Distribution, ecology and potential impacts of the Chinese mitten crab (*Eriocheir sinensis*) in San Francisco Bay. University of California, Berkeley, Water Resources Center, Contribution, 26. 74 pp

Ryland, J.S. 1967. Polyzoa. Oceanography and Marine Biology Annual Review, 5: 343–369.

Schnakenbeck, W. 1924 Ueber das Auftreten chinesischer Krabben in der Unterelbe. Schr. für Süßwasser- und Meereskunde, 5

Stachowicz, J. J., Terwin JR, Whitlach RB and Osman RW 2002. Linking climate change and biological invasions: Ocean warming facilitates nonindigenous species invasions. Proceedings – National Academy of Sciences, 99: 15497–15500.

Stegenga, H. and Mol, I. 1983. Flora van de Nederlandse zeewieren. Hoogwoud: Koninklijke Nederlandse Natuurhistorische Vereniging.

Stegenga, H. 2000. Nieuwe algen in Zuidwest-Nederlandse stagnante zoute en brakke wateren. Gorteria, 26: 1–8.

Stegenga, H., Mol, I., Prud'Homme van Reine, W.F. and Lokhorst, G.M. 1997. Checklist of the marine algae of the Netherlands. pp. 1–57.

Strasser, M. 1999. *Mya arenaria* – an ancient invader of the North Sea coast. Helgoländer Meeresunters., 52: 309–324.

Sukopp, H. and Brande, A. 1984. Beiträge zur Landschaftsgeschichte des Gebietes um den Tegeler See. Sitzungsber. Ges. Naturforsch. Freunde Berlin, 24: 198–214/1–7 pp.

van Beek, G.C.W. 2006. The Round goby *Neogobius melanostomus* first recorded in the Netherlands. Aquatic Invasions (2006) 1: 42–43

Van Benthem Jutting, T. 1943. Mollusca. C. Lamellibranchia. — Fauna van Nederland 12: 1–477.

Vrolik, W., Harting, P., Storm Buysing, D.J., van Oordt, J.W.L. and von Baumhauer, E.H. 1860. Verslag over den Paalworm, uitgegeven door de Natuurkundige Afdeeling der Koninklijke Nederlandsche Akademie van Wetenschappen, Amsterdam, 153 pp.

Walne, P.R. 1956. The biology and distribution of the slipper limpet *Crepidula fornicata* in Essex Rivers. Fisheries Investigations, Series II 20(6): 50pp

Weidema, I.R. 2000. Introduced species in the Nordic countries. Nordic Council of Ministers, Copenhagen. Nord Environment, 2000:13, 242 pp.

Wolff, W.J. and Reise, K. 2002. Oyster imports as a vector for the introduction of alien species into Northern and Western European coastal waters. Invasive aquatic species of Europe. Distribution, impact and management. (ed. by E. Leppäkoski, S. Gollasch, and S. Olenin), pp. 193–205. Kluwer Academic Publishers, Dordrecht.

Wolff, W.J. 1999. Exotic invaders of the meso-oligohaline zone of estuaries in the Netherlands: why are there so many? Helgoländer Meeresunters., 52: 393–400.

Wolff, W.J. 2005. Non-indigenous marine and estuarine species in The Netherlands. Zoologische Mededelingen, Leiden, 79: 1–116.

Zidowitz, H. 2004. Weißspitzen-Hochseehai im schwedischen Gullmarsfjord. Elasmoskop 8(1): 4–5

**Table 1 Introduced marine and brackish species from the North Sea with an indication of records per country excluding cryptogenic species and species which arrived by drift or range expansion. BE = Belgium, DK = Denmark, GE = Germany, NL = The Netherlands, NO = Norway, SE = Sweden and UK = United Kingdom. A question mark indicates that the species most likely occurs in the country, but records are not yet confirmed. Species without vector indication means the introduction vector is unknown. Key references: Gollasch, 1996; Eno *et al.,* 1997; Reise *et al.,* 1999; Weidema, 2000; Jensen and Knudsen, 2005; Nehring, 2005; Wolff, 2005.**

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acartia tonsa | Copepod | GE | DK | | BE | NL | UK | SE | establ. | marine | x | | |
| Agardhiella subulata | Macroalga | | | | | NL | UK | | establ. | marine | | x | |
| Aglaothamnion halliae | Macroalga | GE | | NO | | | | SE | establ. | marine | | x | |
| Alexandrium angustitabulatum | Dinoflagellate | | | | | | | SE | uncertain | marine | x | | |
| Alexandrium leei | Dinoflagellate | | | | | NL | | | establ. | marine | x | | x |
| Alkmaria romijni | Annelida | | DK | NO | | NL | | | establ. | marine | x | x | |
| Ammothea hilgendorfi | Pycnogonida | | | | | | UK | | establ. | marine | | x | |
| Anguillicola crassus | Nematod | GE | DK | NO | ? | NL | UK | SE | establ. | marine | | | x |
| Anotrichium furcellatum | Macroalga | | | | | NL | UK | | establ. | marine | | x | |
| Antithamnionella spirographidis | Macroalga | | | | BE | NL | UK | | establ. | marine | | x | |
| Antithamnionella ternifolia | Macroalga | GE | | | BE | NL | UK | | establ. | marine | | x | |
| Aphelochaeta marioni | Polychaete | GE | | | | NL | UK | | establ. | marine | x | x | |
| Asparagopsis armata | Macroalga | | | | | NL | UK | | establ. | marine | | x | |
| Asperococcus scaber | Macroalga | | | | | NL | UK | | establ. | marine | | x | x |
| Atherina boyeri | Pisces | | | | | NL | | | establ. | marine | | x | |
| Aulacomya ater | Bivalve | | | | | | UK | | unestabl. | marine | | x | |
| Balanus amphitrite amphitrite | Cirriped | | | | BE | NL | UK | | establ. | marine | | x | |
| Balanus eburneus | Cirriped | | | | | NL | | | extinct | marine | | x | |
| Bonamia ostreae | Protozoa | | | | | NL | | | establ. | marine | | | x |
| Bonnemaisonia hamifera | Macroalga | GE | DK | NO | ? | NL | UK | SE | establ. | marine | | x | |
| Botrylloides violaceus | Tunicata | | | | | NL | | | establ. | marine | | x | |
| Bougainvillia macloviana | Cnidaria | GE | | | | | | | extinct | marine | | x | |
| Brachynotus sexdentatus | Crustacean | | | | | | UK | | uncertain | marine | x | x | |
| Branchiomma bombyx | Annelida | | | | | NL | | | extinct | marine | x | x | |
| Callinectes sapidus | Decapod | GE | | | BE | NL | | | establ. | marine | x | | |
| Calyptrea chinensis | Gastropod | | | | | NL | | | extinct | marine | | | x |

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caprella mutica | Amphipod | GE | | NO | BE | NL | UK | | establ. | marine | x | x | |
| Cereus pedunculatus | Cnidaria | GE | | | | | UK | | uncertain | marine | x | x | |
| Chattonella antiqua | Rhaphidophyceae | GE | | | | NL | | | establ. | marine | x | | |
| Chattonella marina | Rhaphidophyceae | GE | | | | NL | | | establ. | marine | x | | |
| Chelicorophium curvispinum | Amphipod | GE | | | | NL | | | establ. | brackish | x | | |
| Chionoecetes opilio | Decapod | | | NO | | | | | uncertain | marine | x | x | |
| Clavopsella navis | Cnidaria | ? | | | | | UK | | uncertain | brackish | | x | |
| Clymenella torquata | Polychaete | | | | | | UK | | uncertain | marine | x | x | |
| Codium fragile ssp. atlanticum | Macroalga | | | NO | | NL | UK | | establ. | marine | | x | |
| Codium fragile ssp. scandinavicum | Macroalga | | DK | NO | | | | SE | establ. | marine | | x | |
| Codium fragile ssp. tomentosoides | Macroalga | GE | DK | NO | BE | NL | UK | SE | establ. | marine | | x | |
| Colaconema dasyae | Macroalga | | | | | NL | | | establ. | marine | | x | |
| Colpomenia peregrina | Macroalga | GE | DK | NO | | NL | UK | SE | establ. | marine | | | x |
| Conchoderma auritum | Cirriped | | | | | NL | | | extinct | marine | | x | |
| Corambe obscura (=batava) | Gastropod | | | | | NL | | | extinct | marine | | | |
| Cordylophora caspia | Cnidaria | GE | DK | NO | ? | NL | | SE | establ. | marine | | x | |
| Corethron criophilum | Diatom | GE | | | | | | | establ. | marine | x | | |
| Corophium (= Monocorophium) sextonae | Amphipod | GE | | NO | | NL | UK | | establ. | marine | x | x | |
| Corynophlaea umbellata | Macroalga | | | | | | UK | | establ. | marine | | x | |
| Coscinodiscus wailesii | Diatom | GE | | NO | BE | NL | UK | SE | establ. | marine | x | | x |
| Cotula coronopifolia | Tracheophyta | GE | | | | NL | | | establ. | brackish | | | |
| Crassostrea gigas | Bivalve | GE | DK | NO | BE | NL | UK | | establ. | marine | | | x |
| Crassostrea virginica | Bivalve | GE | | | | NL | UK | | unestabl. | marine | | | x |
| Crepidula fornicata | Gastropod | GE | DK | NO | BE | NL | UK | SE | establ. | marine | | | x |
| Dasya baillouviana | Macroalga | GE | DK | NO | | NL | | SE | establ. | marine | | x | |
| Desdemona ornata | Polychaete | | | | | | UK | | uncertain | marine | x | x | |
| Diadumene lineata | Cnidaria | GE | | | | NL | UK | | establ. | marine | | x | x |
| Dicroerisma psilonereiella | Dinoflagellate | | | | | | | SE | establ. | marine | x | | |
| Didemnum sp. | Tunicata | | | | | NL | | | establ. | marine | | | |
| Diplosoma listerianum | Tunicata | | | | | NL | | | establ. | marine | | x | x |

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elachista sp. | Macroalga | | | | | NL | | | establ. | marine | | | |
| Elminius modestus | Cirriped | GE | DK | | BE | NL | UK | | establ. | marine | | x | |
| Ensis directus | Bivalve | GE | DK | NO | BE | NL | UK | SE | establ. | marine | x | | |
| Eriocheir sinensis | Decapod | GE | DK | NO | BE | NL | UK | SE | establ. | marine | x | | |
| Euplana gracilis | Turbellaria | | | | | NL | | | uncertain | marine | | x | |
| Eurytemora americana | Copepod | | | | | NL | UK | | establ. | brackish | x | | |
| Eusarsiella zostericola | Ostracod | | | | | | UK | | establ. | brackish | | | x |
| Fibrocapsa japonica | Rhaphidophyceae | GE | | | | NL | | | establ. | marine | x | | |
| Ficopomatus enigmaticus | Polychaete | GE | | | BE | NL | UK | | establ. | marine | | x | |
| Fucus evanescens | Macroalga | | DK | NO | | | UK | SE | establ. | marine | | x | |
| Gammarus tigrinus | Amphipod | GE | | | | NL | | SE | establ. | brackish | | | x |
| Garveia (=Bimeria) franciscana | Cnidaria | GE | | | BE | NL | | | establ. | brackish | | x | |
| Gonionemus vertens | Cnidaria | GE | | NO | BE | NL | UK | SE | establ. | marine | x | x | x |
| Gracilaria vermiculophylla | Macroalga | GE | DK | | | NL | | SE | establ. | marine | | x | |
| Grandidierella japonica | Amphipod | | | | | | UK | | uncertain | marine | x | | |
| Grateloupia filicina var. luxurians | Macroalga | | | | | | UK | | establ. | marine | | | x |
| Grateloupia turuturu (= doryphora) | Macroalga | | | | | NL | UK | | establ. | marine | | x | x |
| Gymnodinium catenatum | Dinoflagellate | | | | | NL | | | establ. | marine | x | | |
| Gymnodinium cf. nagasakiense | Dinoflagellate | | | NO | | NL | | | establ. | marine | x | | |
| Gyrodinium corallinum | Dinoflagellate | | | | | | | SE | establ. | marine | x | | |
| Haliclona (= Acervochalina) loosanoffi | Porifera | GE | | | | NL | | | uncertain | marine | | x | |
| Haplosporidium armoricanum | Protozoa | | | | | NL | | | extinct | marine | | | x |
| Hemigrapsus penicillatus | Decapod | | | | BE | NL | | | establ. | marine | x | x | |
| Hemigrapsus sanguineus | Decapod | | | | | NL | | | uncertain | marine | x | | |
| Heterosiphonia japonica | Macroalga | | | NO | | NL | UK | SE | establ. | marine | | x | x |
| Homarus americanus | Decapod | | | NO | | | | | unestabl. | marine | | | x |
| Hydroides dianthus | Polychaete | | | | | | UK | | establ. | marine | x | x | |
| Hydroides elegans | Polychaete | GE | | | | NL | UK | | establ. | brackish | x | x | |
| Hydroides ezoensis | Polychaete | | | | | | UK | | unestabl. | marine | x | x | x |

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Imogine necopinata | Turbellaria | | | | | NL | | | uncertain | brackish | | | x |
| Incisocalliope aestuarius | Amphipod | | | | BE | NL | | | establ. | brackish | x | | |
| Janua brasiliensis | Polychaete | | | | | NL | UK | | uncertain | marine | | x | x |
| Karenia (=Gymnodinium) aureolum | Dinoflagellate | GE | | NO | | | UK | | establ. | marine | x | | |
| Karenia (=Gymnodinium) mikimotoi | Dinoflagellate | GE | DK | NO | BE | NL | UK | SE | establ. | marine | x | | |
| Laminaria ochotensis | Macroalga | GE | | | | | | | uncertain | marine | | x | |
| Leathesia verruculiformis | Macroalga | | | | | NL | | | establ. | marine | | x | |
| Lebistes reticulatus | Pisces | GE | | | | NL | | | establ. | brackish | | | x |
| Lepidopleurus cancellatus | Polyplacophora | | | | | NL | | | extinct | marine | | | x |
| Limulus polyphemus | Xiphosura | GE | DK | | | NL | | | unestabl. | marine | | | x |
| Marenzelleria cf. viridis | Annelida | GE | DK | | | NL | UK | SE | establ. | brackish | x | | |
| Marenzelleria cf. wireni | Annelida | GE | DK | NO | BE | NL | | | establ. | marine | x | | |
| Marsupenaeus (=Penaeus) japonicus | Prawn | | | NO | | | | | unestabl. | marine | | | x |
| Marteilia refringens | Protozoa | | | | | NL | | | extinct | marine | | | x |
| Megabalanus coccopoma | Cirriped | | | | BE | NL | | | establ. | marine | | x | |
| Megabalanus tintinnabulum | Cirriped | | | | BE | | | | establ. | marine | | x | |
| Melita nitida | Amphipod | | | | | NL | | | establ. | marine | x | x | |
| Mercenaria mercenaria | Bivalve | | | | | NL | UK | | establ. | marine | | | x |
| Micropogonias undulatus | Pisces | | | | | NL | | | uncertain | marine | x | | |
| Muggiaea atlantica | Cnidaria | GE | | | | | | | uncertain | marine | x | | |
| Mya arenaria | Bivalve | GE | DK | NO | BE | NL | UK | SE | establ. | marine | x | x | |
| Myicola ostreae | Copepod | | | | | NL | | | uncertain | marine | | | x |
| Mytilicola intestinalis | Copepod | GE | DK | | | NL | | | establ. | marine | | | x |
| Mytilicola orientalis | Copepod | | | | | NL | | | establ. | marine | | | x |
| Mytilopsis (=Congeria) leucophaeta | Bivalve | GE | | | BE | NL | UK | | establ. | brackish | x | | |
| Nematostella vectensis | Cnidaria | | | | | | UK | | establ. | brackish | | x | |
| Nemopsis bachei | Cnidaria | GE | | NO | | NL | | | establ. | brackish | x | x | |
| Neogobius melanostomus | Pisces | | | | | NL | | | establ. | brackish | x | | |

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Neosiphonia (= Polysiphonia) harveyi | Macroalga | GE | DK | NO | BE | NL | UK | SE | establ. | marine | | x | |
| Ocenebra erinacea | Gastropod | | DK | | BE | | UK | | uncertain | marine | | | x |
| Odontella sinensis | Diatom | GE | DK | NO | BE | NL | UK | SE | establ. | marine | x | | |
| Oncorhynchus gorbuscha | Pisces | | | NO | | | | | uncertain | marine | | | x |
| Oncorhynchus keta | Pisces | | | NO | | | | | extinct | marine | | | x |
| Oncorhynchus kisutch | Pisces | | | | | NL | | | extinct | marine | | | x |
| Oncorhynchus mykiss (=Salmo gairdneri) | Pisces | GE | DK | NO | | NL | | | establ. | marine | | | x |
| Orchestia cavimana | Amphipod | GE | | | BE | NL | | | establ. | brackish | x | | |
| Ostroumovia inkermanica | Cnidaria | | | | | NL | | | extinct | brackish | x | x | |
| Palaemon macrodactylus | Shrimp | | | | BE | NL | UK | | establ. | marine | x | | |
| Palinurus elephas | Decapod | | | | | NL | | | extinct | marine | | x | x |
| Paralithodes camtschatica | Decapod | | | NO | | | | | establ. | marine | | | x |
| Pecten maximus | Bivalve | | | | | NL | | | extinct | marine | | | x |
| Petricola pholadiformis | Bivalve | GE | DK | NO | BE | NL | UK | SE | establ. | marine | | | x |
| Pileolaria berkeleyana | Polychaete | | | | | | UK | | establ. | marine | | x | |
| Pilumnus hirtellus | Crustacean | | | | | | | SE | unestabl. | marine | x | x | |
| Pleurosigma planctonicum | Phytoplankton | | | | | NL | UK | | establ. | marine | x | | |
| Polydora hoplura | Annelida | | | | | NL | | | uncertain | marine | | | x |
| Polysiphonia senticulosa | Macroalga | | | | BE | NL | | | establ. | marine | | | x |
| Porphyra miniata | Macroalga | | DK | | | | | | establ. | marine | | x | |
| Porphyra umbilicalis | Macroalga | GE | | | | | | | uncertain | marine | | x | |
| Porphyrostromium sp. | Macroalga | | | | | NL | | | uncertain | marine | | | |
| Prorocentrum redfieldii | Dinoflagellate | GE | | | | NL | | | establ. | marine | x | | |
| Pseudobacciger harengulae | Trematoda | | | | | | | SE | establ. | marine | | | x |
| Pseudodactylogyrus anguillae | Plathelminthes | | DK | NO | | | | | establ. | brackish | | | x |
| Pseudodactylogyrus bini | Plathelminthes | | | NO | | | | | establ. | brackish | | | x |
| Pseudorasbora parva | Pisces | | | | | | UK | | uncertain | marine | | | x |
| Pterosiphonia pinnulata | Macroalga | | | | | | UK | | establ. | marine | | x | x |
| Rapana venosa | Gastropod | | | | | NL | UK | | uncertain | marine | x | | x |

| Species | Group | Country | | | | | | | Status | Habitat | Ballast | Fouling | Aquacult or stock. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rhithropanopeus harrisii | Decapod | GE | | | BE | NL | | | establ. | brackish | | x | |
| Ruditapes (=Tapes) philippinarum | Bivalve | | | NO | | | | | establ. | marine | | | x |
| Sabellaria spinulosa | Polychaete | GE | | | | | | | establ. | marine | x | x | |
| Salmo (=Onchorhynchus) clarki | Pisces | | DK | | | | | | establ. | marine | | | x |
| Sargassum muticum | Macroalga | GE | DK | NO | BE | NL | | SE | establ. | marine | | x | x |
| Scytosiphon dotyi | Macroalga | | | | | | UK | | establ. | marine | | | x |
| Smittoidea prolifica | Bryozoan | | | | | NL | | | establ. | marine | | | x |
| Solidobalanus fallax | Cirriped | | | NO | BE | | | | uncertain | marine | | x | |
| Spartina anglica | Anthophyta | GE | | | BE | NL | UK | | establ. | marine | | | x |
| Spartina x townsendii | Anthophyta | GE | DK | | BE | NL | | | establ. | marine | | | x |
| Spisula solidissima | Bivalve | | | | | NL | | | unestabl. | marine | x | | |
| Stephanopyxis palmeriana | Diatom | GE | | | BE | NL | UK | SE | establ. | marine | x | | |
| Styela clava | Tunicata | GE | DK | | BE | NL | UK | | establ. | marine | | x | x |
| Syllidia armata | Polychaete | | | | | NL | | | extinct | marine | | | x |
| Syllis gracilis | Polychaete | | | | | NL | | | extinct | marine | | | x |
| Telmatogeton japonicus | Chironomid | GE | DK | NO | BE | NL | UK | | establ. | marine | x | x | |
| Teredo navalis | Bivalve | GE | DK | NO | BE | NL | UK | SE | establ. | marine | | x | |
| Thalassiosira hendeyi | Diatom | GE | | | BE | NL | UK | | establ. | marine | x | | x |
| Thalassiosira punctigera | Diatom | GE | | NO | BE | NL | UK | SE | establ. | marine | x | | x |
| Thalassiosira tealata | Diatom | | | NO | BE | NL | UK | | establ. | marine | x | | x |
| Tharyx killariensis | Polychaete | GE | | | | | | | establ. | marine | x | x | |
| Thecadinium yashimaense (= mucosum) | Dinoflagellate | GE | | | | | | | uncertain | marine | x | | |
| Thieliana navis | Cnidaria | | | | | NL | | | establ. | brackish | x | x | |
| Tricellaria inopinata | Bryozoan | | | | BE | NL | UK | | establ. | marine | | x | |
| Trinectes maculatus (=Achirus fasciatus) | Pisces | | | | | NL | | | unestabl. | marine | x | | |
| Ulva pertusa | Macroalga | | | | | NL | | | establ. | marine | | | |
| Undaria pinnatifida | Macroalga | | | | BE | NL | UK | | establ. | marine | | | x |
| Urosalpinx cinerea | Gastropod | | | | | | UK | | uncertain | marine | | | x |
| Verrucophora cf. fascima | Dinoflagellate | | | | | | | SE | establ. | marine | x | | |

# Annex 7: Rapid Response

**Guidelines Draft Annotated Document for Review, prepared by Judith Pederson, USA.**

In marine ecosystems, once species become established it is virtually impossible to eradicate them. Management actions have focused on prevention; however, new introductions continue to occur. One strategy is to develop a rapid response to an early detection to eradicate a species completely or contain it to prevent further spread. This document is a review of the elements that should be considered and used when developing a Rapid Response Plan.

The purpose is to develop a generic approach to rapid response that can be modified for international, national, regional and local levels of authority. The Rapid Response Approach Guidelines presuppose that there is a process whereby early detection of unwanted species can be communicated to authorities. There is no standardized monitoring approach to early detection of invasions. In the U.S. often school age (elementary school to high school), undergraduate, and graduate students, naturalists, scientists with long-term monitoring stations, rapid assessment surveys, and recreational divers have found new species and sent them to experts for identification. The accurate identification of the species is verified by taxonomists and forms the basis for considering a Rapid Response. Two other components are essential for conducting a response, e.g., a responsible party (e.g. a government agency, non-government organization etc.) that receives information on new reports of new invasions and a list of unwanted species (with flexibility to consider species not on the list). There also needs to be an authority (government agency, ad hoc committee, etc.) that has the authority to respond and determine if action is needed and what level of response is appropriate. Such authorization should be decided upon in advance.

The Rapid Response Plan Guidelines provided in this document are for estuarine and marine waters, but with minor modification, it could apply to other ecosystems. The following assumptions were used in preparing this document:

- The primary goal is eradication of unwanted species, although this decision is a part of the decision process.
- A secondary goal may be to contain the species or manage it in the short- or long-term.
- The approach is suitable for the species and consistent with regulations of the political body or bodies that have oversight of treatment options.
- The rapid response protocol should be flexible in both specific approaches adopted and the timing of implementation of the protocols. Often what appears to be the optimal approach does not work in the field and other methods need to be employed.
- The underlying approach is based on sound science.
- The plan can be modified for plants or animals (including fish, parasites, etc.) or microbes and other diseases.
- A public outreach and education effort is established early and throughout the process, including how individuals can prevent invasions.

The Rapid Response Guidelines highlight the need to identify species of high risk a priori, with the caveat that any species may become invasive. There may be lag times of a few years to decades before some species disperse (Crooks and Soule, 1999). Examples include the compound sea squirt *Didemnum* sp. found in the northeast U.S., which was identified as early as 1993 or possibly earlier, but not reported until 2000. By this time it had spread from the Damariscotta River to Connecticut. Dispersal of some species is much more rapid, e.g. *Hemigrapsus sanguineus* which spread from the Delaware Bay and Cape May, New Jersey with a sighting of one gravid female to south of Boston within 12 years (McDermott, 2000). Furthermore, many macroalgae (e.g. *Caulerpa* spp., *Gracilaria vermiculophylla* and several other red algal species) can spread immediately by regrowth of moved (e.g. in fishing nets, on ropes, in bilge water) vegetative fragments (even < 1 cm). Also planktonic organisms may easily disperse further by currents.

Type of responses (mechanical, chemical, biological) as controls and vector management is discussed for different taxonomic groups. Because this guidance would apply to all levels of government, specific regulations and permits are not identified as these vary from governing body to governing body. Nonetheless, there is a need for cooperation at all levels and across borders to fully eradicate and control invasive species. Throughout the process the public, politicians, and stakeholders should be involved and outreach efforts should provide accurate information on the understanding of the threat, uncertainty in the knowledge of the species or its potential to cause harm, the potential for success (or failure), and the costs and benefits of the actions. The first section reviews seven steps involved in a Rapid Response Protocol, the next section highlights general options for treatment of marine biota, the third section reviews some eradication efforts as case studies. In addition to the seven steps other elements are also important in successful planning and implementation. These include leadership, co-ordination, adequate available funding, and other support resources (such as forming a scientific advisory group) (Dechoretz, 2003). Although not explicitly stated throughout the steps, public education on preventing introductions is assumed and is an especially important component of the vector management options.

## Section I

### *Rapid Response Protocol*

The following seven steps identify the major decision points or information needed for developing a Rapid Response plan (Figure 1). These include (1) confirmed species identification, (2) risk potential for species in questions, (3) detailed characterization of area of impact, (4) selection of treatment, (5) treatment plan and implementation, (6) monitoring for effectiveness, and (7) evaluation to determine what future actions may be needed.

### *Step 1: Identification and Confirmation of Introduced Species*

Species identification is key component of the development of a Rapid Response Plan. Misidentification may lead to actions that were unnecessary and costly. One option is to have a list of taxonomists who are willing to assist with rapid identifications. In some cases, verification may involve molecular studies, thus, reaching agreement with a lab that can conduct these analyses ahead of time reduces the length of time before accurate species identification can occur. Once the species of concern are verified, public outreach efforts should be initiated. These would include information on the species; impacts from the species or related taxa reported in other locations (if known); scenarios with and without eradication actions; and the physical, chemical, biological, and vector management options.

Box 1.

One recent example of species identified by molecular analysis was the reclassification and identification of *Porphyra* sp. in New England (Bray *et al.,* 2005; West *et al.,* 2005). Using both morphological evaluations and molecular studies, two new introduces species of *Porphyra* were found from Massachusetts to Maine. The two introduced species were *Porphyra yezoensis*, strain NA4 and the Asian species, *P. katadae*.

### *Step 2:Risk Assessment*

Presenting information on potential risk benefits from pre-determining what species might invade and estimating risk associated with each species. Risk assessment approaches range from very detailed data-intensive analysis to less data intensive assignments of high, moderate and low priority. Risk assessments may take into account, human health, biodiversity, potential to invade other areas, and impacts to valued resources (e.g. aquaculture).

An overview of risk assessments will provide decision makers with background information. The decision to attempt eradication, to quarantine, or to not take any action is, in part, based on public perception, regulations, costs, potential impacts with and without action, and a commitment by agencies on policy makers.

***Step 3. Characterization of area impacted.***

In developing a plan for response, the area currently impacted by the introduced species should be delineated and defined. Predicted areas of impact should also be identified to provide additional information for evaluating risk, for consideration in choosing treatment options, and to keep public (shareholders) informed. Consideration should be given to the size of a buffer zone around the impacted area. The buffer zone should be related to the potential for spread of the organism and be included in monitoring plan to ensure it is not spreading into new areas. Organisms that have life history characteristics favoring dispersion, e.g. crab larvae that have prolonged pelagic existence, are unlikely candidates for eradication.

The types of data to be included in the characterization report include physical habitat, (e.g., bathymetry, bottom type, currents, temperature, and salinity), presence of threatened and endangered species, impacts to human health, and other species and valued resources. The evaluation process should also include the potential for the species to continue its spread.

Because it is likely that an agency or government department head will make the final decision to proceed with developing a rapid response implementation plan, they should be kept informed throughout evaluation process. If the area is too large, there may be a decision to not proceed. However, even for highly dispersive organisms, the option to contain organisms may well delay spread until other long-term eradication approaches are employed and has been favored by some agencies. Nonetheless, the area and potential to spread to buffer areas should be assessed at this stage and may result in a no action decision.

***Step 4. Selecting Treatment Options.***

Eradication options fall into four general categories – physical, chemical and biological and vector management (Table 1). Physical and chemical options are more likely to be used in rapid responses, but each has disadvantages. For example, physical and chemical actions may extirpate valued native or threatened or endangered species. Mechanical disruptions may also create more propagules that can disperse, for species that can reproduce asexually. Some chemical options, e.g. applications of pesticides are often controversial and may leave long-lived residues. Biological control may be used as a long-term approach, but its use in marine and estuarine ecosystems is rare, if it is used at all. When populations have spread covering large areas physical or chemical options may not be feasible. If a biological agent has been previously determined to be specific to the species (i.e. not affecting any native relatives) and will not itself cause further harm, it may be used to control or manage populations. However, such risks must be evaluated in advance.

Vector management includes understanding the source and the secondary vectors that facilitate spread once a population is established. Ballast water management is one of the significant vectors with international and national efforts to regulate, establish management practices that minimize or prevent introductions, and support development of treatment technologies to prevent new introductions. However, hull fouling of all types of vessels (e.g. recreational and commercial fishing boats, recreational ships, and commercial vessels) is a vector that is not being adequately addressed. Other major vectors include bait, aquaculture, trade of living organisms (e.g. for aquaria, consumption, ornamental purposes) and canals.

### *Step 5. Choosing a Treatment Approach and Developing an Implementation Plan.*

Once a treatment approach has been identified, a Rapid Response Plan should be designed. Treatment choices will take into account the species, the extent of impact, the habitat, costs, benefits, likelihood of success, and the options available for the locality. Because permitting chemicals, pesticides, and physical activities in some habitats (e.g. salt marshes or submerged aquatic vegetation beds) may be a lengthy process. To facilitate implementation, it is recommended that options be pre-approved or a shortened permitting process be established to ensure timely action.

In addition to the regulations, public opinion and political will may be the determining factor in the implementation. Realistic expectations of taking actions or doing nothing should be part of the ongoing updates and information for the public and decision-makers.

### *Step 6. Monitoring for effectiveness.*

In order to evaluate the effectiveness of the rapid response actions, a monitoring plan should be part of the implementation plan. If done correctly, this is not an insignificant cost and may last for several years. For example, monitoring for *Caulerpa taxifolia* continues five years after the eradication effort (Anderson, 2005). In addition, the monitoring program involved placing plastic plants to test the effectiveness of the monitoring program. In other instances, monitoring may include testing for residues from toxic materials used as the extirpation agent. For example, organic chemicals such as pesticides, petroleum hydrocarbons, etc. are often perceived as more dangerous than metals or chemicals that break down *in situ*.

### *Step 7. Evaluation of Treatment to Determine if Additional Steps are Needed*

The monitoring activities should indicate the level of success. The first options may not be as effective as anticipated and additional measures may be added to the protocol. For example, hand picking may not remove all plants, chemicals and/or covering areas may need to be included in the efforts to fully eliminate any remaining species. Attempts to eradicate the sea star *Asterias amurensis* in Port Philip Bay, Australia, from 1995–1998, were abandoned after monitoring indicated the population was established (McEnnulty *et al.*, 2001) and further removal efforts would not be successful. Thus, there may be a decision to take no further action.

### *Step 8. Implications for legislation*

Efforts to respond to new invasions are costly and may not be successful. The awareness of impacts to the ecosystem and implications for the community may stimulate efforts to improve prevention of new introductions. The outcome may be to consider legislation that prevents new invasions. For example, the *Caulerpa taxifolia* eradication efforts lead to a ban on importation of *Caulerpa* to California and other states. Similarly, ballast water legislation resulted from zebra mussel invasions in the Great Lakes.

### *Summary*

Rapid Response efforts require cooperation and coordination at all levels of government and often involves several political entities. Making the decision to eradicate is as much a political decision as a scientific one. The scientific information should be the basis for the decision and provided to policy makers, politicians and the public. To be most effective, preliminary information on potential invaders should be documented along with basic physiological and ecological information that includes impacts of the invaders in other countries. The risk assessment will include information on the likelihood of reintroduction risk, related taxa, and the ability to quarantine the area during eradication.

The generic approach described above does not include the regulatory and permitting requirements that vary considerably. Thus, each country or region should consider pre-

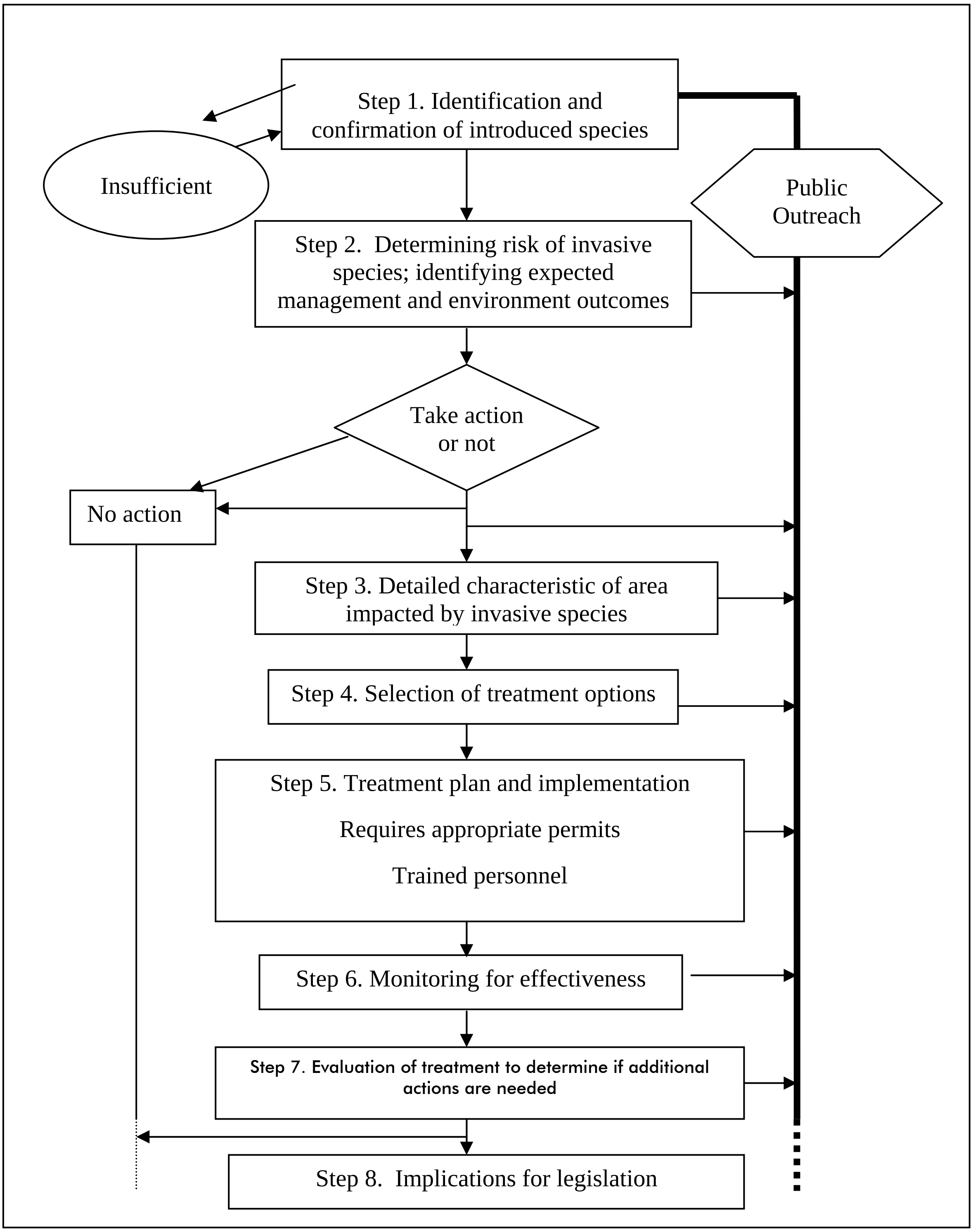


**Figure 1. Rapid Response Guidance for marine and estuarine biota.**

approval for actions that require lengthy approval processes. Keeping both the public and policy-makers informed throughout the process is considered a key component in the decision-making process.

**Table 1. Overview of control options for several taxonomic groups modified from McEnnulty *et al.* 2001 and other references.**

| TAXONOMIC GROUP | CONTROL OPTIONS | EXAMPLES | REFERENCES |
|---|---|---|---|
| Phytoplankton, HABs | Physical | Improved circulation, decreased eutrophication, sonication, clays and flocculants | McEnnulty *et a.l*, 2001; Raloff, 2002 |
| | Chemical | Hydrogen peroxide, chlorination, rarely used but could work in small lakes | McEnnulty *et al.*, 2001 |
| | Vector Management: Ballast water treatment | Exchange, pH, salinity, chlorine, oxygen deprivation, UV, hydrogen peroxide, electric-shock, heat, copper sulfate | |
| | Biological | Fungi, predators, parasites, viruses to limit phytoplankton blooms, etc., rarely used | |
| Macroalgae | Physical | Diver removal, suction, cover, harvesting, heat, cold; concern for pieces settling | Anderson, 2005; McEnnulty *et al*,. 2001 |
| | Chemical | Copper sulfate, herbicides, antifoulants, chlorine, lime | Anderson, 2005; McEnnulty *et al.*, 2001. |
| | Vector Management | Fisheries, aquaculture, ballast water & hull fouling, recreational boats, aquarium trade, package material for transports of live shellfish or baits | Trowbridge, 1998; McEnnulty *et al.*, 2001 |
| | Biological | Herbivores but questionable if they are truly species-specific, no known host specific parasites | Meinesz *et al.*, 1999; Harris and Jones, 2005; McEnnulty *et al.*, 2001 |
| Ctenophores and Cnidarians | Physical/<br>Chemical<br>Vector Management | None are effective | Graham *et al.*, 2003; McEnnulty *et al.*, 2001 |
| | Biological | Predators considered high risk, fish, *Beroe* in Black Sea was unintentional | McEnnulty *et al.*, 2001 |
| Molluscs | Physical | Handpicking, harvesting, filters (larvae), thermal shock, salinity, UV (larvae), electricity, ultrasonic, flow, bounty programs, selective fishing effort | McEnnulty *et al.* 2001 |
| | Chemical | Antifoulants, chlorine, copper sulfate, mollusicides, pesticides | McEnnulty *et al.* 2001 |
| | Vector Management | Ballast water, hulls, canals, aquaculture, recreational boats, food trade | Moy, 1999; McEnnulty *et al.*, 2001 |
| | Biological | Polyploids, parasites, predation, pathogens, sterility | |
| Crustaceans | Physical | Trapping, fishery, sound pulses, screens, etc. | McEnnulty *et al.*, 2001; W. Walton, pers. comm. |
| | Chemical | Poisoned bait, pesticides (insecticides), metals, organic chemicals, salinity, hormonal interruptive molecules, etc. | McEnnulty *et al.*, 2001 |

| | | | |
|---|---|---|---|
| | Vector Management | Ballast, hulls, aquaculture, recreational boats and fishing, food and aquarium trade | Ruiz *et al.*, 1998; McEnnulty *et al.*, 2001 |
| | Biological | Castrating parasites (but not species specific), predatory fish, crabs, birds, genetic control – not yet effective | Thresher, 1996; Goddard *et al.*, 2005, Torchin *et al.*, 2005; McEnnulty *et al.*, 2001 |
| Wood borers and other borers | Management | Plastic etc. wraps, vacuum/ pressure, turpentine, insecticides, plastic replacements, wood selectivity | McEnnulty *et al.*, 2001 |
| Polychaetes | Physical | Divers, hot water, wax on prey shells, heat, ultrasound, freshwater | Culver and Kuris, 1999, 2000; McEnnulty *et al.*, 2001 |
| | Chemical | Metals, petroleum hydrocarbons, detergents, pesticides, radiation, microencapsulated toxins | McEnnulty *et al.*, 2001 |
| | Vector Management | Hulls, ballast, aquaculture, fisheries, bait | McEnnulty *et al.*, 2001 |
| | Biological | No known specialized parasites, copepods, bacteria, viruses, fungi, etc., | McEnnulty *et al.*, 2001 |
| Echinoderms | Physical | Bounty, fisheries, manual removal, specialized dredges, trapping, reduced density lowers reproduction, food and fertilizer | McEnnulty *et al.*, 2001 |
| | Chemical | Metals, lime, toxin filled pole spears | Thresher *et al.*, 1998; McEnnulty *et al.*, 2001 |
| | Vector Management | Ballast, hulls, moorings, aquaculture management, live and fresh food trade, ornamentals, | Thresher *et al.*, 1998; McEnnulty *et al.*, 2001 |
| | Biological | Natural chemicals, genetic manipulation, parasites (ciliate, etc.), | Thresher *et al.*, 1998; McEnnulty *et al.*, 2001 |
| Bacteria | Vector management | Heat (cooking), sanitation, education, food safety etc., ballast water treatments (not currently effective), aquaculture, UV, bacteriophages | McEnnulty *et al.*, 2001; Morrison and Rainnie, 2004 |
| Phanerogams (saltmarsh and seagrasses) | Physical | Hand pulling, steam, harvesting (N.B. seedbanks might be left), | Daehler and Strong, 1996, 1997; McEnnulty *et al.*, 2001 |
| | Chemical | Herbicides | |
| | Biological | Specific herbivores but questionable if they are truely species-specific | |
| | Vector Management | Intentional plantations against erosion, package material for transports of live shellfish or baits (e.g. *Zostera japonica)* | |
| Fish | Physical | Removal, drawdowns, electro-fishing | McEnnulty *et al.*, 2001 |
| | Chemical | Pisicide (e.g., rotenone), lime, etc., contaminated diets, pheromones, trap and kill | McEnnulty *et al.*, 2001 |

| | | | |
|---|---|---|---|
| | Biological | Virus, predator stocking, gender manipulation (etc.) | McEnnulty *et al.*, 2001 |
| | Vector Management | Aquaculture, ballast water, trade with live organisms (food, aquaria, ornamental purposes (lakes)) | |
| Parasites | Vector Management | Aquaculture, ballast water, ornamentals, bait | |

## Literature cited


Anderson, L.W.J. 2005. California's reaction to *Caulerpa taxifolia*: a model for invasive species rapid response. Biological Invasions, 7:1003–1016.

Bray, T.L., Neefus, C.D., and Mathieson, A.C. 2005. Two Asian Species of *Porphyra* Found on the New England Coast. In Northeast Aquatic Nuisance Species Panel. 2005. Implementing Rapid Response to Aquatic Nuisance Species in the Northeast: Key Components of a Successful Program.

Caulerpa Working Group. 2005. National management Plan for the Genus *Caulerpa*. U.S. Fish and Wildlife, Washington, D.C.

Chinese Mitten Crab Working Group. 2003. National Management Plan for the Genus *Eriocheir* (Mitten Crabs). US Fish and Wildlife, Washington, D.C.

Coutts, A.D.M. 2002. The development of incursion response tools-underwater vacuum and filter system trials. Cawthron Report no. 755. Cawthron, Nelson, New Zealand.

Crooks, J.A. and Soule, M.E. 1999. Lag times in population explosion of invasive species: causes and implications. Pp 103–124 In: Sandlund, OT, Schei PJ and Viken Å (eds.) Invasive Species and Biodiversity Management. Kluwer Academic Publishers, Dordrecht, The Netherlands. 431 pp.

Culver, C.S. and Kuris, A.M. 1999. The sabellid pest of abalone: the first eradication of an established introduced marine bioinvader? pp. 100–101. In: Pederson, J. ed., First National Conference on Marine Bioinvasions January 24–27, 1999. Massachusetts Institute of Technology, Massachusetts, USA.

Culver, C.S. and Kuris, A.M. 2000. The apparent eradication of a locally established introduced marine pest. Biological Invasions, 2: 245–253.

Daehler, C.C. and Strong, D.R. 1996. Status, prediction and prevention of introduced cordgrass Spartina spp. Invasions in Pacific estuaries, USA. Biological Conservation, 78: 51–58.

Daehler, C.C. and Strong, D.R. 1997. Reduced herbivore resistance in introduced smooth cordgrass (*Spartina alterniflora*) after a century of herbivore-free growth. Oecologia, 1100: 99-108.

Dethier, M.N. and Hacker, S.D. 2005. Improving Management Practices for Invasive Cordgrass in the Pacific Northwest: A Case Study of *Spartina anglica*. Washington Sea Grant Program, Seattle, Washington.

Goddard, J.H.R., Torchin, M.E., Kuris, A.M., and Lafferty, K.D. 2005. Host specificity of Sacculina carcini, a potential biological control agent of the introduced European green crab Carcinus maenas in California. Biological Invasions, 7: 895–912.

Graham, W.M., Martin, D.L., Felder, D.L., Asper, V.L., and Perry, H.M. 2003. Ecological and economic implications of a tropical jellyfish invader in the Gulf of Mexico. Biological Invasions, 5: 53–69.

Hallegraeff, G.M., Valentine, J.P., Marshall, J.-A., and Bolch, C.J. 1997. Temperature tolerances of toxic dinoflagellate cysts: application to the treatment of ships' ballast water. Aquatic Ecology, 31: 7–52.

Harris, L.G., Jones, A.C. 2005. Temperature, herbivory and epibiont acquisition as factors controlling the distribution and ecological role of an invasive seaweed. Biological Invasions, 7: 913–924.

Kuris, A.M. 2003. Did biological control cause extinction of the coconut moth, *Levuana iridescens*, in Fiji? Biological Invasions, 5: 133–141.

Lafferty, K.D. and Kuris, A.M. 1996. Biological control of marine pests. Ecology, 77(7): 1989–2000.

Maine Department of Environmental Protection. 2006. Rapid Response Plan for Invasive Aquatic Plants, Fish and other Fauna. Maine, Department of Environmental Protection, Augusta, Maine.

McDermott, J.J. 2000. Natural history and biology of the Asian shore crab Hemigrapsus sanguineus in the Western Atlantic: A review with new information. 13–199 pp., In: Pederson, J. (ed.), Marine Bioinvasions: Proceedings of the First National Conference January 24–27, 1999. Massachusetts Institute of Technology, Massachusetts, USA.

McEnnulty, F.R., Bax, N.J., Schaffelke, B., and Campbell, M.L. 2001. A review of rapid response options for the control of ABWMAC listed introduced marine pest species and related taxa in Australian waters. Centre for research on introduced marine pests. Technical Report No. 23: CSIRO Marine Research, Hobart, 101 pp.

Meinesz, A. (translated by Simberloff, D.) 1999. *Killer algae*. The University of Chicago Press, Chicago, USA. 360 pp.

Morrison, S. and Rainnie, D.J. 2004. Bacteriophage therapy: an alternative to antibiotic therapy in aquaculture? Can. Tech. Rep. Fish. Aquat. Sci., 2532: v + 23 p.

Moy, P.B. 2000. Development of an aquatic nuisance species barrier in a commercial waterway. Pp 357. In: Pederson, J. (ed.), Marine Bioinvasions: Proceedings of the First National Conference January 24–27, 1999. Massachusetts Institute of Technology, Massachusetts, USA.

NEANS (Northeast Aquatic Nuisance Species). 2003. Rapid Response to Aquatic Nuisance Species in the Northeast: Developing an early detection and eradication protocol. Workshop proceedings Bar Harbor, Maine May 20 and 21, 2003. Northeast Aquatic Nuisance Species, Boscawen, New Hampshire.

NEANS (Northeast Aquatic Nuisance Species). 2005. Implementing Rapid Response to Aquatic Nuisance Species in the Northeast: Key Components of a Successful Program. May 3, 2005. Northeast Aquatic Nuisance Species, Boscawen, New Hampshire.

Raloff, J. 2002. Taming toxic tides: can we slay poisonous algal blooms with clay? Science News, November 30, 2002.

Taylor, M., Hay, C., Forrest, B. 1999. Patterns of Marine Bioinvasion in New Zealand and Mechanisms for Internal Quarantine. In Pederson, J., ed. Marine Bioinvasions, Proceedings of the First National Conference. Pp 289–295.

Thresher, R.E. 1996. Environmental tolerances of larvae of the European parasitic barnacle, *Sacculina carcini* (Rhizocephala: Sacculinidae): implications for use as a biological control agent against the introduced European crab, *Carcinus maenas*. Crimp Technical Report No. 7.

Torchin, M.E. 2005. Differential Parasitism of native and introduced snails: replacement of a parasite fauna. Biological Invasions, 7: 885–894.

Trowbridge, C.D. 1998. Ecology of the green macroalga *Codium fragile* (Suringar) Hariot 1889: invasive and non-invasive subspecies. Oceanography and Marine Biology. An Annual Review, 36: 1–64.

Trowbridge, C.D. 1999. An assessment of the potential spread and options for control of the introduced green macroalga *Codium fragile* ssp. *tomentosoides* on Australian shores. Unpublished Report to CSIRO Marine Research, Hobart, Australia. 43 pp.

US EPA (US Environmental Protection Agency). 2005. Overview of EPA Authorities for Natural Resource Managers Developing Aquatic Invasive Species Rapid Response and Management Plans. U.S. Environmental Protection Agency Office of Wetlands, Oceans and Watersheds, Washington, D.C.

West, A.L., Mathieson, A.C., Klein, A.S., Neefus, C.D., Bray, T.L. 2005. Molecular ecological studies of New England species of Porphyra (Rhodophyta, Bangiales). Nova Hedwigia, 80: 1–24.

# Annex 8: Ten-Year summary of National Reports 1992–2002

## Status of Introductions of Non-indigenous Marine Species to North Atlantic and Adjacent Waters According to National Reports Considered at Meetings of the Working Group on Introductions and Transfers of Marine Organisms 1992-2002

### ICES Cooperative Research Report

Editors

Stephan Gollasch, Dorothee Kieser, Dan Minchin and Inger Wallentinus

# Foreword

As a fishery-oriented inter-governmental organisation, ICES has been confronted early on with issues related to the introductions of non-indigenous species, in particular diseases and parasites transferred with live transport of fish and shellfish for relaying, stocking, ranching and for fresh-fish markets. During the late 1960s and early 1970s, the need to assess the risks associated with deliberate transfers of species was primarily of concern. As a result the Working Group on Introductions and Transfers of Marine Organisms (WGITMO) was launched with its first meeting held in Convy, Wales, April 4, 1979. Since the working group met almost on an annual basis – with the 25th Anniverary meeting held in Vancouver, Canada in 2003.

The first status report on introduced species in the North-Atlantic and its adjacent waters, prepared by WGITMO, appeared in 1980. The second Status Report of Introductions of Non-Indigenous Marine Species into North-Atlantic Waters 1981–1991 was published as ICES Cooperational Research Report No. 231 in 1999. This report is a continuation of the earlier efforts and summarizes species introductions as reported during WGITMO meetings 1992–2002 (Table 1). The list of participants at the meetings considered here is provided in Annex 2.

**Table 1. Sequence of WGITMO meetings with indication of meeting dates, venue and chairman.**

| Year | Date | Location | Chair | Meeting number |
|---|---|---|---|---|
| 1992 | April 14-17 | Lisbon – Portugal | J.T. Carlton | 14 |
| 1993 | April 26-28 | Aberdeen - Scotland | J.T. Carlton | 15 |
| 1994 | April 20-22 | Mystic CT - U.S.A. | J.T. Carlton | 16 |
| 1995 | April 10-13 | Kiel – Germany | J.T. Carlton | 17 |
| 1996 | April 22-26 | Gdynia – Poland | J.T. Carlton | 18 |
| 1997 | April 22-25 | La Tremblade - France | J.T. Carlton | 19 |
| 1998 | March 25-27 | The Hague - Netherlands | J.T. Carlton | 20 |
| 1999 | April 14-16 | Conwy - United Kingdom | J.T. Carlton | 21 |
| 2000 | March 27-29 | Parnu – Estonia | J.T. Carlton | 22 |
| 2001 | March 21-23 | Barcelona – Spain | S. Gollasch | 23 |
| 2002 | March 20-22 | Gothenburg - Sweden | S. Gollasch | 24 |

The National Reports received during the reporting period (Table 2) were considered in detail when preparing this report. It should be noted that the attendence at WGITMO meetings was not continuous for all ICES Member Countries. Canada, England & Wales, Ireland, Sweden and the United States of America delivered National Reports to all meetings. Non-ICES Member Countries, such as Australia and Italy also provided comprehensive information on introduced species.

In addition to intentionally imported and/or released organisms, unintentional species introductions were also of concern: Chapter 1 provides information on disease agents and parasites. Macroalgae and phytoplankton are dealt with in chapter 2 and invertbrates in chapter 3. Fish are covered in chapter 4. Comprehensive annexes provide information of first records of non-indigenous species (Annex 1 – not limited to ICES Member Countries) and deliberate species introductions as well as live species imports and transfers (Annex 2).

Taxonomic inconsistencies (identical species named differently in National Reports from different countries) could not be overcome and this is why this report provides taxonomic data as submitted in the individual National Reports.

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**Table 2. National reports received at WGITMO meetings 1992–2002.**

| National Report | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | | | | | | | X | | | | X |
| Belgium | | | | | | | | | | X | X |
| Canada | X | X | X | X | X | X | X | X | X | X | X |
| Denmark | | X | | | | | | | | | |
| England & Wales | X | X | X | X | X | X | X | X | X | X | X |
| Estonia | | | | | | | | X | X | X | X |
| Finland | X | X | X | X | X | X | | X | X | X | X |
| France | | X | X | X | | X | X | X | X | X | X |
| Georgia | | | | | | | | | | X | |
| Germany | | | X | X | X | X | X | X | X | X | X |
| Ireland | X | X | X | X | X | X | X | X | X | X | X |
| Israel | | | | | | | X | | | | |
| Italy | | | | | | | X | | X | X | X |
| Netherlands | | | | | | | X | X | X | X | |
| Norway | X | X | X | | X | X | X | X | X | X | X |
| Poland | | X | | | X | X | | X | X | | X |
| Portugal | X | | | | | | | | | | |
| Scotland | X | | X | X | | | | | | | |
| Spain | X | X | | | | | | | | X | |
| Sweden | X | X | X | X | X | X | X | X | X | X | X |
| U.S.A. | X | X | X | X | X | X | X | X | X | X | X |
| **Total** | **10** | **11** | **10** | **9** | **9** | **10** | **12** | **12** | **13** | **15** | **14** |

# 1 Viruses, bacteria, fungi and parasites

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## Introduction

The introduction of fish pathogens and parasites through human-mediated activities has been a major concern world-wide. To prevent introductions of disease agents via intentional transfers of aquatic animals, governments as well as international bodies (e.g. ICES, OIE- World Organization for Animal Health) have developed regulations, codes of practice and guidelines.

One of the best described introductions of a parasite through intentional fish movements is the transfer of the trematode, *Gyrodactylus salaris*. As stated by Johnson and Jensen (1991), the parasite was transferred with Atlantic salmon smolts from Sweden to Norway. The infected smolts were placed in a hatchery from where they were outplanted to several rivers. It is assumed that the Atlantic salmon populations in the exposed rivers declined due to the spreading of the parasite and the damage it caused to the juvenile fish. In an effort to control the parasite many rivers were depopulated and subsequently restocked with uninfected fish. However, since stocking only occurred with a few species (primarily Atlantic salmon) there was a significant effect not only on the target species but on all other fin fish species that were native to the depopulated rivers.

Another example of introduction of fish disease agents is described by Lightner *et al.* (1992) in various publications. The work clearly shows the spreading of shrimp diseases with the transport of infected animals. The spread of crayfish plague caused by the fungus, *Aphanomyces astaci*, into and within Europe from North America is also well documented (Bower and McGladdery, 2001 and references therein). While crayfish native to North America are resistant to the disease, the disease has had severe impacts on some European stocks. The disease is thought to have spread starting in Italy in the 1860 following the introduction of American freshwater crayfish. The fungus was transferred to Britain in 1981 and also spread to Turkey, Greece and Norway during the 1980s.

The spread of the bacterial fish disease, furunculosis from Scotland to Norway via infected smolts is also well-documented. (Johnsen, 1994). Following importation of rainbow trout from Denmark, furunculosis was first detected in Norway in 1964. Through disease control measures, the disease appeared eradicated from Norwegian farms by 1969. However, it was detected again following the importation of smolts from Scotland in 1985. The disease is presumed to have spread from farmed fish to wild stocks in rivers.

Hence international codes and individual country regulations to reduce the risk of inadvertent transfer of pathogens and parasites through intentional fish movements (including shellfish and crustacean) are essential. In general, they apply to aquaculture activities. However, regulations often fail to cover common commercial activities such as relaying and other temporary holding in fish habitat from which the disease agents could escape and infect susceptible species in the environment.

In addition, a category of transfers that has largely been ignored for its risk of transferring fish pathogens is the aquarium and display fish trade. A recent example is the transfer of spring viremia of carp (SVC) with ornamental Koi carp from a koi supplier in West Virginia. SVC is an OIE listed disease which can affect numerous carp species (e.g. common carp- *Cyprinus carpio*, grass carp- *Ctenopharyngodon idellus*, silver carp- *Hypothalmichthys molitrix*, bighead carp- *Aristychthys nobilis*). To track and eradicate fish from that source to minimize impact on the US carp populations was an expensive undertaking for USA regulatory authorities.

Similarly, Koi Herpes virus is thought to have been transferred with Koi carp. It was first detected in Israel and is thought to have spread to Europe, Indonesia, the USA and recently Japan. Recent (October 2003) outbreaks have affected both the edible common carp and the Koi industry in Japan and are a concern to breeders in other countries. (Information from the International Society for Infectious Diseases, http://www.isid.org -Promed-Mail January 3, 2004)

## 1992–2002 Summary

This chapter gives a summary from 1992 to 2002 of the pathogens and parasites noted in National reports of member and guest countries making up the ICES Working Group on Introductions and Transfers (Table 1).

As the reader will see, the information is very patchy. Additional information may be obtained from the ICES Working Group on Diseases and Pathology of Marine Organisms which records major disease occurrences, including newly emerging and exotic diseases in member countries. The reader may also wish to check for OIE reports on current fish health issues and new findings.

**Table 1. Summary table of reported pathogens and parasites.**

| PATHOGEN/ PARASITE | YEAR REPORTED | COUNTRY |
|---|---|---|
| *Anguillicola crassus* | 1995 | Germany |
| … | 1997 | Germany |
| … | 1998 | Germany, Netherlands |
| … | 2001 | Germany, Ireland |
| … | 2002 | Germany, Ireland, Sweden |
| *Bonamia* | 1995 | France |
| … | 2001 | Spain |
| *Gyrodactylus salaris* | 1992 | Norway |
| … | 1993 | Finland |
| *Haplosporidium nelsoni* (MSX) | 2001 | USA |
| ISA virus | 1999 | UK |
| … | 2001 | UK |
| … | 2002 | USA |
| *Marteilia* | 1995 | France |
| … | 2001 | Spain |
| *Myicola orientalis* & *Mytilicola orientalis* | 1993 | Ireland |
| … | 1995 | Ireland |
| … | 1997 | Ireland |
| … | 1998 | Ireland |
| … | 2001 | Ireland |
| *Perkinsus* | 2001 | Spain |
| *Pseudogyrodactylus bini* | 2002 | USA |
| *Pseudogyrodactylus anguillarum* | 2002 | USA |
| QPX | 1997 | Canada |
| Sabellid Fan worm | 1998 | USA |
| VHS virus | 1995 | Scotland |
| *Vibrio vulnificus* | 1998 | Norway |

The most frequent reports concern the parasitic nematode, *Anguillicola crassus*. This parasite is reported to be a natural parasite of eels in Southeast Asia. It is thought to have been introduced to Europe in the early 1980s (DeCharleroy, 1990). Its life cycle involves fish where it is a parasite of the swimbladder and a crustacean as an intermediate host. Copepod and ostracod and at least one species of snail have been reported as intermediate hosts and it has several fish reservoir (paratenic) hosts. This multiplicity of hosts gives it the ability to spread considerably in new environments (Gulf States Marine Website http://nis.gsmfc.org/nis_factsheet.php?toc_id=9). The 1995 German report indicates that 100% of the eel population of the Elbe River was infected. However, subsequent reports from both Germany and the Netherlands suggests that the infestation rate is decreasing. At the same time its range is thought to increase (German report 1997, 1998). Ireland includes comments about its spread between river systems and surmises that it may have been introduced into its fresh water systems via live-haul (viviere) trucks. Once established it not only affects eels, it also is found in paratenic hosts including the ruffe (*Gymnocephalus cernuus*) and black goby (*Gobius niger*).

Ireland has repeatedly reported problems with Myicola orientalis and Mytilicola orientalis. The parasites now seem established in certain areas following their initial introduction with half-grown oysters from France. This points to some of the problems associated with relaying of live material.

*Bonamia ostreae* and *Marteila* sp. are recognized world-wide as parasites of oyster that have had significant impacts on oyster populations in areas where they are newly introduced (Bower, 2003). Bonamia is thought to have been introduced via transfers of *Ostrea edulis* to the East Coast of the USA and to Europe in the late 1970s (Elston *et al.*, 1986; Friedman and Perkins, 1994; Cigarría and Elston, 1997).

## References


Bower, S.M., McGladdery, S.E. 2001. Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish: Table of Contents. URL: http://www-sci.pac.dfo-mpo.gc.ca/shelldis/toc_e.htm

Cigarría, J. and Elston, R. 1997. Independent introduction of *Bonamia ostreae*, a parasite of *Ostrea edulis* to Spain. Diseases of Aquatic Organisms, 29: 157–158.

DeCharleroy, D.L., Grisez, L., Thomas, K., Belpaire, C., Ollevier, F.. 1990. The life cycle of Anguillicola crassus. Diseases of Aquatic Organisms, 8: 77–84.

Elston, R.A., Farley, C.A., and Kent, M.L. 1986. Occurrence and significance of bonamiasis in European flat oysters *Ostrea edulis* in North America. Diseases of Aquatic Organisms, 2: 49–54.

Friedman, C.S. and Perkins, F.O. 1994. Range extension of Bonamia ostreae to Maine, U.S.A. Journal of Invertebrate Pathology, 64: 179–181

Gulf States Marine Site: Material on *Anguillicola crassus*: http://nis.gsmfc.org/nis_factsheet.php?toc_id=9

Johnsen, B.O. and Jensen, A.J.. 1991. The *Gyrodactylus* story in Norway. Aquaculture, 98(3,4): 289–302.

Johnsen, B.O. and Jensen, A.J. 1994. The spread of furunculosis in Norwegian Rivers. Journal of Fish Biology, 45(1): 47–55.

Lightner, D.V., Bell, T.A., Redman, R.M., Mohney, L.L., Natividad, J.M., Rukyani, A., and Poernomo, A. 1992. A review of some major diseases of economic significance in penaid prawns/shrimp of the Americas and Indopacific. *In* Diseases in Asian aquaculture, pp 57–80. Ed. By I. M. Shariff, R.P. Subsinghe and J.R. Arthur. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Office International des Epizooties. 2002. International Aquatic Animal Health Code 2002, Paris, France, 157 pp.

# 2 INTRODUCTIONS AND TRANSFERS OF PLANTS

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## 2.1 Introduction

The information in this part is compiled from the ICES WGITMO Reports during the period 1992–2002, as well as from literature, since many countries have not contributed with National reports. Furthermore, information on macroalgae, phytoplankton and phanerogams has in general only been included in parts of the National reports (in 75 out of totally 126 National reports to the ICES WGITMO during the period 1992–2002), and only in one case has an introduced benthic microalgae been reported (literature has not been search for this group). In some countries no new plant introductions have occurred. The aim was also to follow up the fate of old introductions, and the present status is reported, whenever information was available. The areas covered are the countries along the coasts of the North Atlantic and the Baltic Sea, including also the non-Atlantic coasts of ICES member countries (in USA the most spectacular macroalgal introductions have occurred on the Pacific coast, and may well occur also on the Atlantic coasts of North America), as well as the other European countries in the W Mediterranean Sea. On the other hand information from Australia, Georgia, and Israel in the ICES WGITMO Reports has not been included, except for when reporting on eradication programmes and targeted risk species.

Benthic algae and phanerogams are listed by country for the different coastal areas, while phytoplankton species are dealt with by sea areas, at the end of this chapter. Established species reported in the last Status Report (Wallentinus, 1999a) are also listed for each country, together with the first record of attached plants (it should be noted that the printing of that Status Report was delayed by more than six years, thus many general references on introduced algae between 1992 and 1999 were not included). Listed introductions also include species having arrived into a country by dispersal from other countries, to which they were once introduced, in one way or the other.

Macroalgal introductions are summarized in Table 2.1. For full taxonomic affiliations of the species see Guiry *et al.* (2006).

Introduced phanerogams in coastal areas are seldom reported. For each European country a list is given, compiled by Wallentinus (2002: Appendix 1), most of these species not included in the previous Status Report (Wallentinus, 1999a). However, most of them are old introductions, which grow, or have the potential to grow (i.e. they may not occur along the sea shores in areas, where they have been introduced), at or in close proximity to the sea, and only a few are living submerged. The lists do generally not include species, which are not naturalized such as e.g. tomato plants, *Solanum lycopersicum* (Tutin *et al.*, 1972), which in most countries also can be found as adventive plants in banks of seaweeds and seagrasses cast ashore on the beaches. For North America only tentative lists are given and they only apply to the Atlantic coasts of S Canada and the N US, and additionally plants introduced into San Fransisco Bay are listed. Due to time limitation, it has in general not been possible to follow up the current status of the introduced phanerogams.

Not included in this report are all algal species brought to laboratories for small scale, indoor studies in taxonomy, ecology and physiology, and for maintaining algal cultures in the laboratory. Such deliberate introductions have probably been made to most universities, research laboratories and field stations, and would give an immense list, if at all possible to assemble. The same also applies to microalgae used for food in hatcheries.

## 2.2 Species of special concern

Some algae have been specifically mentioned in the terms of references to or recommendations by the ICES WGITMO or the ICES/IMO/IOC SGBOSV and Status reports were received. The overall performances of these algae are briefly summarized below.

### 2.2.1 The Japanese kelp *Undaria pinnatifida*

The first European record of this brown alga was in Mediterranean France in 1971 following imports of oysters from Japan. Since "wakame" was a sought after food item for Asiatic restaurants, in 1983 it was brought to the Atlantic coast of N France (mainly around Brittany) for cultivation. Small-scale distribution of plants in the wild was seen already in in 1986 in Rance (see below), and in 1987 at the Island of Ouessant (ICES WGITMO, 1987, Floc'h *et al.*, 1991). For details on the history of the accidental and intentional introductions of this species in Europe, and the risk that it would disperse to other areas see the previous Status Report (Wallentinus, 1999a) and Wallentinus (1999b, submitted), the latter two also reporting on first records on other continents where it then had been introduced (China, Taiwan, New Zealand, Australia, Argentina, Mexico, and California).

In N France six sites were seeded with *Undaria* in 1991, but only one showed a good harvest, amouting totally to less than 50 tonnes. The densities were reported to be low and it was concluded that the species had not become permanently established in the wild except for at St Malo (ICES WGITMO, 1993; cf. however Floc'h *et al.*, 1991). A Status report for Spain 1992 stated that the alga was relatively common in the Ria de Arosa, N Spain (incl. on mussel rafts), at that time the only site in Spain (ICES WGITMO, 1992). It was said to have a smaller impact on the environment there, than *Sargassum muticum*. *U. pinnatifida* probably had arrived to N Spain by transfers of oysters from the Thau lagoon in S France, and farming experiments in open water were conducted at a few sites in Galicia (ICES WGITMO, 1993).

In 1994 a Status report was delivered by France as requested in the ICES C.Res. 1989/4.4. That report listed eight farming sites after 1990, with a production of between 40 to 75 tonnes fresh weight per year, with two sites later abandoned. It was emphasized that *U. pinnatifida* only had colonized some areas close to farming sites, at St Malo and Charente Maritime, while other sites had small and fluctuating populations (cf. however, Floc'h *et al.* 1996), and that there was no ecological impact and several grazers were eating the alga (ICES WGITMO, 1994). Two other papers on *U. pinnatifida* in N France were also discussed at that meeting (Castric-Fey *et al.*, 1993; Hay and Villouta, 1993). Castric-Fey *et al.* (1993) reported on diving surveys, outside the farming area at Rance, where farming had occurred since 1983, the first "wild" plants recorded already in 1986, and where large populations of mixed size classes (i.e. plants being present all year) were seen in 1992. *U. pinnatifida* by then covered almost all available substrata, not already occupied by the perennial *Laminaria* species. They also discussed that there might be a competion with the native annual kelp *Sacchorhiza polyschides*, but still considered that there was no detrimental effect of *U. pinnatifida* on the environment. Hay and Villouta (1993) reported on the huge amounts *U. pinnatifida* cast ashore at St Malo, which were also seen at the Seaweed Symposium taking place there in 1992, while at that time the amounts drifting ashore at Iles d'Oussant were much smaller.

The Status report from 1996 emphasized the new establishment on the English S coast (see more at 2.3.1.10), and the risk that it would extend its range in W Europe, through e.g. shipping. It also concluded that the species by then had been accidentally introduced to New Zealand, Tasmania, Argentina, N Spain, in the Mediterranean (France and Italy) and that most of the original farms on the Atlantic coast of France, to which it was introduced deliberately, then were out of business (ICES WGITMO, 1996 and references therein). The French report, in 1997, stated that the natural subtidal populations had declined significantly, especially in N Brittany, due to grazing by the snail *Gibbula*, which, however, was a temporary decrease and the abundances later returned to initial levels, Furthermore, it was also said that only few, not hibernating, natural populations were found outside longline cultures in SW France (ICES WGITMO, 1997, 1998). Two papers by Castric-Fey *et al.* (1999a, 1999b) gave a more detailed picture of the situation at St Malo, N. France, where after the first years the species had established in several ha along the shoreline, and in 1992 reached depths of 12 m. In 1994 there was a substantial, but temporary, decline due to abalone grazing, with biomasses again increasing during 1996 and 1997, and a further spread northwards to Normandy in 1997. They also mentioned that two morphological forms occurred in the area, and that two generations could succeed each other during the year, making it possible to detect both young and old sporophytes in early autumn (ICES WGITMO, 1999).

The first record of *U. pinnatifida* in the Netherlands was from Oosterschelde in March 1999 (ICES WGITMO, 2000). The first record in Belgium was either 1999 (Wallentinus, 1999b) or 2000 at Zeebrugge (ICES WGITMO, 2001). In the Oosterschelde dense populations were soon established, and it was spread, probably by movements of oyster pots, to Lake Grevlingen (ICES WGITMO, 2001). See also 2.3.1.7, 2.3.1.8.

In USA the species was first found established at several sites in California in 2000, the assumed vector being either hull fouling or ballast water (Silva *et al.*, 2002; ICES WGITMO, 2002, see also 2.3.4.2).

At the “Biocontrol meeting” in 1997 (ICES WGITMO, 1997; ICES SGMBIS, 1997), Australian participants told about their eradication attempts with physical removal from a marine reserve area, since they considered the natural enemies to be too few to have any effect. Furthermore, nine tested herbicides had limited success on the sporophytes, while tests on the gametophytes still were to be carried out.

A review of this species’ performance, dispersal, possible vectors and potential harm or utilization was given by Wallentinus (1999b and references therein), and more information is available in an updated Alien Species Alert Report (Wallentinus, submitted). The extreme tolerance of the microsopic gametophytes, being able to survive out of water for more than a month, was emphasized, making it a high risk species for dispersal, since they can occupy minute crevices of ships. It was predicted that the species could be able to establish in most cold and warm temperate areas worldwide, providing salinities are not below 20 psu, especially close to harbours and aquaculture sites. *U. pinnatifida* is also included in Australia’s target list of unwanted species (ICES WGITMO, 1998).

Engel *et al.* (2003) looked at the geographical mitochondrial gene lineages of 16 populations worldwide to elucidate the migration routes of the species. Two such studies have later been published (Daguin *et al.*, 2005; Voisin *et al.*, 2005).

### 2.2.2 The Japweed *Sargassum muticum*

For the history of the accidental and intentional introductions of this species in Europe, first reported record in 1973 in S England, see the previous Status Report (Wallentinus, 1999a) and Wallentinus (1999c), the latter also reporting on other areas of introduction.

A brief review on the status of its distribution in ICES countries was included in the ICES WGITMO report 1992 (Wallentinus, 1992). It was at that time found from the S coast of Norway and the N west coast of Sweden in the north (but not in the Baltic Sea), to Spain and Portugal in the south, with the exception of Ireland and Scotland. In the Mediterranean it had at that time only been found in France, probably having arrived there with oysters. At the American Pacific coast, it then occurred from the N part of British Columbia southwards to the middle part of Mexico, while there were no records from the Atlantic coasts.

In the Mediterranean, it had spread to Venice Lagoon, Italy, in 1992, where the spread was slow the first years, but at the end of the 1990s, it had in some areas outcompeted the native brown alga *Cystoseira barbata* (see more at 2.3.3.3)

In 1995, it was for the first time recorded from Northern Ireland (ICES WGITMO, 1995) where an eradication programme had started, and two tonnes been collected (ICES WGITMO, 1996), albeit such efforts, when it was found in England, were unsuccessful (Critchley *et al.*, 1986). In 2001, the first plants were recorded from the W and SW coast of Ireland (ICES WGITMO, 2002). See also 2.3.1.11.

In N France, it had during the 1990s resulted in a progressing decline of the native kelp *Laminaria digitata* (Cosson, 1999, see also 2.3.1.9). Negative effects on other perennial seaweeds had also been seen in N Spain, (e.g. Viejo, 1997, see also 2.3.1.12). Also in Limfjorden, Denmark, a decline of other perennial species had been recorded (Stæhr *et al.*, 2000; Wernberg *et al.*, 2000, see also 2.3.1.5)

For the expansions along the Norwegian coast, the Swedish west coast, the Danish Kattegat coast and the German North Sea coast see 2.3.1.3, 2.3.1.4, 2.3.1.5 and 2.3.1.6.

A review of this species' performance, dispersal, possible vectors and potential to cause harm was given by Wallentinus (1999c and references therein). The high fecundity, monoecious life cycle, with retained germlings on the parent plant, and large bouayance, were emphasized high risk factors, as well as its combined r and K strategies for a successful establishment and growth (Farnham, 1997). Wallentinus (1999c) predicted it to be able to establish in most cold and warm temperate areas worldwide, providing salinities are not too low, as fertilization does not seem to occur below ca 16 psu, while germlings can survive even 5–6 (Hales and Fletcher 1989). *S. muticum* will also be included in Australia's target list of unwanted species (ICES WGITMO, 1998).

### 2.2.3 The aquarium strain of the tropical green alga *Caulerpa taxifolia*

A background description of the introduction of *C. taxifolia* in the Mediterranean, first seen in 1984, as well as more general aspects of the genus, was given as an annex to the previous Status report (Wallentinus, 1999a), bearing in mind that changes after 1992 were not included. In a Status report on the distribution in the Mediterranean in 1992, the alga was stated to have spread 3 km E and 150 km W of Monaco, and that it had a potential to spread to Spain and Portugal, but probably not to the U.K. and northwards (ICES WGITMO, 1992). The Status report of 1993, concluded that the area occcupied was estimated to have increased by a factor six each year, and that the species can spread naturally up to 200 m along the shore annually, under favourable conditions, but that also anthropogenic dispersal had occurred (ICES WGITMO, 1993). The competition with the seagrass *Posidonia oceanica* was pointed out (see also e.g. Devillele and Verlaque, 1995). In 1994, the question of *Caulerpa taxifolia* in the Mediterranean being different from the normal tropical plants was raised, a strain being created during its time as an aquarium cultivar, which survives temperatures as low as 7°C with growth from 13°C (ICES WGITMO, 1994 and references therein). It was also stated that *C. taxifolia* at that time had spread to Elba and Sicily, and also had been recorded at Livorno, Italy, and at Palma de Mallorca, Spain. Scientific literature, reviewed for the 1995 meeting, had shown that *C. taxifolia* could tolerate temperatures of 10°C, for at least three months, and that growth was performed between 10 and 30°C. Literature evidence also pointed out that it may threaten the biodiversity in the areas of introduction, and also some new toxic compounds had been isolated (ICES WGITMO, 1995). At the meeting in 1996 (ICES WGITMO, 1996), it was pointed out that further spread in the Mediterranean probably occurred by small boats, carrying fragments, and that sexual reproduction does not occur. In 1996, *C. taxifolia* was growing in about 3000 ha of the Mediterranean, where it had outcompeted most native species and, due to the presence of the toxin caulerpenyne, was not grazed by most herbivores (ICES

WGITMO, 1997). In 1997 the species occurred in Monaco (down to 100 m depth), France, Italy, Spain and Croatia, and eradication was carried out, when new sites with small patches had been detected (ICES WGITMO, 1998). Several studies were also made on its influence on biodiversity. In 1998, *C. taxifolia* was estimated to cover around 4600 ha in the Mediterranean, (ICES WGITMO, 1999). It was then also reported that in some areas the majority of all harbours had been colonized, and functioned as dispersal centres, indicating that fishing and maritime activities were the main vectors. In the late 1990s, there have been several pilot studies to use electrodes as a tool for eradication, however, efforts made in a nature reserve at Port-Cros, S France, failed, and instead resulted in further dispersal of fragments (ICES WGITMO, 2000; Meinesz *et al.*, 2001).

In 2000 this strain of *Caulerpa taxifolia* was reported from near San Diego on the Pacific coast of USA, where a substantial eradication campaign took place (ICES WGITMO, 2001; 2002; Anderson, 2005, see also 2.3.4.2).

The "Barcelona Appeal", released by the Plenary Assemblage of the 2[ND] Workshop on *Caulerpa taxifolia*, December 15–17, 1994, to alert the authorities and international organisations was included in the ICES WGITMO report of 1995. The published proceedings from this meeting (Ribera *et al.*, 1996) include 50 papers on different aspects of *Caulerpa taxifolia*. The Appeal stated that the species could grow on all substrates, and in all kinds of environments, as well as down to 99 m depth (however, in lower densities at these depths). The Status report, delivered to the 1996 WG meeting, pointed out that plants in certain regions may cover 100% of the seafloor, which could have a negative influence on diving and tourism. All recorded plants had been males, propagating efficiently through fragmentation and it may outcompete other species including the native *C. prolifera*. Also the question of using Carribbean sacoglossan snails of the genera *Elysia* and *Oxynoe*, to control *C. taxifolia*, was raised at that time and further elaborated, together with other candidates for marine biocontroll activities, resulting in the recommendation to thoroughly review the various methods that have been used to control introduced marine species at the 1997 WG meeting (ICES WGITMO, 1996). The Mediterranean sea slug, *Lobiger serradifalci*, was reported to eat *C. taxifolia* (ICES WGITMO, 2000), but it was later found that this species helped in dispersing *C. taxifolia*, by producing fragments, which could regenerate into new plants (Zuljevic *et al.* 2001).

At the "Biocontrol meeting" in 1997, Dr Meinesz and his student presented their laboratory experiments with Caribbean sacoglossan snails, which they motivated with the large area overgrown by *C. taxifolia*, making eradication by physical or chemical means impossible, as well as that the native sacoglossan snails had pelagic larvae, and thus would disperse from the release areas (ICES WGITMO, 1997; ICES SGMBIS, 1997; Meinesz, 1997). They concluded that it was possible to cultivate enough snails, for a potential release with high efficiency (500–1000 sea slugs per $m^2$). Details of the species used in the experiments were also given, but a release had to wait an approval by the French authorities. That issue was much debated at an international seminar, arranged by the French Academy of Sciences in March 1997 (Anon., 1997), when also other issues of *C. taxifolia*, as well as of other introductions, were dealt with.

The WGITMO has also expressed concern of the further spread of this strain to other areas, being easily available from the aquarium trade, or by transportion as fragments on pleasure boats, and Member countries were asked to survey, where the species was displayed, or otherwise available, and how the effluents from those facilities were treated (ICES WGITMO, 1997). The results of the surveys, in the different countries, were presented one year later (ICES WGITMO, 1998). Since 1993, in France it is illegal to trade and transfer *C. taxifolia*, and the same may apply to Spain. However, several species are available in pet shops, and many may not be able to discriminate between *C. taxifolia* and *C. mexicana*, which is not illegal. Furthermore, in France *Caulerpa* is widely displayed in tropical aquaria, and since the growth is rapid, the way of discarding material may be crucial, even if the water is recycled. It was also discussed, if *C. taxifolia*, as well as the invasive *C. racemosa*, could be included in the CITES regulations Annex B Article 3(2)(d) as example of species that may constitute a severe threat to indigenous wild flora and fauna.

A WG meeting at Heraklion, Greece, in March 1998 (Gravez *et al.*, 2001), with people working with the invasive *Caulerpa* species in the Mediterranean (21 countries were represented), unanimously recommended sustained coordination among the countries to limit the spread, national programmes at several levels, better information to all potential users of coastal areas, and a ban on marketing and usage of both *C. taxifolia* and *C. racemosa*, and to avoid any use of *Caulerpa* species in aquaria, except for the native *C. prolifera (*ICES WGITMO, 1998). Collections of *Caulerpa* species from the aquarium trade, mainly *C. taxifolia*, *C. racemosa* and *C. prolifera*, have been collected in an archive in France by professor Meinesz, Nice, to enable genetic studies of species being moved around (ICES WGITMO, 1999).

At the end of year 2000, Meinesz *et al.* (2001) summarized the situation in the Mediterranean as the following "*Caulerpa taxifolia* is present in 6 countries (Croatia, France, Italy, Monaco, Spain Tunisia) with 103 independent areas of colonization, involving 131 $km^2$ of concerned area, along 191 km of coastline" and remarking that "80% of the areas colonized were along 500 km of the coastline between Toulon (France) and Genoa (Italy)", the area where the first dispersal was seen. They considered the species to still be in the expansion phase. Additional information on *Caulerpa* in the Mediterranean was given by Ribera Siguan (2002).

### 2.2.4 The cultivated Japanese nori *Porphyra yezoensis*

At the WG meeting in 1992, the proposal to introduce this species for farming in Cobscook Bay, Maine, was treated, on a formal request from the State of Maine; the start planned to take place in July 1992, and had been approved by the State of Maine (ICES WGITMO, 1992). One question was if *P. yezoenzis* could reproduce sexually in the wild, and if drifting objects (incl. lost aquaculture equipment) could carry plants out of the bay and further south, to areas where sexual reproduction was possible, bearing in mind its high growth potential. It was recommended at that meeting that ICES continued the consideration of the release on the Atlantic coast of the USA, and its potential for spread into Canada and into southern waters.

At the meeting in 1993 a detailed outline of the commercial nori project was presented, and the WG was told that the first seeded nets had been released in Maine, in August 1992 (ICES WGITMO, 1993). This was based on a permit from the State of Maine, before the recommendations were taken by ICES in 1993. Dr Levine, representing the farming company, commented that even if plants reached areas S of Cape Cod, with summer temperatures sufficiently high for sexual reproduction, the photo periods with long days would have a negative effect on the release of the conchospores. The ICES WGITMO, although noting that establishment may occur even further north in thermal effluents, considered the risk of natural reproduction to be small, and if realized, the ecological consequences would be limited.

In 1993, a site was also established in New Brunnswick, Canada (ICES WGITMO, 1994), but no continuation followed in 1994, due to administrative problems (ICES WGITMO, 1995). However, in 1996, the importation to New Brunnswick was authorized by Canadian federal authorities, amounting to 100 nori nets originating from the Maine farming site (ICES WGITMO, 1997). At the WG meeting at Mystic Seaport, in 1994, a site visit was made to the cultivation site in Maine, and an annual report was received (ICES WGITMO, 1994). In 1996, there was a request to introduce new axenic strains of *P. yezoensis* (see strains listed in ICES WGITMO, 1996), and the discussion ended in a recommendation that, if such strains did not differ from the previously introduced one concerning reproductive behaviour (i.e. especially temperature demands), it would not meet objections. However, it was noted that a more aggressive monitoring programme then was needed.

After the advice of ICES WGITMO, at the site visit in 1994, salmon cages had been inspected for any occurrence of the species, but no attached plants were found on them, while plants were found on the the ropes supporting the nori cultures. It was assumed that a full life cycle had not been completed (plants could have developed from asexual monospores), and empty scallop shells had been spread to look for the conchocelis stage, but none was found (ICES WGITMO, 1995). More shells were released during 1995, but no conchocelis stages were found, and monospores were found only in young gametophytes (ICES WGITMO, 1996). In 1995, also a new farming site had been established, and technical development made, and a polyculture system, with salmon cages close by, was tested in 1996 (ICES WGITMO, 1997). By using electrophoretic technique three plants of *P. yezoensis* had been found outside the farm area in 1996, in 1997 five, and in 1998 zero plants, but the risk of spreading outside the farming area was reported to be minimal, since monospores do not survive the winter season, and native *Porphyra* species were outcompeting *P. yezoensis* (ICES WGITMO, 1997, 1998, 1999, 2000; Watson *et al.*, 2000). If the reported record of *Porphyra yezoensis* from Dover Point in New Hamshire (West *et al.*, 2005), much further south the American east coast, has anything to do with this farming is not known. The species was identified by using ITS1 and rbcL sequence, and when comparing with data in GenBank, it was found to be identical to *P. yezoensis* forma *narawaensis* cultivar F-6. This was not among the strains listed as of interest (ICES WGITMO, 1996).

There was concern about the raised issue of potential utilization of transgenic (through protoplast fusion) *P. yezoensis*, or of native *Porphyra* species, and the conclusion was that all such attempts were to be reported (ICES WGITMO, 1996). Later, it was stated that no genetically modified strains of *Porphyra* species would be released in the US waters (ICES WGITMO, 1997, 1998). In 1999, it was reported that tetraploid *Porphyra yezoensis* had been artificially produced, having twice as high growth rate as the diploid specimens, which could have ecological implications, if released into the sea for farming. The WGITMO recommended to consult the ICES WGAGFM for advice, concerning the use of tetraploid species for farming (ICES WGITMO, 1999).

During 1999, a trial to use frozen seeding nets of *P. yezoensis*, at an approved new farm site in Maine, and under new mangament, was unsuccessful, due to improper storage conditions. With that the farming of *P. yezoensis* in Maine by the CPI/PhycoGen companies stopped (ICES WGITMO, 2000).

### 2.2.5 Dinoflagellates of the genus *Pfiesteria*

The species *Pfiesteria piscicida* (previously called *P. piscimorte*) has a pecular life cycle, described to involve as much as 24 different stages, some cysts and some amoeboids, besides motile cells, and some strains have toxins known to cause both fish kills and to directly affect man (Burkholder *et al.*, 1995; Steidinger *et al.*, 1996). Zoospores have also been shown to negatively influence survival of bivalve larvae, and hence may affect shellfish recruitment (Springer *et al.*, 2002). The species was first mentioned in the ICES WGITMO reports in 1993, with reference to a recent HAB-meeting. In 1994, there was great concern over its potential to be dispersed by ballast water, and a resolution encouraged ICES Member countries to develop ballast water and sediment management practices (ICES WGITMO, 1994). A second species, *P. shumwayae*, with a similar complex life cycle and toxic strains, has been described (Glasgow *et al.*, 2001). Later that species has been transferred to a new genus, *Pseudopfiesteria* (Litaker *et al.*, 2005).

Using PCR-based methods, both *P. piscicida* and *P. shumwayae*, have been encountered in ballast water in ships, arriving at Chesapeake Bay (9% and 18 % of the samples, respectively, Doblin *et al.*, 2002). They also found the same species in water samples from NOBOB ships (16% and 24% respectively), but only in one sample from the sediments. Considering the wide global distribution (see below), the authors could not judge if this pattern is due to a historical cosmopolitan spread, or to anthropogenic activities such as shipping. Another possible vector could be shellfish movements, since zoospores of *P. piscicida* has been shown to survive gut passage of molluscs, by forming temporary cysts (Springer *et al.* 2002), and this possiblity has been highlighted as a risk for intra-state movements of shellfish within the US (Shumway *et al.* 2002).

In the early 2000s cysts of both *P. piscicida*, and the then newly described *P. shumwayae*, were identified from the Oslofjord through 18S rDNA analyses, where the latter was identical to the American strain and only three base pares differed for the former. This difference may point to either a recent singular translocation, or a homogenous Atlantic distribution with an ongoing gene flow. Species of *Pfiesteria* were later found in about 30 % of the localities surveyed in SE Norway, especially in brackish water conditions (Jakobsen *et al.*, 2002, ICES WGITMO, 2002). *P. shumwayae* has also been identified by molecular technique from estuaries around New Zealand (Rhodes *et al.*, 2002), as well as from Australia (Rublee *et al.* 2002).

There has been a large amount of papers on *Pfiesteria* and *Pfiesteria*-like organisms (PLOs, see e.g. Steidinger *et al.*, 2001). In the early 2000s, there was a fierce debate on if the complex life cycle of the genus was accurate, as well as, if the species *P. shumway* had toxins. Litaker *et al.* (2002a, 2002b) claimed they only found a typical dinoflagellate life cycle, while the other side (e.g. Burkholder and Glasgow, 2002) emphasized the former had only used non-inducible, non-toxic strains of *P. piscicida*, which do not evolve all stages. Furthermore, Berry *et al.* (2002) and Vogelbein *et al.* (2002) claimed that *P. shumway* was non-toxic, and killed fish by other means than by exotoxins. The discussions along these lines have continued.

## 2.3 Introduced benthic algae in the different countries, arranged by coastal areas

### 2.3.1 The eastern Atlantic coasts (incl. the North Sea, the Skagerrak and the Kattegat)

#### *2.3.1.1 Iceland*

No National reports have been delivered and I have found no new information in the literature on any other macroalga having been introduced nor on the current status of the two species listed below.

Previously established (Wallentinus, 1999a)

| Red algae | Brown algae | Green algae | Phanerogams |
|---|---|---|---|
| *Bonnemaisonia hamifera*, 1978 | None reported | *Codium fragile*, early 1970s | None reported |

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in **bold**=invasive, in **bold + underlined** = highly invasive taxa.

| | |
|---|---|
| **Rumex obtusifolius** | **Matricaria suaveolens** |

### *2.3.1.2 The Faroe Islands*

No National reports have been delivered and I have found no new information in the literature on any other macroalga having been introduced, nor on the currrent status of *Bonnemaisonia hamifera*.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera,* 1980 | None reported | None reported | None reported |

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in **bold**=invasive, in **bold + underlined** = highly invasive taxa.

| | |
|---|---|
| **Rumex obtusifolius** | **Matricaria suaveolens** |

### *2.3.1.3 Norway*

New introductions 1991–2002

In 1996 the red alga called *Dasysiphonia* sp. was recorded for the first time S of Bergen (60.12° N, 5.10°E) (Lein, 1999; ICES WGITMO, 1999). According to Verlaque (2001) the species is identical to *Heterosiphonia japonica*, however, an ongoing taxonomic revision may show that this species should be removed from the genus *Heterosiphonia* (see also Bjærke and Rueness, 2004a). The most likely vector is shipping, since there are frequent routes between Bergen and the Netherlands, where it was recorded in 1994 (see 2.3.1.7), although ships from the Pacific cannot entirely been ruled out. During the late 1990s the alga was fairly common in many areas around Bergen (ICES WGITMO, 2000) and was already in 1997 found at Flørö, (61.60°N, 4.97°E) (Lein, 1999). In 2000 it had spread rapidly both north- and southwards of Bergen and was found E of Lindesnes (58.0°N, 7.1°E) on the Skagerrak coast, which is moving against the currents, and thus could be due to shipping activities or new introductions (ICES WGITMO, 2001). In 2001 the N limit was still in the district of Sogn and Fjordane (ICES WGITMO, 2002). A few years later, it occurred abundantly, as a several dm tall epiphyte, all from the mouth of the Oslofjord through to Sognefjord north of Bergen, its dispersal facilitated by vegetative reproduction (Bjærke and Rueness, 2004a, pers. comm.).

Hopkins (2002) also listed the red algae *Gracilaria gracilis* and *Sphaerococcus coronopifolius* as introduced in Norway. The former is a native species in N European waters (see also Rueness, 1998), previously called *G. verrucosa*. The latter was first found in Norway, in 1994 in the outer Oslofjord (ca. 59.3°N, 9.5°E; Rueness 1998), and has since 1990 been seen on the Swedish west coast in the Koster area (ca. 58.9°N, 11.0°E), where it is considered to be a range extension from more southern shores (Karlsson *et al.* 1992). Thus, this species is less likely a species introduced by human activities into Norway.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera,* 1902 | *Fucus evanescens,* 1890s | *Codium fragile* ssp. *atlanticum,* <1895 | None reported |
| *Dasya baillouviana,* 1966 | *Colpomenia peregrina,* 1933 | *Codium fragile* ssp. *scandinavicum,* 1929 | |
| *Polysiphonia harveyi*[1)], 1983 | *Sargassum muticum,* 1988 | *Codium fragile* ssp. *tomentosoides,* 1946 | |

1) Valid name *Neosiphonia harveyi* (Guiry *et al.* 2006); year of first record Bjærke and Rueness 2004b

Introduced macroalgae prior to 1991, but not listed above

The small red alga *Aglaothamnion halliae*, seen already in 1980 but then not recognized as an introduced species (Rueness and L'Hardy-Halos, 1991 and references therein, as *A. westbrookiae*), has during the last decade been seen frequently in S Norway, often occurring on wooden pillars in harbour areas (Bjærke and Rueness, 2004c).

Current status of old introductions

The dispersal of *Sargassum muticum* along the Norwegian coast has been reported in all National reports delivered during the period 1992–2002 (no report in 1995). In 1992 the species was reported to have established permanently on the Skagerrak coast (ICES WGITMO, 1992), which also had been reported earlier (ICES WGITMO, 1990). In 1993 it had reached the Bergen area, on the Norwegian west coast (ICES WGITMO, 1993, 1994), and sparse populations existed in Hordaland (ca. 60.7°N, 5–7°E), N of Bergen in 1995 (ICES WGITMO, 1996). In the summer of 1996, dense populations were found in a number of bays in Rogaland (ca. 59.2°N, 5.5°E), N of Stavanger (ICES WGITMO, 1997). In 1997 *S. muticum* was found on the N side of Sognefjord (ca. 61.1°N, 05°E), indicating a potential to spread even further north (ICES WGITMO, 1998). No drastic changes occurred the following years (ICES WGITMO, 1999, 2000, 2001). In the early 2000s, it had also established in the inner part of the Oslofjord, while there was no confirmation of any spread northwards (ICES WGITMO, 2002).

The following status of earlier introductions was given by Rueness (1998):

Sporophytes, mainly sterile, of *Bonnemaisonia hamifera* is now one of the most common red algae and occurs along the whole coast, from the shores to deep down, while gametophytes only have been found a few times.

*Fucus evanescens* (native in N Norway), which is quite tolerant to eutrophication, is now the most common fucoid in the Oslofjord, where it also can form hybrids with *F. serratus* (Coyer *et al.*, 2002).

*Codium fragile* is common along the S coast of Norway, but has also spread north, as far as Nord-Troms (ca. 70°N, 18–20°E).

The red alga, *Neosiphonia harveyi*, now recognized to be of Japanese origin (McIvor *et al.*, 2001), has during the 1990s spread and become common in the Oslofjord and along the coast up to Bergen.

On the other hand *Colpomenia peregrina* is not a common species, occurring in summer to autumn at not too exposed sites in the outer archipelago from Vestfold (ca. 59°N, 10°E) to Nord-Trøndelag (ca. 65°N, 11°E).

There was no information on the abundance of *Dasya baillouviana*, which seems to occur only along the Skagerrak coast.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| Ranunculus cymbalaria | **Cardaria draba** | Veronica austriaca | **Lactuca tatarica** |
| **Fallopia japonica** | **Eurucastrum gallicum** | **Ambrosia artemisifolia** | **Matricaria suaveolens** |
| **Persicaria pensylvanica** | **Isatis tinctoria** | **Centaurea aspera** | Senecio palustris |
| Rheum x rhabarbarum | Lobularia maritima | **Centaurea diffusa** | **Solidago canadensis** |
| Rumex confertus | Rosa rugosa | **Conyza canadensis** | ***Elodea canadensis*** |
| Frankenia pulverulenta | **Medicago arabica** | **Cotula coronopifolia** | **Polypogon monspeliensis** |
| **Populus alba** | **Lythrum hyssopifolia** | **Helianthus annuus** | **Asparagus officinalis** |
| Salix viminalis | Apium graveolens | **Inula britannica** | Iris sibirica |
| Brassica oleracea | **Datura stramomium** | | |

### *2.3.1.4 Sweden, the west coast*

New introductions 1991–2002

No new introductions of macroalgae were included in the Swedish reports during the period 1992–2002. However, the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) was stated by Athanasiadis (1996a) to occur in an offshore area in the middle of Bohuslän (ca. 58.5°N, 11.1°E), since the early 1990s and he indicated that there might be previous records under the name *P. fibrillosa*. Furthermore, in 2003 it was recognized that the Japanese red alga "*Dasysiphonia* sp." had spread to the Koster archipelago (ca. 58.9°N, 11.0°E) from Norway (cf. 2.3.1.3) already in 2002 and then was re-encountered in 2003 (Axelius and Karlsson, 2004). According to Verlaque (2001) the species is identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a), however, an ongoing taxonomic revision may show that this species should be removed from the genus *Heterosiphonia*.

Previously established (Wallentinus, 1999a)

| Red algae | Brown algae | Green algae | Phanerogams |
|---|---|---|---|
| *Bonnemaisonia hamifera*, 1905[1)] | *Fucus evanescens*, 1924 | *Codium fragile* ssp. *scandinavicum*, 1932 | None reported |
| *Dasya baillouviana*, 1953 | *Colpomenia peregrina*, 1950 | *Codium fragile* ssp. *tomentosoides*, 1938 | |
| | *Sargassum muticum*, 1987 | | |

1) Year changed following Kylin 1944

Current status of old introductions

The dispersal of *Sargassum muticum* along the Swedish west coast has been subject to several surveys and has been included in most National reports during the period (ICES WGITMO, 1992; Karlsson *et al.*, 1992; ICES WGITMO, 1994–2002; Karlsson and Loo; 1999). The first record, from the N Kattegat coast (57.51°N, 11.71°E), was in the summer of 1991 (ICES WGITMO; 1992). In 1993 and 1994 no attached plants had been found further south, although searched for, while drifting plants were frequently seen down to the middle part (ca. 57.1°N, 12.3°E) of the province of Halland (ICES WGITMO; 1994, 1995). In 1995 it had spread further in the N part of Halland, while still only drifting plants occurred further south (ICES WGITMO; 1996). The survey carried out in 1996 (Karlsson and Loo; 1999) revealed that since 1993 *S. muticum* had spread 100 km to the south, found at Träslövsläge (57.05°N, 12.25°E), S of the city of Varberg, and it had also proceeded to the inner archipelagoes in Bohuslän (ICES WGITMO, 1997). No further changes had occurred between 1997 and 2002 (ICES WGITMO, 1998, 2000, 2001, 2002). It was especially vigorous, as well as heavily epiphytized, in proximity to the cooling water discharge at the nuclear power plant at Ringhals

(57.26°N, 12.10°E), N Halland, where it probably had started to colonize already in 1992–1993 (ICES WGITMO, 1997). It was in the early 2000s a common plant along the Skagerrak and N Kattegat coasts, and in some areas in N Bohuslän it had then become very abundant and may cause decline of other fucoids (Carl-Johan Svensson pers. comm.). Dense populations also act as barriers for water movements, which may lead to stagnation and enhancements of growth of ephemeral algae (ICES WGITMO, 1997; Jan Karlsson pers. comm., IW pers. obs.). The potentially toxic dinoflagellate *Prorocentrum lima* has often been encountered in large amounts on its canopies (Mats Kuylenstierna pers. comm.).

The status of *Fucus evanescens* was studied in N Bohuslän and in the Öresund area (Wikström *et al.*, 2002; ICES WGITMO, 2002). In N Bohuslän (ca. 58.8°N, 11.2°E) there might have been a slight increase, as in the N part of Öresund (ca. 56.3°N, 12.5°E), while a decline was seen in the S Öresund compared to the drastic increases in the 1960–1970s. It was the fucoid tolerating most eutrophication, disappearing last and returning first in the S Laholm Bay (56.43°N, 12.85°E) during the 1980s (Wennberg, 1992). Its further dispersal into the Baltic coasts of Sweden may be limited due to its low fertility at salinities of 10 psu or lower (Wikström *et al.*, 2002).

A few gametophytes of *Bonnemaisona hamifera* were seen in the outer Koster archipelago (58.85°N, 11.0°E) in 1999, but this is not a common phenomenon (Annelie Lindgren pers. comm.). The southern border of the species is in the Öresund. The sporophytes, mainly sterile, are common on the N part of the west coast, and a project has started to look at the possibility to use its halogenated metabolites as an antifouling compound (Gunnar Cervin, pers. comm.). In 1999 very large specimens of the red alga *Dasya baillouviana* were encountered at the discharge from the nuclear power plant at Ringhals, N Halland, which is the southernmost record for Sweden (ICES WGITMO, 2000).

Phanerogams, often old introductions (all of Sweden)

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| Ranunculus cymbalaria | **Erucastrum gallicum** | Veronica austriaca | **Matricaria suaveolens** |
| Illecebrum verticillatum | **Isatis tinctoria** | **Ambrosia artemisifolia** | **Solidago canadensis** |
| **Silene conica** | Lobularia maritima | **Ambrosia psilostachya** | ***Elodea canadensis*** |
| **Fallopia japonica** | Rosa rugosa | **Centaurea aspera** | ***Elodea nuttallii*** |
| **Persicaria pensylvanica** | Astragalus arenarius | **Centaurea diffusa** | Beckmannia eruciformis |
| Rumex confertus | **Medicago arabica** | **Conyza canadensis** | **Polypogon monspeliensis** |
| **Populus alba** | **Lythrum hyssopifolia** | **Cotula coronopifolia** | **Polypogon viridis** |
| Salix viminalis | Apium graveolens | **Helianthus annuus** | **Asparagus officinalis** |
| Brassica oleracea | **Datura stramomium** | **Iva xanthifolia** | Iris sibirica |
| **Cardaria draba** | Calystegia pulchra | **Lactuca tatarica** | Iris versicolor |

### *2.3.1.5 Denmark (all coasts)*

No new introductions of macroalgae were reported in the period 1992–2002 neither in the National report (only delivered in 1993), nor in the literature for that period.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera*, 1901 | *Colpomenia peregrina*, 1939 | *Codium fragile* ssp. *scandinavicum*, 1919 | (*Myriophyllum sibiricum*)[1)] |
| *Dasya baillouviana, 1961* | *Fucus evanescens, 1948* | *Codium fragile ssp. tomentosoides, 1920* | |
| | *Sargassum muticum, 1984* | | |

1) *Myriophyllum sibiricum* is to be considered as a range extension, thus not an introduced species

Introduced macroalgae prior to 1991, but not listed above

The Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) according to Maggs and Stegenga (1999 and reference therein) occurred at Nissung Bredning (ca. 56.6°N, 9.4°E), E Jutland, already in 1980 and probably earlier (under the name of *P. fibrillosa*). Its present status is not known and *P. harveyi* was not listed in the earlier version of the checklist of Danish seaweeds (Nielsen, 2002).

The occurrence of *Mastocarpus stellatus* at the harbour in Thisted, Limfjorden, (56.95°N, 8.70° E) and at Århus (56.16°N, 10.20°E) according to Rosenvinge (1920) dates back to at least 1869 and 1911–12, respectively, and was re-encountered by him in the same area, but not elsewhere. He proposed that the species had arrived to both areas by vessels, since it grew close to harbours only. The species has now also been recorded from Fredrikshamn (57.46°N, 10.52°E) (Køie *et al.*, 2000). The species is native in the North Atlantic and occurs in Norway, south to Arendal (58.47° N, 8.74°E), on the Skagerrak coast.

Current status of old introductions

The only National report from Denmark, during the period (ICES WGITMO, 1993), listed an ongoing spread of *Sargassum muticum* in the Kattegat (cf. 2.3.1.4). In 1998 *S. muticum* was found attached also in the area S of the mouth of Limfjorden (ca. 56.9°N, 10.3°E) (cf. 2.3.1.4) and drifting N of Århus (Køie *et al.*, 2000). Its increased abundance in Limfjorden, during the 1990s, when it became a dominant species, could be correlated with a corresponding decline of other perennial species, such as the brown algae *Fucus vesiculosus*, *Halidrys siliquosa* and *Laminaria saccharina* as well as of the introduced green alga *Codium fragile* (Stæhr *et al.*, 2000) They also reported that imports of both European and Pacific oysters from France had taken place during the early 1980s, which may explain its early presence in Limfjorden, compared to the much later arrival on the German North Sea coast, where, however, drift plants had been seen frequently during the 1980s (see 2.3.1.6). Also its phenology (as a mean to interact) was thoroughly studied in Limfjorden, where *S. muticum* has invaded the habitat of and has had a negative influence, through its pseudo-perennial strategy, on the native, truely perennial fucoid *Halidrys siliculosa* (Wernberg *et al.*, 2000).

Examinations of field-collected (the Kattegat) hybrid specimens between *Fucus evanescens* and *F. serratus*, being intermediate in morphology and dioecious, showed that they were fertile and all were results of fertilization of *F. evanescens* eggs (Coyer *et al.*, 2002).

Sporophytes of *Bonnemaisonia hamifera*, mostly sterile, occur commonly on the North Sea and Kattegat coasts and also sporadically in the Belt Sea (Køie *et al.*, 2000). They also reported that *Fucus evanescens* is common on the coasts of E Jutland, Fyn and Själland, and that *Colpomenia peregrina*, since 1970, occurs in the N Kattegat down to Hirsholmarna (57.50°N, 10.62°E), E Jutland. According to them *Codium fragile* occurs southwards to N Själland and the area N of Århus, but nothing was said about its abundance.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Silene conica** | Lobularia maritima | **Ambrosia psilostachya** | ***Elodea canadensis*** |
| **Fallopia japonica** | Rosa rugosa | Artemisia stellariana | ***Elodea nuttallii*** |
| **Persicaria pensylvanica** | **Medicago arabica** | **Conyza canadensis** | **Polypogon monspeliensis** |
| **Populus alba** | **Lythrum junceum** | **Cotula coronopifolia** | **Spartina anglica** |
| Salix viminalis | **Datura stramonium** | **Helianthus annuus** | Spartina x townsendii |
| **Cardaria draba** | Calystegia pulchra | **Solidago canadensis** | Iris sibirica |
| **Erucastrum gallicum** | Veronica austriaca | **Lactuca tatarica** | Iris versicolor |
| **Isatis tinctoria** | **Ambrosia artemisifolia** | **Matricaria suaveolens** | |

### *2.3.1.6 Germany, the North Sea coast*

New introductions 1991–2002

A re-introduction of the Japanese brown alga *Sargassum muticum*, as well as of the native brown alga *Ascophyllum nodosum*, was claimed to have occurred to an area near Sylt (ca. 54.8°N, 8.2°E) in the North Sea, through imports of seed oysters, which had been "parked" ouside the hatchery in Ireland (ICES WGITMO, 1999). *S. muticum* was dispersing further at the beginning of the 2000s (ICES WGITMO, 2001, 2002).

Bartsch and Kuhlenkamp (2000) reported that the red alga *Polysiphonia lanosa* was not seen growing as an epiphyte on the fucoid *Ascophyllum nodosum* on Helgoland (54.20°N, 7.87°E) before the 1990s, but only occurred on drift plants. Since *P. lanosa* commonly occurs in the North Sea area, this might be a range extension, which, however, is expanding on the island.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera*, ca. 1900 | *Sargassum muticum* 1988 | *Codium fragile* ssp. *tomentosoides*, 1930 | None reported |
| *Mastocarpus stellatus*, late 1970s | | | |
| (*Porphyra yezoensis*[1)], *1984)* | | | |

1) Genetically different from the Japanese material and its identy has been doubted (Maggs and Stegenga 1999, Bartsch and Kuhlenkamp 2000 and references therein).

Introductions of macroalgae prior to 1991, but not listed above

The Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) has according to Maggs and Stegenga (1999 and reference therein) been recorded on Helgoland (54.20°N, 7.87°E) before 1978 (under the name of *P. violacea*). Nothing is known about its current status.

Kornmann and Sahling (1983) depicted a red alga found on Helgoland since 1960, which they called *Callithamnion byssoides*, but according to Jan Rueness (pers. comm.) the alga in question is identical to *Aglaothamnion halliae*, and thus introduced.

Current status of old introductions

After having been released as an ecological experiment in the late 1970s, the red alga *Mastocarpus stellatus* has since become very abundant on Helgoland (Bartsch and Kuhlenkamp, 2000), and brought a decline in the littoral populations of the red alga *Chondrus* *crispus*, probably due to the better ability of *M. stellatus* to produce mycosporine-like amino acids (MAAs), which protect it from UV-B radiation (Bischof *et al.*, 2000).

In Königshafen Bay (55.05°N, 8.38°E), at the island of Sylt, the N Wadden Sea, *Sargassum muticum*, first recorded in the area in 1993, was still a prominent part of the vegetation both in the bay and outside some years later, and outside the bay co-occurred with the introduced green alga *Codium fragile*. The latter was previously seen also in the bay, thus having become more scarce (Schories *et al.*, 1997 and references therein). *S. muticum* has become increasingly common on Helgoland during the 1990s (Bartsch and Kuhlenkamp, 2000).

Also *Bonnemaisonia hamifera* has increased in abundance, and fertile gametophytes were common at Helgoland in 1999, while *Codium fragile* ssp. *tomentosoides* then only had a restricted distribution there (Bartsch and Kuhlenkamp, 2000).

Phanerogams, often old introductions (all of Germany)

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold +** **underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Chenopodium botrys** | Astragalus arenarius | **Centaurea diffusa** | ***Elodea canadensis*** |
| Gypsophila scorzonerifolia | **Oenothera strica** | **Conyza canadensis** | ***Elodea nuttallii*** |
| **Fallopia japonica** | **Datura stramonium** | **Cotyla coronopifolia** | Beckmannia eruciformis |
| Brassica oleracea | Calystegia pulchra | **Iva xanthifolia** | **Spartina anglica** |
| **Cardaria draba** | **Centranthus ruber** | **Lactuca tatarica** | Spartina x townsendii |
| **Isatis tinctoria** | **Ambrosia artemisifolia** | **Matricaria suaveolens** | Typha laxmanni |
| Vaccinium macrocarpon | **Ambrosia psilostachya** | **Solidago canadensis** | **Iris versicolor** |
| Rosa rugosa | | | |

Wolff (2005) listed *Cotula coronopifolia* as introduced in Germany already in 1739.

### *2.3.1.7 The Netherlands*

New introductions 1991–2002

In 1993, an introduced red alga, identified as *Polysiphonia senticulosa* (might be conspecific with *P. morrowii*, see also Verlaque, 2001), was found at Gorishoek (Maggs and Stegenga, 1999) and was said to have increased to be common in winter and spring in Yerseke Oesterbank (ca. 51.3°N, 4.2° E). They also predicted its spreading to other European countries. In 1999 it had spread over the entire Oosterschelde (ca. 51.4–51.7°N, 3.7–4.3°E), and was one of the dominating species in Strijenham in 1998 (ICES WGITMO, 2000).

Two records of the red alga *Grateloupia doryphora* (valid name *G. turuturu*; Gavio and Fredericq, 2002) were also reported by Maggs and Stegenga (1999) from a former oyster pond at Yerseke (51.29°N, 4.05°E) in 1993 and 1996. Wolff (2005) wrote that later on several large plants (up to 1 m) have been found, and that it occurs abundantly in some areas.

The North Pacific green alga *Ulva pertusa* was first recorded in the Dutch Delta in 1993 (Wolff, 2005) and became very common later on.

The first record of the red alga called *Dasysiphonia* sp. was also mentioned by Maggs and Stegenga (1999), found in a former oyster pond at Yerseke in 1994. According to Verlaque (2001) the species should be identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a), however, an ongoing taxonomic revision may show that the species should be removed from the genus *Heterosiphonia*. Information given by Wolff (2005) stated it to be common to abundant in the early 2000s.

In the late 1990s, the Pacific red alga *Gracilaria vermiculophylla* was sampled by Dr. H. Stegenga in the brackish Oostvoornse, close to Rotterdam, a species that in the early 2000s spread to several countries on the North Sea coast (Rueness, 2005).

The NW Pacific brown alga *Leathesia verruculiformis* has been found in Lake Grevlingen (ca. 51.8–51.9°N, 3.8–4.15°E) and in the Oosterschelde since 1994, as an epiphyte on *Sargassum muticum* (ICES WGITMO, 2000).

The minute red alga *Acrochaetium balticum* was first reported from the brackish Lake Veere (ca. 51.3°N, 3.4°E) in 1998, the small Mediterranean brown alga *Asperococcus scabra* in Lake Grevlingen in 1998, and the North American red alga *Agardiella subulata*, attached to shells, at Yerseke in Oosterschelde in December 1998 (ICES WGITMO, 2000).

In March 1999, for the first time in the Netherlands, 60 cm long sporophytes of the Japanese kelp *Undaria pinnatifida* were recorded on shells in an oysterpond near Yerseke, and in May the same year, one plant was found near Strijenham, both sites in the Oosterschelde (ICES WGITMO, 2000). There was a rapid colonization, and in some places 5–6 ha could be found in the Oosterschelde, and plants were also washed ashore on the N side. *U. pinnatifida* was also found in smaller densities in the saltwater Lake Grevlingen, probably being transported there by oyster pots. In the Oosterschelde it grows mainly on *Crassostera gigas*, but also on mussels, and being slippery, *U. pinnatifida* causes problems for fishermen to retrieve the oysters and the pots need to be cleaned before harvest (ICES WGITMO, 2001).

Previously established (Wallentinus, 1999a)

| Red algae | Brown algae | Green algae | Phanerogams |
|---|---|---|---|
| *Dasya baillouviana*, 1950 | *Colpomenia peregrina* 1920 | *Codium fragile* ssp. *tomentosoides*, 1900 | *Elodea canadensis*, late 1800s[2)] |
| (*Bonnemaisonia hamifera* drift only) | *Sargassum muticum*, 1980 | *Codium fragile* ssp. *atlanticum*, | *Elodea nuttallii*, early 1900s[2)] |
| (*Asparagopsis armata* drift only) | | | |
| (*Antithamnionella sarnensis*[1)] drift only) | | | |

1) Valid name *A. ternifolia* and according to Maggs and Stegenga (1999) it was found attached already in 1951, but is not permanently established according to Wolff (2005), 2) For time of introduction see van der Velde *et al.*, 2002

Introduced macroalgae prior to 1991, but not listed above

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999), as an introduction from the Mediterranean, and was first found at Yerseke (in an oyster pond) in 1968. According to Wolff (2005) it was only temporarily established between 1950 and 1977 (the earlier date was from an unidentified herbarium specimen).

According to Maggs and Stegenga (1999), the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) has been growing in the Netherlands at least since 1960, becoming a very common species in Oosterschelde and Lake Grevelingen on many different substrates (incl. cages and yacht moorings), occurring also in the N parts of the country.

The red alga *Antithamnionella spirographidis* was found near Yerseke in 1974 and has since 1993 become rather common in the tidal Oosterschelde, but also occurs in the stagnant saline Lake Grevelingen (Maggs and Stegenga, 1999; Wolff, 2005).

Wolff (2005) listed the following benthic, mainly small, algae (not listed above) to also have been introduced before 1991 (year of first record in brackets): the red alga *Acrochaetium* *densum* (1967), *Colaconema dasyae* (1953); the brown algae: *Botrytella* sp. (1919), *Elachista* sp. (1993), *Myriactula* sp. (1980).

Current status of old introductions

There are many papers on *Sargassum muticum* in the Netherlands from the 1980s (for references see Wallentinus, 1999a, 1999c), while less has been published in the 1990s. It was discussed by den Hartog (1997) that it may have a negative effect on eelgrass beds, if colonizing bare patches or on the edges. According to Wolff (2005) it is an abundant species, especially in Lake Grevlingen.

Of the previously listed introductions, Maggs and Stegenga (1999) described *Dasya baillouviana*, as since 1993 having expanded, being found also in stagnant brackish water (down to 10 psu) as well as in tidal areas during summer and early autumn.

No records of attached *Bonnemaisonia hamifera* nor of *Asparagopsis armata* in the Netherlands were mentioned by Maggs and Stegenga (1999). Wolf (2005) wrote that those species are still not established in the Netherlands.

According to references in Wolff (2005), the North American red alga *Agardiella subulata* is since 1999 fairly abundant in some areas.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| Corispermum intermedium | Rosa rugosa | **Conyza canadensis** | ***Elodea nuttallii*** |
| **Fallopia japonica** | **Datura stramonium** | **Lactuca tatarica** | **Schoenoplectus mucronatus** |
| **Populus alba** | Calystegia pulchra | **Matricaria suaveolens** | **Paspalum disticum** |
| **Cardaria draba** | **Ambrosia artemisifolia** | Senecio inaequidens | **Polypogon monspeliensis** |
| Lobularia maritima | **Ambrosia psilostachya** | **Solidago canadensis** | **Spartina anglica** |
| Vaccinium macrocarpon | **Ambrosia psilostachya** | ***Elodea canadensis*** | Spartina x townsendii |

The Dutch report (ICES WGITMO, 1998) mentioned that the dune grass *Ammophila arenaria* is widely used for planting in dune areas, while the cordgrass *Spartina x townsendii* no longer is planted, but has become well established. However, according to Tutin *et al.* (1980) *Ammophila arenaria* is native to the Netherlands.

Wolff (2005) listed *Cotula coronopifolia* as introduced already in 1846, occuring later in both brackish and freshwater marshes.

### *2.3.1.8 Belgium*

Belgium is one of the few countries having plants included in the legislation on intentional introductions since 1999. By a royal decree, it may also be possible to eradicate alien nuisance species (ICES WGITMO, 2001).

New introductions 1991–2002

There is a first record of the Japanese kelp *Undaria pinnatifida* at the marina of Zeebrugge (51.34°N, 3.18°E) dated 1999 (Wallentinus, 1999b), while the National report (ICES WGITMO, 2001) gave the year 2000. A small population was established, but no spreading had occurred (ICES WGITMO, 2002). It was seen as a range extension from N France (ICES WGITMO, 2001).

The Japweed *Sargassum muticum* was found attached in 1999 at Zeebrugge and Oostende (51.25°N, 2.93°E), but later disappeared at the first site. It was speculated that oyster imports could be the vector (ICES WGITMO, 2001).

The greeen alga *Codium fragile* ssp. *tomentosoides* was first seen forming dense populations in 1998-2000 at Oostende, but was not present there in 2001 or 2002, probably outcompeted by *Sargassum muticum* (ICES WGITMO, 2001) or by changed water regimes (ICES WGITMO, 2002).

The red alga *Antithamnionella spirographidis* was present at Oostende in 1992 and had been established at Zeebrugge after 1983 (Maggs and Stegenga, 1999; ICES WGITMO, 2001).

Also the red alga *Polysiphonia senticulosa* (might be conspecific with *P. morrowii*, see also Verlaque, 2001*)* has been reported in 2001 and 2002 from Oostende, growing where previously *Sargassum muticum* had occurred. Although occurring in neighbouring the Netherlands (2.3.1.7), it was not though to have come from there, since no oysters had been taken from the Netherlands, only from England and Atlantic France, where the species has not been recorded, and from British Columbia, which might be the source (ICES WGITMO, 2002).

According to Maggs and Stegenga (1999 and reference therein) the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.* 2006) has been found in Belgium (under the name of *P. fibrillosa*) before 1995. The same also applies to the red alga *Antithamnionella ternifolia.*

Previously established taxa (Wallentinus, 1999a)

| <u>**Red algae**</u> | <u>**Brown algae**</u> | <u>**Green algae**</u> | <u>**Phanerogams**</u> |
|---|---|---|---|
| None reported | (*Sargassum muticum* only as drift) | (*Codium fragile* ssp. *tomentosoides* only as drift) | None reported |

<u>Phanerogams, often old introductions</u>

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in <u>**bold + underlined**</u> = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Chenopodium botrys** | Lobularia maritima | <u>**Ambrosia artemisifolia**</u> | <u>***Sagittaria graminea***</u> |
| Corispermum intermedium | **Angelica archangelica** | <u>**Ambrosia psilostachya**</u> | <u>***Elodea canadensis***</u> |
| <u>**Fallopia japonica**</u> | <u>**Datura stramonium**</u> | <u>**Conyza canadensis**</u> | ***Elodea nuttallii*** |
| <u>**Populus alba**</u> | Calystegia pulchra | **Matricaria suaveolens** | <u>**Polypogon monspeliensis**</u> |
| <u>**Cardaria draba**</u> | Scutellaria hastifolia | Senecio inaequidens | <u>**Spartina anglica**</u> |
| <u>**Erucastrum gallicum**</u> | **Centranthus ruber** | **Solidago canadensis** | Spartina x townsendii |

### *2.3.1.9 France, the Atlantic coast*

<u>New introductions 1991–2002</u>

The red alga *Grateloupia filiformis* var, *luxurians* was first encountered at St Samson en Plougasnou (48.70°N, 3, 82°W), N Brittany, in 1992, occurring at the same localities as *G. doryphora* (Cabioch *et al.*, 1997; valid name *G. turuturu*; Gavio and Fredericq, 2002)), most problably introduced by shellfish movements, but shipping cannot be ruled out, since the species has occurred since long in S England (see 2.3.1.10). The species was well established by the end of the 1990s.

Maggs and Stegenga (1999) reported that the red alga *Dasysiphonia* sp. was found near Roscoff (48.73°N, 2.0°E), N France, in 1995. According to Verlaque (2001) the species should be identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a), however, an ongoing taxonomic revision may show it that it should be removed from the genus *Heterosiphonia*.

In 1996 a species of the red algal genus *Gracilaria* was seen as non-attached mats in several estuaries in Brittany, from Roscoff in the north to S of Lorient, but only vegetative plants were found in the field (Rueness, 2005) and it probably was a recent introduction. Cultivation and molecular analyses later showed it to be identical to the Asiatic species *Gracilaria vermiculophylla* (Rueness, 2005.).

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Polysiphonia harveyi*, 1832 1) | | | |
| *Bonnemaisonia hamifera,* 1898 | *Colpomenia peregrina*, 1905 | *Codium fragile* ssp. *tomentosoides*, 1946 | None reported |
| *Antithamnionella sarniensis* 2), 1910 | *Sargassum muticum*, 1976 | | |
| *Antithamnionella spirographidis*, 1911 1) | *Undaria pinnatifida*, 1983 | | |
| *Asparagopsis armata*, 1922 | | | |
| *Antithamnion densum*, 1964 3) | | | |
| *Mesothamnion caribaeum* 4), 1967 | | | |
| *Lomentaria hakodatensis*, 1984 | | | |
| *Caulacanthus ustulatus*, 1986 5) | | | |
| *Laurencia brogniartii*, 1989 | | | |

1) For 1st record see Farnham (1997); valid name *Neosiphonia harveyi* (Guiryi *et al.*, 2006), 2) Valid name *A. ternifolia*, 3) For 1st record see Athanasiadis (1996b) 4) Valid name *Pleonosporium caribaeum* 5) See Rueness and Rueness (2000) for confirmation of its Asiatic origin

<u>Introduced macroalgae prior to 1991, but not listed above</u>

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999) as an introduction from the Mediterranean, first found in N France prior to 1922.

Magne (1992) reported on the minute red alga *Goniotrichopsis sublittoralis* being recorded from Roscoff, N France, in 1975.

The red alga *Grateloupia doryphora* (valid name *G. turuturu*, Gavio and Fredericq 2002,) was first encountered at Lorient (47.45°N, 3.22°W), S Brittany, in 1989 and three years later at several sites in N Brittany (Cabioch *et al.,* 1997), most problably introduced by shellfish movements, but shipping cannot be ruled out, since the species has occurred since long in S England (see 2.3.1.10). The species was well established around Brittany in the end of the 1990s and early 2000s, also in eutrophicated areas, with fertile specimens occurring during a large part of the year (Cabioch *et al.,* 1997, Stiger *et al.,* 2003). Simon *et al.* (2001) reported on further dispersal around Brittany, N France in the late 1990s, often occurring in marinas and growing on hulls of leisure boats, as well as on pontoons. Thus shipping probably is a major vector.

Goulletquer *et al.* (2002) also listed the red alga *Hypnea musciformis*, a south European and Mediterranean species, as introduced in Normandy in the 1900s. However, I have found no more information on this introduction, nor has it been listed by anyone else for the Atlantic coast of France, while Wallentinus (1999a) mentioned tank experiments with introduced specimens on Corsica.

<u>Current status of old introductions</u>

For the further establishment in the wild of *Undaria pinnatifida* see 2.2.1.

According to the National report (ICES WGITMO, 1998) no significant changes or further dispersal of *Sargassum muticum* were found in the late 1990s, and in estuaries high turbidity limited further spread. However, Cosson (1999) reported that *S. muticum* has caused a progressing decline of the kelp *Laminaria digitata* at two sites on the coast of Calvados (ca. 49.35°N, 1.0°W), N France, where *Laminaria digitata* has almost disappeared in some areas and in other decreased to 1/3 of the biomasses in 1983. In the late 1990s *S. muticum* could cover up to 80% of the substrate area.

In the early 1990s *Caulacanthus ustulatus* was fairly common in the vicinity of Roscoff, N France, but only rarely in a reproductive stage, thus mainly propagating vegetatively (Rueness, 1997).

Kraan and Barrington (2005 and references therein) reported that a commercial seaweed farm of *Asparogopsis armata* was set up in the mid 1990s on the Island of Ouessant, Brittany, NW France. In the mid 2000s it encompassed 2 ha with 14 km cultivation ropes, with an annual yield of 8 metric tonnes (ww). Wild plants are used as seed stocks and gametophytes propagated vegetatively. In contrast to a similar farm in Ireland (see 2.3.1.11), this farm site has not been included in the French National reports.

Phanerogams, often old introductions (all of France)

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold +** **underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Eschscholzia californica** | Sedum praealtum | **Angelica archangelica** | **Matricaria suaveolens** |
| Aptenia cordifolia | Rosa rugosa | **Hydrocotyle bonariensis** | Senecio inaequidens |
| Carpobrotus acinaciformis | Rosa virginiana | **Datura stramonium** | **Solidago canadensis** |
| **Carpobrotus edulis** | **Acacia cyanophylla** | Calystegia pulchra | ***Elodea canadensis*** |
| Carpobrotus glaucescens | **Acacia dealbata** | **Heliotropium curassavicum** | ***Apanogeton distachyos*** |
| Disyphema crassifolium | **Acacia karoo** | Phlomis fruticosa | Eleocharis bonariensis |
| Drosanthemum floribundum | **Acacia longifolia** | Hebe elliptica | Eleocharis striatula |
| Lampranthus falciformis | **Lupinus alboreus** | **Ambrosia artemisifolia** | **Fimbristylus annua** |
| Lampranthus roseus | Trifolium angulatum | **Ambrosia psilostachya** | Cortaderia selloana |
| Mesymbryanthemum nodiflorum | ***Myriophyllum aquaticum*** | **Ambrosia tenuifolia** | **Paspalum distichum** |
| **Bassia hyssopifolia** | Eucalyptus resinifer | **Aster squamatus** | **Paspalum vaginatum** |
| **Chenopodium botrys** | Eucalyptus robustus | **Baccaris halimifolia** | **Polypogon viridis** |
| **Fallopia japonica** | **Oenothera glazioviana** | **Bidens subalternans** | **Spartina alterniflora** |
| Ceratostigma plumbaginoides | **Oenothera rosea** | **Bidens vulgata** | **Stenotaphrum secundatum** |
| Malcolmia flexuosa | **Oenothera stricta** | **Conyza canadensis** | **Typha domingensis** |
| Malcolmia maritima | Euonymus japonicus | **Cotula coronopifolia** | Typha laxmanni |
| Corema album | Euphorbia polygonifolia | Helichrysum foetidum | **Fascicularia bicolor** |
| Escallonia macrantha | Erodium laciniatum | **Iva xanthifolia** | **Crocosmia x crocosmiiflora** |
| Sedum litoreum | | | |

The National report (ICES WGITMO, 1998) stated that the cordgrasses *Spartina anglica* and *S.* x *townsendii* were first introduced in Normandy in 1906, and in 1985 *Spartina anglica* was first observed in Bay of Arcachon (ca. 44.7°N, 1.1°W), SW France, quickly spreading and in the late 1990s covering hundreds of ha. This led to that a pilot eradication programme was carried out in 1997, using quicklime injected in the sediments to destroy the rhizoms. Also the North American species *S. juncea* (according to Hitchcock, 1950 identical to a variety of *S.*

*patens*, cf. below) has occasionally been observed in this bay. Studies during 1998 showed that the quicklime was partly efficient and caused a decline, but no eradication of the cordgrasses, which would require concentrations far too high to be released in nature (ICES WGITMO, 1999).

According to Goulletquer *et al.* (2002) *Spartina alterniflora* was introduced in Brest (48.38°N, 4.53°W), Brittany, before 1960, and *S. versicolor* (probably identical to the North American species *S. patens* according to SanLeón *et al.*, 1999) in the Bay of Arcachon 1901. SanLeón *et al.* (1999) also mapped several records of *S. patens* from the French Mediterranean coast.

#### *2.3.1.10 United Kingdom (including Wales, Scotland, the Isle of Man and the Channel Islands; for Northern Ireland see 2.3.1.11)*

New introductions 1991–2002

In June 1994 the first records of attached *Undaria pinnatifida* at the Hamble estuary (ca. 50.85° N, 1.3°W) in the Solent region, S England, was confirmed (Fletcher and Manfredi 1995, ICES WGITMO, 1995, 1996). A pilot study was started in 1996 to monitor this species, by then only reported from this estuary in Solent, for its potential to spread further and to compete with other species (ICES WGITMO, 1996). Two additional localities on the S coast of England, as well as on Jersey (ca. 49.2°N, 2.1°W), Channel Islands, were reported in 1996, probably representing new introductions and not range extensions (ICES WGITMO, 1997). In 1997, *U. pinnatifida* had established on still another site, close to the previous ones (ICES WGITMO, 1998). A thorough review on the occurrence and ecology of *U. pinnatifida* in UK and in the North Atlantic was given by Fletcher and Farrell (1999), who stated that it mainly occurs on vertical sides of floating structures, and probably had arrived in England with small boats being anchored in the marinas.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera*, 1890 | *Fucus evanescens*, 1902 | *Codium fragile* ssp. *atlanticum*, early 1800s | None reported |
| *Antithamnionella spirographidis*, 1906 [1)] | *Colpomenia peregrina*, 1905 | *Codium fragile* ssp. *tomentosoides*, 1939 | |
| *Antithamnionella sarniensis*[2)], 1921 | *Sargassum muticum*, 1973 | | |
| *Asparagopsis armata*, 1949 | | | |
| *Grateloupia filicina* var. *luxurians*, <1947[3)] | | | |
| *Pikea californica*, 1967 | | | |
| *Grateloupia doryphora*[3) 4)], 1969 | | | |
| *Agardhiella subulata*, 1973 | | | |
| *Polysiphonia harveyi*[5)], 1976* | | | |
| *Soliera chordalis*, <1976[6)] | | | |
| (*Soliera tenera*[7)], 1978) | | | |

1) For 1st record see Maggs and Stegenga (1999), 2) Valid name *A. ternifolia*, 3) For 1st record see references by Cabioch *et al.* (1997), 4) Valid name *G. turuturu* (Gavio and Fredericq, 2002), 5) Valid name *Neosiphonia harveyi* (Guiry *et al.*, 2006), 6) Might be a cryptogenic species in UK (Farnham, 1997), 7) According to Farnham (1997) this was a misidentification of a *S. chordalis* plant. *) 1908 according to Maggs and Stegenga 1999

Introduced macroalgae prior to 1991, but not listed above

Fletcher and Farrell (1999) gave 1986 as the first record on the S coast of England of the small brown alga, *Corynophlea umbellata,* which was found as an epiphyte on *Sargassum muticum* and assumed this canopy alga to be the vector. They also mentioned the brown alga

*Scytosiphon dotyi* on the E coast of England, as an introduction, which might have been overloooked in the past, but now year of introduction was given.

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999) as an introduction from the Mediterranean, and was first recorded in 1976 in Dorset, S England. They stated that the species seemingly was dispersing to new areas, which easily occurs by fragmentation and secondary attachment.

The red alga *Pterosiphonia pinnulata* was suggested by Maggs and Hommersand (1993) to possibly be introduced, since female plants only occurred, close to an oyster farm.

Current status of old introductions

*Sargassum muticum* had in 1998 extended its area into West Angle Bay (ca. 51.7°N, 5°W), on the SW coast of Wales (ICES WGITMO, 1999), and the following year it was well established there and was also found on the island of Lundy (ca. 51.2°N, 4.7°W), and further dispersal could be predicted (ICES WGITMO, 2000). In 2001 it had moved into the Menai Strait (ca. 53.1°N, 4.3° W), where it was flourishing (ICES WGITMO, 2002).

Maggs and Stegenga (1999) described the status of several earlier introduced red algae: Sporophytes of *Bonnemaisonnia hamifera* are very common, even in areas heavily grazed by sea urchins, as well as in sheltered, almost anoxic, muddy areas, where one metre thick beds can occur. *Grateloupia turuturu* (as *G. doryphora)* was described to be spreading in S England, also recorded in the Channel Islands in 1995. The Japanese (McIvor *et al.*, 2001) red alga *Neosiphonia harveyi* is very common intertidally on different substrates (including on ropes and pontoons in marinas) as well as on areas heavily grazed by *Littorina* snails. It is also frequently found on large, drifting canopy species such as the introduced *Sargassum muticum* and *Codium fragile*, the latter may even have been the vector of its introduction to Europe. The further spread of *N. harveyi* may be enhanced by all plants of *S. muticum* being carried around by the currents. In S England *Antithamnionella spirographides* is especially common in yacht marinas, which may enhance its further dispersal in Europe. *Antithamnionella ternifolia* is common on the British Isles, particularly on artificial substrates such as ropes and marina pontoons and easily disperse by vegetative fragmented stolons.

There are many reports on the negative effects of the introduced *Codium fragile* on native species, however, in some areas the native *C. tomentosum* still florish as on Guernsey (ca. 49.5°N, 2.6°W), where the introduced *C. fragile* ssp. *tomentosoides* is quite sparse (Trowbridge *et al.*, 2003).

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Equisetum ramosissimum** | **Isatis tinctoria** | Phlomis fruticosa | ***Sagittaria graminea*** |
| Clematis flammula | Lobularia maritima | Scutellaria hastifolia | *Sagittaria rigida* |
| **Eschscholzia californica** | Malcolmia littorea | Hebe dieffenbachii | ***Sagittaria subulata*** |
| Aptenia cordifolia | Malcolmia maritima | Hebe salicifolia | ***Elodea canadensis*** |
| Carpobrotus acinaciformis | Vaccinium macrocarpon | Hebe x franciscana | ***Elodea nuttallii*** |
| Carpobrotus aequilaterus | Pittosporum crassifolium | Linaria arenaria | ***Apanogeton distachyos*** |
| (Carpobrotus chilensis ?) | Pittosporum tenuifolium | Veronica austriaca | Juncus subulatus |
| **Carpobrotus edulis** | Escallonia macrantha | Coprosoma repens | **Ammophila breviligulata** |
| Carpobrotus glaucescens | Sedum prealtum | **Centranthus ruber** | Cortaderia selloana |
| Disphyma crassifolium | Rosa luciae | **Ambrosia artemisifolia** | Cortaderia richardii |

| | | | |
|---|---|---|---|
| (Drosanthemum candens ?) | Rosa rugosa | **Ambrosia psilostachya** | **Lagurus ovatus** |
| Drosanthemum floribundum | Rosa virginiana | Artemisa stellariana | **Paspalum distichum** |
| Erepsia heteropetala | **Lupinus arboreus** | Asteriscus aquaticus | **Polypogon viridis** |
| Lampranthus falciformis | Tetragonobulus maritimus | **Baccharis halmifolia** | **Spartina alterniflora** |
| Lampranthus roseus | ***Myriophyllum aquaticum*** | Brachyglottis monroi | Spartina pectinata |
| Oscularia deltoides | ***Myriophyllum verrucosum*** | **Centaurea aspera** | Typha laxmanni |
| Ruschia caroli | **Lythrum junceum** | **Conyza canadensis** | **Fascicularia bicolor** |
| Atriplex halimus | Oenothera cambrica | **Cotula coronopifolia** | Ochagavia carnea |
| Atriplex suberecta | Oenothera fallax | Gaillardia x grandiflora | Agapanthus praecox |
| **Fallopia japonica** | **Oenothera glazioviana** | Gazania rigens | **Allium sativum** |
| **Persicaria pensylvanica** | **Oenothera rosea** | Grindelia stricta | **Kniphofia praecox** |
| Rheum x rhabarbarum | **Oenothera stricta** | **Helianthus annuus** | Kniphofia rufa |
| Rumex confertus | Griselina littoralis | **Inula britannica** | Kniphofia uvaria |
| **Rumex cuneifolius** | Euonymus japonicus | **Iva xanthifolia** | **Crocosmia crocosmiifolia** |
| Limonium hyblaeum | **Angelica archangelica** | **Lactuca tatarica** | Iris spuria |
| **Tamarix gallica** | **Datura stramonium** | **Matricaria suaveolens** | **Iris versicolor** |
| **Populus alba** | **Solanum laciniatum** | Olearia macrodontha | Iris x robusta |
| Salix viminalis | Calystegia pulchra | Senecio inaequidens | Phormium cookianum |
| **Cardaria draba** | Dichondra micrantha | **Senecio leucanthemifolius** | **Phormium tenax** |
| **Erucastrum gallicum** | | **Solidago canadensis** | Yucca recurvifolia |

### *2.3.1.11 Ireland and Northern Ireland*

New introductions 1991–2002

In 1995, *Sargassum muticum* was first encountered in Strangford Lough (54.52°N, 5.65°W), Northern Ireland, in the vicinity of bags with Pacific oyster, and the plants were estimated to be 2-3 years old. Pacific oysters had been imported from Guernsey in 1988 (Boaden, 1995, ICES WGITMO, 1995). The survey carried out in 1995 resulted in removal of about 2.5 tonnes, but plants still remained and there were new surveys and clearings in the summer of 1996 (ICES WGITMO, 1996, 1997). New eradications took place during 1997 and the following years, but failed (ICES WGITMO, 1998, 2000). In 2001 the first plants were recorded in Bertraghboy Bay on the W and in Kenmare Bay (ca. 51.7°N, 110°W), on the SW coast of Ireland, probably having been there for two years or more and a field study was carried out during 2002. The vectors may either have been drift from England, visiting leisure crafts or imported oysters (ICES WGITMO, 2002). Plants occur mainly on sheltered to semi-exposed shores in the mid intertidal to upper subtidal together with fucoids and *Laminaria saccharina* (Gallagher *et al.,* 2003).

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera,* 1891 | *Colpomenia peregrina,* 1931 | *Codium fragile* ssp. *atlanticum*, ca. 1808[3)] | None reported |
| *Asparagopsis armata,* 1939* | | *Codium fragile* ssp. *tomentosoides,* ca. 1950 | |
| *Cryptonemia hibernica*[1)], 1971 | | | |
| (*Gracilaria multipartita,* only detached 1977-1981) | | | |

*Polysiphonia harveyi*[2)], 1980s
*Antithamnion densum*, 1990

1) See further references given by Wallentinus (1999a), 2) Valid name *Neosiphonia harveyi* (Guiry *et al.*, 2006), 3) Trowbridge, 1998. *) Tetrasporophytes

#### Introduced macroalgae prior to 1991, but not listed above

Maggs and Hommersand (1993) also listed the red alga *Antithamnionella spirographidis* from Cork and Down in Ireland, but no year of first record was given.

#### Current status of old introductions

On the Irish west coast *C. fragile* ssp. *atlanticum* had increased in relative abundance at all tidal levels in 1999–2000, compared to a survey in 1971, while the dominance of *C fragile* ssp. *tomentosoides* had declined. The native *C. tomentosum* constituted the same percentage of the population as it did in 1971 (Trowbridge, 2001).

In the late 1990s trial cultivation of the introduced red alga *Asparagopsis armata* started on the west coast of Ireland to be used in the cosmetic industry (ICES WGITMO, 1998; Kraan and Barrington, 2005). Those continued in the early 2000s, with plans of increasing the longline cultivations. *A. armata* is common in the wild, at some sheltered localities and occurs in the early 2000s on the S, SW and W coasts of Ireland (ICES WGITMO, 2002). Kraan and Barrington (2005) reported in a survey of previous records of gametophytes and tetrasporophytes along the Irish coast, and only found gametophytes within a radius of 75 km from the farming sites. They considered ther farm in Ard bay to be a source pool for the gametophytic populations (by fragmentation) and that, in general, temperatures are too low for sexual reproduction of this species, However, they did not consider the it to be an invasive species in the area, and even mentioned that it has increased biodiversity.

#### Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold +** **underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Carpobrotus edulis** | Escalonia macrantha | Hebe salicifolia | ***Elodea canadensis*** |
| Lamprantus falciformis | Rosa rugosa | Hebe x franciscana | ***Elodea nuttallii*** |
| **Fallopia japonica** | **Lupinus arboreus** | **Centranthus ruber** | Cortaderia selloana |
| Rheum x rhabarbum | **Medicago arabica** | Artemisia stellariana | **Spartina anglica** |
| **Populus alba** | Hippophae rhamnoides | Artemisia stellariana | Spartina maritima |
| Salix viminalis | **Onoethera glazioviana** | **Lactuca tatarica** | Spartina pectinata |
| **Isatis tinctoria** | **Datura stramonium** | **Matricaria suaveolens** | Spartina x townsendii |
| **Cardaria draba** | Calystegia pulchra | Olearia macrodonta | **Crocosmia x crocosmiiflora** |
| Lobularia maritima | Phlomis fruticosa | **Solidago canadensis** | **Phormium tenax** |
| Erica terminalis | | | |

### *2.3.1.12 Spain, the Atlantic coast (incl. the Canary Islands)*

#### New introductions 1991–2002

Pena and Barbara (2003) reported of records of *Dasysiphonia* sp. in the harbour of A Coruña (ca. 43.4°N, 8.4°W), NW Spain, and, quoting J. Cremadas, Maggs and Stegenga (1999), reported that a red alga, very similar to *Dasysiphonia* sp., has been very common in Galicia, N Spain, since the 1990s. According to Verlaque (2001) *Dasysiphonia* sp. should be identical to

*Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a), however, an ongoing taxonomic revision may show that it should be removed from the genus *Heterosiphonia*.

The brown alga *Stypopodium schimperi*, a Lessepsian immigrant in the Mediterranean, has been recorded from the Canary Islands (Sanson *et al.*, 2002). The Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neospihonia harveyi*, Guiry *et al.* 2006) was first recorded on Teneriffe in 1991–92, growing on buoys, ships' hulls and ropes (Rojas Gonzáles *et al.*, 1994).

The red alga *Palmaria palmata* has been farmed in a large scale in N Spain (José Rico pers. comm.). The species occurs naturally in the area, but the quantities are too low for the demand, and this should thus be seen as restocking.

Previously established (Wallentinus, 1999a)

| Red algae | Brown algae | Green algae | Phanerogams |
|---|---|---|---|
| *Asparagopsis armata*, 1920s | *Colpomenia peregrina*, <1960s | *Codium fragile* ssp. *tomentosoides*, <1957 | None reported |
| *Antithamniella sarniensis*[1)], 1920s | *Sargassum muticum*, 1985 | | |
| (*Dipterosiphonia dentritica**, 1960) | *Undaria pinnatifida*, 1990 | | |
| *Antithamniella spirographides*, <1986 | | | |
| *Mesothamnion caribaeum*[2)] late 1970s (Can.Isl) | | | |
| *Platysiphonia caribaea*, late 1980s (Can.Isl) | | | |
| *Predaea huismanii*, late 1980s (Can.Isl) | | | |
| *Grateloupia doryphora*[3]), 1990 | | | |
| *Grateloupia filicina* var. *luxurians*, 1990 | | | |
| (*Pikea californica*[4)], 1991) | | | |
| *Lomentaria hakodatensis*, 1992[5)] | | | |
| (*Bonnemaisonia hamifera*?)[6)] | | | |

1) Valid name *A. ternifolia*, 2) Valid name *Pleonosporium caribaeum* 3) Valid name *Grateloupia turturu* (Gavio and Fredericq, 2002), 4) According to ICES WGITMO, 1993 this was a misidentification, 5) Listed in ICES WGITMO ,1992, 6) See below, *) probably native

Introduced macroalgae prior to 1991, but not listed above

The E Australian red alga *Gymnophycus hapsiphorus*, first recorded in 1989, was only found in harbours in the Canary Islands, growing on ship's hulls, buoys, ropes etc., and thus Sansón and Reyes (1995) suggested it most probably had been introduced by shipping.

According to Sansón and Reyes (1995) the occurrence of *Grallatoria reptans* on the Canary Islands is a disjunct one, which sometimes points to an introductions. Also *Antithamnion. diminuatum*, which has been recorded from the Canary Islands, is disjunct, since it is a species of the southern hemisphere (Athanasiadis, 1996b).

Ruperez and Saura-Calixto (2001), and several similar papers on utilization of Spanish seaweeds, stated that the red alga *Porphyra tenera* is a Spanish edible seaweed. However, to my knowledge this is an Indo-Pacific alga, which also was imported for farming on the US Pacific coast (Wallentinus, 1999a and references therein). Thus it is unclear if *P. tenera* has been introduced, intentionally or accidentally, to Spain, or if the authors or their material suppliers, do not have the proper taxonomic knowledge to separate species within this genus, which seems more likely.

Current status of old introductions

In 1992 there was a slight increase in the abundance of *Undaria pinnatifida*, and new populations of *Lomentaria hakodatensis* was found in Galicia (ICES WGITMO, 1993; Bárbara and Cremades, 1996). There is an ongoing exploitation and cultivation of *U. pinnatifida* in N Spain, and there are many papers after 2000 describing analyses of that alga, as well as of some edible native seaweeds (e.g. Ruperez and Saura-Calixto, 2001). According to José Rico (pers. comm.), *U. pinnatifida* is farmed on the NW coast all the way down to the bordering river to Portugal.

The ecological constraints for the establishment and abundance of *Sargassum muticum* in N Spain have been discussed by several authors (e.g. Viejo *et al.* 1995; Rico and Fernandéz, 1997; Viejo, 1997; Andrew and Veijo, 1998; Sanchez *et al.*, 2003). The species is patchily distributed and most abundant in sheltered areas and tide pools, but more sensitive to wave exposure, although phenotypic adaptation can occur. When there was a profuse colonization of *S. muticum* perennial seaweeds of the leathery type (e.g. *Bifurcaria bifurcata* and *Cystoseira* spp.) were most negatively affected (Viejo, 1997).

The green alga *Codium fragile* ssp. *tomentosoides* is according to José Rico (pers. comm.) only common on the NE coast, in the Bay of Biscay, while the native species *C. tomentosum* is dominating further west. It also grown on the Canary Islands (Sansón and Reyes, 1995).

According to Diez *et al.* (2003), tetrasporophytes of the red alga *Asparagopsis armata* occurred in half of their surveyed quadrats, with a mean cover of 5 %, while gametophytes only were found in 16 % of the quadrats with a mean cover of 0.4 %. Andreakis *et al.* (2004) listed several collections of gametophytes of *A. armata* from the N Spanish coast, but none of *A. taxiformis* (too cold). Diez *et al.* (2003), also listed *Bonnemaisonia hamifera* in 30 % of the quadrats (mean cover 0.7 %), thus confirming the presence of the species in N Spain (cf. discussion in Wallentinus 1999a). They also found low frequences of the red algae *Antithamnionella spirographides* and *Anothrichium furcellatum*, and of the brown alga *Colpomenia peregrina.*

When monitoring the harbour of A Coruña, NW Spain, in the early 2000s the following previously introduced species were found: *Sargassum muticum*, *Undaria pinnatifida, Codium fragile* and *Lomentaria hakodatensis* (Pena and Bárbara, 2003).

Phanerogams, often old introductions (all of Spain)

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold +** **underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Eschscholzia californica** | **Fallopia japonica** | **Oenothera glazioviana** | **Cotula coronopifolia** |
| Opuntia ammophila | Populus euphratica | **Oenothera rosea** | **Helianthus annuus** |
| Aptenia cordifolia | Salix viminalis | **Oenothera stricta** | Helichrysum foetidum |
| Carpobrotus acinaciformis | Malcolmia flexuosa | Euonymus japonicus | **Solidago canadensis** |
| Carpobrotus aequilaterus | Malcolmia maritima | Euphorbia polygonifolia | ***Elodea canadensis*** |
| Carpobrotus chilensis | Sedum litoreum | **Hydrocotyle bonariensis** | Lilea scilloides |
| **Carpobrotus edulis** | **Acacia cyanophylla** | **Datura stramonium** | **Fimbrisylus ferruginosa** |
| Disphyma crassifolium | **Acacia cyclops** | **Heliotropium curassavicum** | Cortaderia selloana |
| Drosanthemum hispidum | **Acacia dealbata** | **Ageratina adenophora** | **Paspalum distichum** |
| Galenia secunda | **Acacia karoo** | **Ambrosia psilostachya** | **Paspalum vaginatum** |

| | | | |
|---|---|---|---|
| Lampranthus falciformis | **Acacia longifolia** | **Ambrosia tenuifolia** | **Spartina alterniflora** |
| Lampranthus multiradiatus | ***Myriophyllum aquaticum*** | **Aster squamatus** | **Spartina densiflora** |
| **Tetragonia tetragonoides** | Eucalyptus gomphocephalus | **Baccharis halmifolia** | **Stenotaphrum secundatum** |
| **Atriplex semibaccata** | Eucalyptus resinifer | **Bidens subalternans** | **Aloe vera** |
| Atriplex suberecta | Eucalyptus robustus | **Conyza canadensis** | **Phormium tenax** |

The North American cordgrass *Spartina patens* was detected in Galician wetlands in 1997, occurring also at the border to Portugal, and is concidered a weed, which has a negative effect on species diversity in the upper marshes (SanLeón *et al.,* 1999). It has also been found on the Spanish Mediterranean coast, mostly under the name of *S. versicolor,* which for long was thought of as a native Mediterranean plant, but most probably was introduced long ago as packing material in ships' boxes and crates (SanLeón *et al.,* 1999).

### *2.3.1.13 Portugal (incl. the Azores)*

New introductions 1991–2002

Araujo *et al.* (2003) reported of records of the red alga *Grateloupia turuturu* from the NW coast of Portugal in the early 2000s.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Asparagopsis armata*, <1970 | *Colpomenia peregrina*, <1970 | None reported | None reported |
| *Antithamnionella sarniensis*[1)], <1970 | *Sargassum muticum*, 1991[4)] | | |
| *Mesothamnion caribaeum*[2)], 1970s | | | |
| *Symphyocladia marchantioides*, 1971 | | | |
| *Antithamnionella spirographides* ? | | | |
| (*Bonnemaisonia hamifera*?)[3)] | | | |

1) Valid name *A, ternifolia*, 2) Valid name *Pleonosporium caribaeum*, 3) See discussion in Wallentinus 1999a, 4) Listed in ICES WGITMO, 1992

Introduced macroalgae prior to 1991, but not listed above

Tittley and Neto (2005) reported that both subspecies of *Codium fragile*, ssp. *tomentosoides* and *atlanticum*, are widely occurring in the Azores. According to Parente *et al.* (2003), it has been suggested that the occurrence the brown alga *Endarachne binghamiae* could be the result of an introduction, since it is the only site in the North Atlantic and was first seen in 1980, but not reported until 1994. They also stated that it is common throughout the year on mid-tidal, rocky shores in exposed areas and only one stage with plurilocular sporangia have been seen, but no sexual reproduction.

According to Guiry *et al.* (2006), *Antithamnion pectinatum* (according to Cho *et al.,* 2005 should be *A. nipponicum*) occurs on the Azores. *A. diminuatum* is a species of the southern hemisphere, which has also been recorded from the Azores (Athanasiadis, 1996b).

Current status of old introductions

In the early 2000s *Sargassum muticum* is mainly found in tide pools in the SW Portugal, where it can become dominant, and its demography at the southernmost distribution limit in Europe has been studied (Engelen *et al.,* 2003). On the Azores, *Asparagopsis armata* is competitive, which probably has resulted in *A. taxiformis* being less common than earlier

Tittley and Neto (2005). Andreakis *et al.* (2004) listed several collections of gametophytes of *A. armata* from the S Portuguise coast, but none of *A. taxiformis*.

There is no information available on the present status of the other previously introduced seaweeds, nor if the Japanese kelp *Undaria pinnatifida* has reached Portuguese waters. However, since *U. pinnatifida* is cultivated close to the Spanish border (2.3.1.12) in the north, it can be expected to arrive in a near future, if not already having done so.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Eschscholzia californica** | **Rumex cuneifolius** | **Oenothera stricta** | Helichrysum foetidum |
| Aptenia cordifolia | Salix viminalis | Hakea salicifolia | **Matricaria suaveolens** |
| Carpobrotus acinaciformis | Malcolmia flexuosa | **Hydrocotyle bonariensis** | ***Elodea canadensis*** |
| **Carpobrotus edulis** | **Acacia cyanophylla** | **Datura stramonium** | Triglochin striata |
| Disphyma crassifolium | **Acacia cyclops** | Dichondra micrantha | Lilaea scilloides |
| Drosanthemum candens | **Acacia dealbata** | **Heliotropium curassavicum** | **Cyperus brevifolius** |
| Lampranthus falciformis | **Acacia karoo** | Phlomis fruticosa | Cyperus congestus |
| Lampranthus multiradiatus | **Acacia longifolia** | Hebe salicifolia | Cortaderia selloana |
| Mesymbryanthemum crystallinum | Acacia sophorae | **Ageratina adenophora** | **Paspalum distichum** |
| Mesymbryanthemum nodiflorum | ***Myriophyllum aquaticum*** | **Ambrosia artemisifolia** | **Paspalum vaginatum** |
| Ruschia caroli | Eucalyptus resinifer | **Aster squamatus** | **Stenotaphrum secundatum** |
| **Sesuvium portulacastrum** | Eucalyptus robustus | **Conyza canadensis** | **Aloe vera** |
| **Tetragonia tetragonoides** | Oenothera affinis | **Cotula coronopifolia** | **Crocosmia x crocosmiiflora** |
| **Fallopia japonica** | **Oenothera glaziovana** | Gazania rigens | Phormium tenax |
| | **Oenothera rosea** | | |

According to SanLeón *et al.* (1999) the North American cordgrass *Spartina patens* occurs at several sites in Portugal.

## 2.3.2 The Baltic Sea coasts (inside the Kattegat and the Belt sea areas)

### *2.3.2.1 Sweden*

New introductions 1991–2002

Large amounts of a subtropical, estuarine benthic diatom, *Pleurosira leavis* f. *polymorpha* were reported from the cooling water basins at the nuclear power stations at Forsmark (60.38°N, 18.25°E), S Bothnian Sea, and Oskarshamn (57.26°N, 16.49°E), the Baltic proper, probably having arrived through stocking of eels (Jansson, 1994; ICES WGITMO, 1995). Its present status is not known.

Previously established (Wallentinus, 1999a)

| <u>**Red algae**</u> | <u>**Brown algae**</u> | <u>**Green algae**</u> | <u>**Phanerogams**</u> |
|---|---|---|---|
| None reported | None reported | *Chara connivens*, 1950s (probably from the late 1800s[1)]) | *Elodea canadensis*, 1873<br>(*Myriophyllum sibiricum*[2)]) |

1) See Luther 1979, 2) *Myriophyllum sibiricum* is to be considered as a range extension, thus it is not an introduced species

<u>Introduced plants prior to 1991, but not listed above</u>

The submersed phanerogam, *Elodea nuttallii*, was first seen in the country in the end of the 1980s.

<u>Current status of old introductions</u>

The introduced *Chara connivens* has been enclosed in the Swedish Endangered Species Red List as a vulnerable species (Aronsson *et al.,* 1995; Gärdenfors, 2000). Field surveys in 1999, however, revealed that it was more abundant in the Öregrund archipelago (ca. 60.3°N, 18.5°E) than previously believed (ICES WGITMO, 2000). The principle of red-listing introduced species has been discussed at several WG-meetings (e.g. ICES WGITMO, 1998, 1999).

<u>Phanerogams, mainly old introductions, see 2.3.1.4</u>

### *2.3.2.2 Finland*

There are no macroalgae included in the National reports and I have found no information on any introduced macroalgae in the literature, neither have I found any information if the phanerogam *Elodea nuttalli* has been established in Finland (cf. 2.3.2.1)

Previously established (Wallentinus, 1999a)

| <u>**Red algae**</u> | <u>**Brown algae**</u> | <u>**Green algae**</u> | <u>**Phanerogams**</u> |
|---|---|---|---|
| None reported | None reported | None reported | *Elodea canadensis*, 1884<br>(*Myriophyllum sibiricum*[1)]) |

1) *Myriophyllum sibiricum* is to be considered as a range extension, thus not an introduced species

<u>Phanerogams, often old introductions</u>

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in <u>**bold +**</u> <u>**underlined**</u> = highly invasive taxa)

| | | | |
|---|---|---|---|
| Ranunculus cymbalaria | <u>**Cardaria draba**</u> | Apium graveolens | **Inula britannica** |
| <u>**Fallopia japonica**</u> | <u>**Isatis tinctoria**</u> | <u>**Datura stramonium**</u> | **Lactuca tatarica** |
| <u>**Persicaria pensylvanica**</u> | Lobularia maritima | Veronica austriaca | **Matricaria suaveolens** |
| Rumex confertus | Rosa rugosa | <u>**Ambrosia artemisifolia**</u> | **Solidago canadensis** |
| <u>**Rumex obtusifolius**</u> | Astragalus arenarius | <u>**Centaurea diffusa**</u> | <u>***Elodea canadensis***</u> |
| <u>**Populus alba**</u> | Medicago arabica | <u>**Conyza canadensis**</u> | <u>**Polypogon monspeliensis**</u> |
| Salix viminalis | **Lythrum hyssopifolia** | <u>**Helianthus annuus**</u> | **Asparagus officinalis** |
| Brassica oleracea | | | |

### *2.3.2.3 Estonia*

The only macroalga included in the National reports is a reference on a paper dealing with grazing on *Chara connivens* (ICES WGITMO, 2003, cf. below). I have found no information on any other introduced macroalgae in the literature.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | None reported | None reported | *Elodea canadensis*, 1873 |

Introduced macroalgae prior to 1991, but not listed above

There was no report on *Chara connivens* from Estonia in the paper by Luther (1979), who discussed old discharges of solid ballast as a vector. The first record for Estonia is from as late as in the 1980s, as single specimens from Kihnu Island (ca. 58.1°N, 24.0°E) and on the south coast of the island Saaremaa (ca. 58.2°N, 22.6°E), W Estonia (Torn and Martin 2003 and reference therein), their origin, however, not discussed. Considering solid ballast being he vector for the other countries around the Baltic, the species may well have been overlooked in the past. Recently, Torn *et al.* (2003) stated that *Chara connivens* is no longer rare in W Estonia, occurring both around the islands of Saaremaa and Hiumaa, as well as in bays on the mainland facing the Gulf of Riga (ca. 58.2–58.9°N, 22.0–23.6°E), but not along the Gulf of Finland, in salinities from 0.5 to 6.5 psu and down to 3 m depth.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Kask and Vaga, 1966; Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Chenopodium botrys** | **Erucastrum gallicum** | **Ambrosia psilostachya** | **Solidago canadensis** |
| Corispermum intermedium | **Isatis tinctoria** | **Centaurea diffusa** | ***Elodea canadensis*** |
| **Fallopia japonica** | Rosa rugosa | **Conyza canadensis** | Beckmannia eruciformis |
| | Astragalus arenarius | **Helianthus annuus** | **Zizania aquatica** |
| Rumex confertus | **Medicago arabica** | **Iva xanthifolia** | Zizania latifolia |
| **Populus alba** | Apium graveolens | **Lactuca tatarica** | **Asparagus officinalis** |
| Brassica oleracea | **Datura stramomium** | **Matricaria suaveolens** | Iris sibirica |
| **Cardaria draba** | | | |

### *2.3.2.4 Latvia*

No National reports have been delivered and I have found no information in the literature on any other introduced macroalgae, nor on the status of *Chara connivens* or *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | None reported | *Chara connivens*, 1922[1)] | *Elodea canadensis*, 1880s? |

1) See Luther 1979

Phanerogams, often old introductions, see 2.3.7

### *2.3.2.5 Lithuania*

No National reports have been delivered and I have found no information in the literature on any introduced macroalgae, nor on the status of *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | None reported | None reported[1)] | *Elodea canadensis*, 1880s? |

1) See Luther 1979 for misidentifications of freshwater samples named *Chara connivens*

Phanerogams, often old introductions, see 2.3.7

### 2.3.6 Russia, Baltic coast

The only records available of plants introduced into the Baltic coast of the USSR are the early introductions of the charophyte *Chara connivens* (recorded in the 1870s and 1920s, for references see Luther, 1979) and the phanerogam *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | None reported | *Chara connivens*, 1870[1)] | *Elodea canadensis*, 1880s? |

1) See Luther 1979

Phanerogams, often old introductions, see 2.3.7

### 2.3.7 Baltic coasts of former Soviet – Introduced phanerogams

Only for Estonia have I been able to find separate information on introduced phanerogams and the following Table is based on information in Flora Europea, where the Baltic coasts of the former Soviet were treated collectively.

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold +** **underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Chenopodium botrys** | **Erucastrum gallicum** | **Lactuca tatarica** | ***Elodea canadensis*** |
| Corispermum intermedium | **Datura stramonium** | **Matricaria suaveolens** | **Zizania aquatica** |
| **Fallopia japonica** | **Conyza canadensis** | **Solidago canadensis** | **Asparagus officinalis** |
| **Cardaria draba** | | | |

### 2.3.8 Poland

There are no macroalgae included in the National reports and no information on any new introduced macroalgae have been found in the literature, nor on the status of the previous introductions.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | None reported | *Chara connivens*, <1865[1)] | *Elodea canadensis*, 1870 |

1) See Luther 1979

Phanerogams, often old introductions

Established taxa occurring close to the sea shore, incl. in low saline estuarine environments, on sand dunes, mud and on rocks (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Chenopodium botrys** | **Erucastrum gallicum** | **Ambrosia artemisifolia** | **Iva xanthifolia** |
| **Silene conica** | Lobularia maritima | **Ambrosia psilostachya** | **Lactuca tatarica** |
| **Fallopia japonica** | Rosa rugosa | **Centaurea diffusa** | **Matricaria suaveolens** |
| **Populus alba** | **Datura stramonium** | **Conyza canadensis** | **Solidago canadensis** |
| **Cardaria draba** | Calystegria pulchra | | ***Elodea canadensis*** |

## 2.3.9 Germany, Baltic coast

New introductions 1991-2002

The red alga *Dasya baillouviana* was found in the autumn of 2002 in the outer Kiel Bight (Athanasios Athanasiadis pers. comm.), which is not surprising since it has occurred on the E coast of Jutland for many years (see. 2.3.1.5 and Wallentinus, 1999a).

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| None reported | *Fucus evanescens*, 1989 | *Chara connivens*, 1858 | None reported |

Current status of old introductions

Grazing effects on *Fucus evanescens* was described by Schaffelke *et al.* (1995) and the authors stated that the species had increased in abundance, since its first appearance, and was less preferred than *F. vesiculosus* by the grazing isopod *Idothea baltica* and that this could contribute to its increase.

Phanerogams, often old introductions, see 2.3.1.6.

## 2.3.3 The Mediterranean Sea

### *2.3.3.1 Spain, the Mediterranean coast*

New introductions 1991–2002

In the summer of 1998 the first specimens of *Caulerpa racemosa* were found on Mallorca, showing a regression in winter, but then a large increase in the summer of 1999 when it occupied 3 ha. According to Verlaque *et al.* (2000) it probably belongs to the invasive variety, which is considered a recent immigrant (Verlaque *et al.*, 2003). In 2000 it was common in the whole of Palma Bay (ca 39.5°N, 2.6°E), having increased its area by around 20 times. Small populations had also been recorded near the port at Ibiza (38.90°N, 1.45° E) and at Grao de Costellón (ca. 40°N, 0°E), on the Mediterranean mainland coast (ICES WGITMO, 2001).

The National report (ICES WGITMO, 2001) also stated that several red algae had been increasing and spreading, probably being transported by ships, since they were first recorded in the Balearic Islands, where leisure boat traffic is frequent. *Acrothamnion preissii*, being first recorded in the Mediterranean in the 1960s (see 2.3.3.2 and 2.3.3.3), was found on the coast of Mallorca in the early 1990s and was later observed on more localities, as well as on the northern coast of Menorca. It forms dense tufts on the seagrass *Posidonia oceanica* and can replace the characteristic native epiphytes (ICES WGITMO, 2001). The invasive red alga *Womersleyella setacea*, first seen on the French Mediterranean coast in the 1980s (2.3.3.2) and spreading in Italy in the 1990s, turned up on the coasts of the Balearic Islands at Cabrera (ca. 39.1°N, 2.9°E) and Menorca, as well as on the island Alboran, during the early 1990s.

The very dense turfs have a strong negative impact on both the benthic communities and on fishery (ICES WGITMO, 2001).

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Asparagopsis armata*, 1920s | | | |
| (*Dipterosiphonia dendritica*[1)], 1960s) | None reported | *Caulerpa taxifolia*, 1992[2)] | None reported |
| *Bonnemaisonia hamifera*, late 1980s | | | |

1) Probably native, 2) Listed in ICES WGITMO, 1993 for the Balearic Islands, and said to have been eradicated (but cf. below)

Introduced macroalgae prior to 1991, but not listed above

The red alga *Lophocladia lallemandii* was sighted at the S Spanish Mediterranean coast in the late 1980s. In 2000 it had become quite invasive on the coast of Ibiza, where it could reach more than 100% cover, and the dense turfs produce seasonal blooms, which may affext the native flora and fauna (ICES WGITMO, 2001).

*Antithamnion amphigeneum*, first seen on the island Alboran (35.98°N, 3.01°W) in 1990, was observed spreading on the coast of Mallorca in the beginning of the 1990s, later also found in low abundances at Medes islands on the Catalanian coast and near Valencia (ca. 39.5°N, 0.4°W) (ICES WGITMO, 2001), probably transported by boats.

According to references given by Cabioch *et al.* (1997) the red alga *Grateloupia doryphora* (valid name *G. turuturu*, Gavio and Fredericq, 2002,) was seen on the coast of Malaga as early as in 1948.

Magne (1992) reported on the minute red alga, *Goniotrichopsis sublittoralis*, being recorded from Mallorca in 1989.

Soto Moreno and Conde Poyales (1993) included the red alga *Antithamnionella spirographides* in the list of species occuring on the island Alboran.

According to Occhipinti Ambrogi (2002) the Atlantic/Pacific brown alga *Desmarestia viridis* was recorded from Malaga (ca. 36.7°N, 4.4°E) in 1984.

Current status of old introductions

*Caulerpa taxifolia* had stablized at the E coast of Mallorca (Porto Petro, Cala d'Or, Porto Colom) affecting around 60 ha along 9.4 km coast in 2000, while no records had been made on the mainland coast (ICES WGITMO, 2001, Meinesz *et al.*, 2001).

Phanerogams, often old introductions see 2.3.1.12.

### *2.3.3.2 France, the Mediterranean coast (incl. Corsica)*

New introductions 1991–2002

A large number of newly introduced macroalgae, mostly having reproducing thalli and not just fragmentation, have turned up in the Thau Lagoon (ca. 43.4°N, 3.6°E) after 1991 and was reported by Verlaque (2001), but these species have not been included in the French National reports. In 1993, or early 1994, the Asiatic red alga *Chondrus giganteus* f. *flabellatus* was seen for the first time in Europe and in the Mediterranean, probably arriving there by newly illegally imported oysters from Japan, where this alga is endemic (Verlaque and Latala, 1996, Verlaque, 2001). They also reported that it became common already in September 1995, and all reproductive stages were seen, and further, should it reach the Atlantic coast, it might be a threat to the commercially important carrageenophyte *Chondrus cripus*, through competition or hybridization.

Verlaque (2001) also listed several other newly introduced species. The Pacific red alga *Ahnfeltiopsis flabelliformis* was first seen in the lagoon in 1994, arriving by recent transfers of Japanese oysters and later having had a detrimental effect on native species. The same year and vector was given by him for the calcareous crust *Lithophyllum yessoense*, a species which in Japan is a dominant species that outcompete others by its grazer-resistance and strategy to peel off the epithallus as well as having a high capacity for thallus regeneration. Also the red alga *Prionitis patens*, endemic to Korea and Japan, was thought to have come to the lagoon with recent transfers of Japanese oysters, as had the Pacific/ Indian Ocean red alga *Herposiphonia parca*. He also concluded that the red algae *Grateloupia filicina* var. *luxurians* and *Polysiphonia morrowi*, new to the Mediterranean in 1997, might have come either directly from the Pacific or from aquaculture sites in Europe, where the former earlier had been introduced in several areas (see 2.3.1.9, 2.3.1.10, 2.3.1.12), and the latter may be conspecific with the record of *P. senticulosa* from the Netherlands (2.3.1.7). Also the brown alga *Scytosiphon dotyi* may have come either way with oysters, first seen in 1994, and the same applies to the brown alga *Acrothrix gracilis*, new to the Mediterranean in 1998. On the other hand the red alga *Chondria coerulescens* must have an Atlantic origin and could have arrived with transfer of oysters. Also the brown alga *Cladosiphon zosterae*, recorded in the lagoon in 1998, but seen already in the 1970s in Italy, has an Atlantic origin and probably arrived with oyster transfers.

The red alga called *Pterosiphonia* sp., first seen 1998 (Verlaque, 2001), was later identified as the Pacific species *P. tanakae* (Boudouresque and Verlaque, 2002). In 1998, the red alga *Heterosiphonia japonica* (which may be removed to another genus after revison) was first seen in the Mediterranean in this lagoon, and Verlaque (2001) concluded it may have come with oysters, either directly from the Pacific, or from aquaculture sites in Europe, while shipping cannot totally be ruled out (cf. 2.3.1.3, 2.3.1.7, 2.1.3.9, 2.3.1.12). A minute red alga *Rhodothamniella* cf. *codicola* (valid name *Acrochaetium codicolum*) was first detected in the lagoon in 1997, but may have come much earlier, with the introduction of *Codium fragile*, on which it is an epiphyte. However, this conclusion must await a definite identification.

*Grateloupia lanceolata*, an endemic red alga to China and Korea, was not recognized as an introduction in the Thau Lagoon until 1993, but probably arrived much earlier and then had been confused with *Grateloupia turuturu* (Verlaque, 2001).

The red alga *Hypnea valentiae* is considered a Lessepsian immigrant in the E Mediterranean, but Verlaque (2001 and references therein) doubted this is the case for the Thau lagoon and and considered it more likely to have come from Asia with oysters.

Large populations of the tropical green alga *Caulerpa racemosa* were reported from Marseille, S France, in 1997 (ICES WGITMO, 1998, Verlaque *et al.*, 2000). Later morphological and molecular genetic studies have shown this invasive variety to be a recent invasion (Verlaque *et al.*, 2003).

The red *Laurencia caduciramulosa*, described from Vietnam, was recorded at seven sites on the French south coast close to harbours in 2002 (Klein and Verlaque, 2005). They suggested that it could be a secondary introduction by shipping from S Italy, where it was first recorded 1991, later also found in further SW in 1998. Furthermore, the disjunct dispersal in the Mediterranean, the closeness of the areas studied to harbours, and the relative low abundances, point to a recent introduction in the Mediterranean.of the species. So far, it is not considered as invasive, although it can propagate vegetatively by small lateral branches (Klein and Verlaque, 2005).

Previously established (Wallentinus, 1999a), some years corrected after Verlaque (2001) and underlined species were seen in the Thau lagoon in the late 1990s and species in bold have had a detrimental effect on native species in the lagoon.

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Asparagopsis armata*, 1926 | ***Colpomenia peregrina***, 1956 | ***Codium fragile***, 1950s | |
| *Porphyra yezoensis*, 1975 | ***Undaria pinnatifida***, 1971 | *Caulerpa taxifolia*, 1984 | |
| ***Chrysymenia wrightii***, 1978 | *Laminaria japonica* 1976 | | |
| *Aglaothamnion feldmanniae*, 1979 | ***Desmarestia viridis***, 1978 | | |
| (*Dipterosiphonia dendritica**, 1979) | *Leathesia difformis*, 1979 | | |
| (*Laurencia microcladia**, 1979) | ***Sargassum muticum***, 1980 | | |
| *Lomentaria hakodatensis*, 1979 | *Sphaerotrichia divaricata*[5], 1980 | | |
| *Acrothamnion preissii*, 1981 | *Chorda filum*, 1981 | | |
| ***Grateloupia doryphora***[1], 1982 | *Fucus spiralis*, 1987 | | |
| *Polysiphonia setacea*[2], 1987 | | | |
| ***Lomentaria hakodatensis***, 1979 | | | |
| *Antithamnion nipponicum*[3], 1988 | | | |
| *Polysiphonia nigrescens*[4], 1988 | | | |

1) Vald name *G. turuturu*, Gavio and Fredriques 2002; 2) Valid name *Womersleyella setacea*; 3) Also referred to as *A. pectinatum* 4) Valid name *P. fucoides*, 5) Confirmed to be of Japanese origin (Peters *et al.*, 1993), * According to Ribera Siguan (2002) not an introduced species

Introduced macroalgae prior to 1991, but not listed above

Still more introductions of macroalgae to the Thau lagoon, S France, were reported by Verlaque (2001), most of them first recorded in the 1980s. The red alga *Dasya* sp. was first seen in 1984, and probably arrived there with the mass importations of oysters from Japan in the 1970s. It was later identified as *Dasya sessilis* (Boudouresque and Verlaque, 2002) and, according to Verlaque (2002), it has later developed abundant reproductive populations. Also the Asiatic red alga *Laurencia okamurae*, seen since 1984, probably came by the same vector. Verlaque (2001) also listed the red alga, *Agardiella subulata*, first seen in 1984, and probably having arrived with oyster transfers from the Atlantic coast, as well as the small red alga *Rhodophysema georgii*, first seen in 1978, but not recovered in surveys during the late 1990s. The red alga *Griffithsia corallinoides*, first seen in 1984, might have either a North Pacific or Atlantic origin. He also reported on a then yet not identified species of the red algal genus *Grateloupia* seen in 1985, which might be of a Pacific origin. Included was also the red alga *Polysiphonia atlantica*, which was considered by him as an introduction in the area throug shipping or oysters, while Ribera Siguan (2002) considered it to be native to the Mediterranean.

The brown alga *Halothrix lumbricalis* was first seen in 1985 and could have either an Atlantic or a Pacific origin, as could *Pilayella littoralis*.

Green algae, new to the Mediterranean, include the endemic Japanese species *Derbesia rhizophora*, recorded in 1984, and the Asiatic *Ulva pertusa* first seen in 1984, both probably also a result of the massive import of Japanese oysters in the 1970s. In a later paper (Verlaque *et al.*, 2002) it was stated that abundant populations of *Ulva pertusa* have been seen since 1994, and that the specimens agreed well with this Asiatic species. *Monostroma obscurum*, seen in 1985, could have either an Atlantic or a North Pacific origin, and have had a detrimental effect on the native seaweeds.

Earlier introductions encompass the red algae *Polysiphonia paniculata*, seen in 1967 but not recovered in surveys during the late 1990s, and *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) probably having been in the Mediterranean since very long, and with a detrimental effect on the native seaweeds, although frequently referred to as *P. mottei.* The brown alga *Leathesia difformis*, occurring in all temperate seas, may have been there since 1905, but was not seen during the surveys in the late 1990s.

<u>Current status of old introductions</u>

For *Caulerpa taxifolia* expansion was noted during the early 1990s (e.g. Boudouresque *et al.*, 1992; ICES WGITMO, 1993), and no sign of regression was noted in the late 1990s, the maximum densities found between 1 and 30 m, with densities increasing also at depths below 30 m, then often exceeding 25% cover. At new localities with small patches eradication by hand and with a cover leaking copper was used (ICES WGITMO, 1998, see also 2.2.3). In 1998 *C. taxifolia* began to invade also dense *Posidonia* beds (ICES WGITMO, 1999, see also Devillele and Verlaque, 1995). In 2000, a survey, covering over 21 000 ha in two bays were leisure boots are frequently moored, revealed that over 8000 ha were heavily colonized by *C. taxifolia* (ICES WGITMO, 2002).

In 1992 the abundance of *Laminaria japonica* was reported to be declining (ICES WGITMO, 1993) and Verlaque (2001) found no plants in the survey of the Thau lagoon, albeit he did not look for it during winter.

On the other hand *Porphyra yezoensis* and *Grateloupia doryphora* (valid name *G. turuturu*, Gavio and Frederique 2002) were reported to have spread in 1992 (ICES WGITMO, 1993), while Verlaque (2001) found no plants of *Porphyra yezoenis* in the survey of the Thau lagoon, albeit he did not look for it during winter.

Phanerogams, often old introductions, see 2.3.1.9.

### *2.3.3.3 Italy*

By courtesy of professor Mario Cormaci, Rome University, I have received the Official list from the Ministry of the Environment for algal taxa to be considered as introduced along the Italian coasts, including year of first record and publication. These years of first record are used, if not otherwise stated.

<u>New introductions 1991–2002</u>

The invasive variety of *Caulerpa racemosa* (Verlaque *et al.*, 2000, 2003) was first reported from the Lampedusa Island (35.5°N, 12.6°E) in 1993. In the late 1990s the same variety also occurred in the Ionian and S part of Sicily, Gulf of Cagliari (ca. 39.2°N, 9.2°E), Gulf of Salerno (ca. 40.7° N, 14.7°E) and near Genoa (44.4°N, 8.9°E) in Tuscany (ICES WGITMO, 1998, Verlaque *et al.*, 2000), in many places causing decline in native seaweed abundancies and biodiversity (Occhipinti Ambrogi, 2002). In 1999 it had expanded rapidly due to fishing activities disseminating fragments to new sites (ICES WGITMO, 2000). In 2001 it was very abundant at Lampedusa Island (ICES WGITMO, 2002). It was recently also found near Taranto (40.5°N, 17.2°E), and its competiton with the seagrass *Posidonia oceanica* depends on the densities of the meadows, while *Cymodocea nodosa* is more vulnerable and in many places is replaced by *Zostera noltii* (ICES WGITMO, 1998; Occhipinti Ambrogi, 2002). According to studies by Piazzi *et al.* (2001), at the Tuscan coast, *C. racemosa* is even more invasive than *C. taxifolia,* having increased its surface area and number of patches with 285% and 121% in one year, compared to an increase of 68% and 11%, respecively, for *C. taxifolia*. The stolon growth *in situ* was also higher with 2.03 cm day$^{-1}$ compared to 0.97 for *C. taxifolia*.

Since 1992, *Undaria pinnatifida* and *Sargassum muticum* (the latter may have arrived earlier) have started to build up large populations in in Venice (45.5°N, 12.5°E), the vector being either shipping or mussel importations (ICES WGITMO, 1996, 2000). The development of *U. pinnatifida* has been very rapid in the centre of Venice (ICES WGITMO, 2001) and in 2004 it was very common along many of the canals in the city (IW pers. obs.). On the other hand, *S. muticum* took longer time to disperse, but in 2001 had increased and almost outcompeted the native large brown alga *Cystoseira barbata* (ICES WGITMO, 2001). In 1998 *U. pinnatifida* was found near Taranto, having arrived there by oysters imported from France (Occhipinti Ambrogi 2002 and reference therein).

The pantropic red alga, *Womersleyella setacea*, was first recorded at the coast of Livorno in 1986 and was collected at the island Lampedusa in 1993. During the 1990s it has been spreading in Italien waters and is even growing on *Caulerpa* spp., forming thick mats on the surface, which prevent settlement of other organisms (Occhipinti Ambrogi, 2002).

Cormaci *et al.* (1992) reported the following new red algae: the southern African *Botryocladia madagascariensis*, recorded in 1991 at Lampedusa Island and Sicily, the west African *Ceramium strobiliforme* from Salina Island in 1991, and the Red Sea species *Chondria pygmaea* from Catania harbour in 1991.

According to Verlaque (1994) the red alga *Asparagopsis taxiformis*, probably a Lessepsian immigrant, was recorded for the first time in Italy, in the early 1990s, at the island of Elba (ca. 42.8°N, 10.3° E). Later in the 1990s it was spreading in the Gulf of Naples (Flagella *et al.* 2003) with gametophytes dominating during winter, but occurring all year through and present in 75% of the sites assessed, but with a lower degree of cover and frequency than *Caulerpa racemosa*. Barone *et al.* (2003) reported gametophytes from W Sicily, occurring there since 2000. Also Andreakis *et al.* (2004) and Ní Chualáin *et al.* (2005) considered *A. taxiformis* as introduced in the Mediterranean, and being genetically different from the clade found in the Carribean Sea and on the Canary Islands. Andreakis *et al.* (2004) reporded records from several places on the Italian west coast. However, the species is not included in the official list.

In 1994 the Asiatic red alga, *Antithamnion pectinatum* (according to Cho *et al.*, 2005 the correct identity is *A. nipponicum*), was first found in the Venice Lagoon, growing on mussels and other algae (Curiel *et al.,* 1996) and has later spread widely (Occhipinti Ambrogi, 2002). Oyster movements seem to be the most likely vector. The species *A. amphigenum* was found for the first time the same year at Spezia harbour, NW Italy (Rindi *et al.*, 1996).

The Asiatic red alga, *Polysiphonia morrowii*, was first recorded in spring 1999 in the lagoon S of Venice, where imported clams and fish are handled (Curiel *et al.*, 2002). One year later it had spread to several new sites in the centre of Venice (Occhipinti Ambrogi, 2002).

In 2001 the Asiatic red alga, *Lomentaria hakodatensis*, was found associated with *Sargassum muticum* in the S sector of the Venice Lagoon (ICES WGITMO, 2002). This Asiatic alga has occurred in Mediterranean France since 1979 (2.3.3.2), as well as on the N coast of Spain since 1992 (2.3.1.12) and on the Atlantic coast of France since 1984 (2.31.9).

The diminutive deep-water red alga, *Apoglossum gregarium*, was first found in 1992 at several sites in the Tuscian archipelago, incl. the island Elba, by Sartoni and Boddi (1993), who, however, doubted that it was a recent introduction, due to its occurrence in deep water only, but it is included in the official list.

The official list also includes the red algae *Chondria polyrhiza*, first recorded from Cheradi Island, S Italy in 1992, *Hypnea cornuta*, the first record from Mar Piccolo, Taranto, S Italy published 2002, and the brown alga *Leathesia difformis*, the record from Venice Lagoon published 1999. In a later paper, Cecere *et al.* (2004) described that *Hypnea cornuta* occurs both attached and as free-floating population throughout the Mar Piccolo, and that it could have arrived from the Indo-Pacific or the eastern Mediterranean, either by shipping or by transfers of mussels. Furthermore, it can propagate vegetatively by stellate branches or fragmentation.

In Venice lagoon, the brown algae *Punctaria tenuissima* and *Ectocarpus siliculosus* var. *hiemalis* were first recorded in 1999 (Ribera Siguan, 2002 and reference therein) and an unidentified species of the genus *Sorocarpus* in 1996 (Curiel *et al.*, 1999), the latter genus recorded for the first time in the Mediterranean (not included in the official list).

The red alga, *Laurencia caduciramulosa*, described from Vietnam, was first recorded from the Lachea Islands, close to Sicily, and the harbour of Catania in 1991 (for references see Klein and Verlaque, 2005). In 1998 it was found on the Linosa Island (Peleagen Island SE of Italy), and Klein and Verlaque (2005) suggested that S Italy probably was the primary introduction area in the Mediterranean.

Rindi *et al.* (2002) listed *Symphyocladia marchantioides* among red algae present in Tuscany, NW Italy. Besides the Azores, the species is only recorded from the southern hemisphere and northern Pacific, and might thus be an introduction. However, the species is not included in the official list.

The benthic dinoflagellate *Ostreopsis ovata*, typical for tropical to subtropical waters, has been found on the west coast of Italy (Tognetto *et al.*, 1995; Vila *et al.*, 2001), but could also be native in the area.

Italy, not being an ICES Member country, was not covered by the previuos Status reports, but for some macroalgae also occurring in other countries records were mentioned (see below).

Previously established (Wallentinus, 1999a)

| RED ALGAE | BROWN ALGAE | GREEN ALGAE | PHANEROGAMS |
|---|---|---|---|
| *Acrothamnion preissii*, 1969 | *Desmarestia viridis*[2)], 1849 | *Caulerpa taxifolia*, 1991-92 | None reported |
| *Aglaothamnion feldmanniae*, 1976 | | | |
| *Polysiphonia nigrescens*[1,2)] <1985 | | | |

1) Valid name *P. fucoides*, 2) Not included in the official list

Introduced macroalgae prior to 1991, but not listed above

The long list of introduced macroalgae provided with the Italian report in 2000 (ICES WGITMO, 2000), as well as additional species in the official list, is given below for earlier introductions not mentioned above. Time of first records (or listed for Italy) are taken from: 1) The official list, 2) Occhipinti Ambrogi 2002, and 3) Verlaque, 1994, 4) Verlaque, 2001, 5) ICES WGITMO, 2000, 6) Tutin *et al.*, 1980

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Asparagopsis armata*, 1920s | *Colpomenia peregrina*, 1939[3)] | *Codium fragile* ssp. *tomentosoides*, 1973[1)] | *Halophila stipulacea*, <1980[6)] |
| *Soliera filiformis*, 1922[1)] | *Padina boergesenii*, 1963[1)] | *Caulerpa scalpelliformis*[2)5)] | |
| *Grateloupia doryphora*, 1969[2)] | *Scytosiphon dotyi*, <1978[1)] | | |
| *Lophocladia lallemandi*, 1969[1)] | *Halothrix lumbricalis*, 1978[1)] | | |
| *Neosiphonia harveyi*, 1969[1)] | *Cladosiphon zosterae*, <1975[4)] | | |
| *Bonnemaisonia hamifera*, 1973[1)] | | | |
| *Laurencia majuscula*, 1983-84[1)] | | | |
| *Hypnea spinella*, 1985[1)] | | | |

*Agardhiella subulata*, 1987[1)]
*Laurencia chondroides*, 1990 [1)]
*Plocamium secundatum*, 1991[1)]
*Acanthophora najadiformis*[2),5)]
*Antithamniella spirographidis*[2)5)]
*Griffithsia corallinoides*[2)5)]

Verlague (1994 and references therein) also mapped the red alga *Antithamnion decipiens* (as *A. ogdeniae*) for the W coast of Italy in 1989, and *Hypnea cervicornis* from Syracuse, Siciliy (<1988), the latter, however, could be the same record as the above listed *Hypnea spinella* from the same place. According to Ribera Siguan (2002) and Athanasiadis (1996b) the red alga *Antithamnionella sublittoralis*, found in 1988 at Syracuse, Sicily, could be a recent introduction to the Mediterranean. However, it is not included in the official list. Ribera Siguan (2002) and Athanasiadis (1996b) also considered the closely related *A. elegans* (not included in the official list), which was detected as sterile plants in the harbour of Naples already in the late 1800s, as an introduction from Japan, where fertile plants occur.

Current status of old introductions

*Caulerpa taxifolia* was in the late 1990s present in the Ligurian Sea (several ha of the Western Riviera colonized), in Tuscany and Sicily (ICES WGITMO, 1998, see also 2.2.3). In 1999 it occurred along almost all the Italian northwest coast, forming large populations in the infralittoral fringe, and new records had been made in the Messina Strait (ca. 38–38.4°N, 15.7°E) (ICES WGITMO, 2000; Meinesz *et al.*, 2001), the latter estimating that 9415 ha was concerned in the beginning of 2000s. In areas with nutrient-enriched sediments, it is outcompeting the native seagrass *Cymodocea nodosa*, while *Posidonia* beds with high densities of seagrasses are less vulnerable (Occhipinti Ambrogi, 2002 and references therein).

According to Piazzi and Cinelli (2003), *Posidonia* meadows in NW Italy are almost totally dominated by the introduced turf red algae *Acrothamnion preisii* and *Womersleyella setacea.* However, the latter dominated on rocks, where it has replaced *A. preisii*, and partially also on "matte". In areas where *C. racemosa* has invaded, *W. setacea* is absent, but it does occur together with *C. taxifolia*. Sampling rhizoms in *Posidonia* meadows from 21 sites in W Italy, Piazzi *et al.* (2002) showed that *W. setacea* was present at 17 and *A. preisii* at 10 sites. They also conluded that the functional algal diversity was high, if these two species were not present, or if they did not form dense turfs, while mainly filamentous algal species occurred if they formed turfs.

The brown alga *Desmarestia viridis* was in the 1990s common in Chioggia (45.22°N, 12.28°E), S of Venice, competing with the other two introduced large brown algae, *S. muticum* and *U. pinnatifida* (ICES WGITMO, 2001).

The red alga *Lophocladia lallemandii* is buoyant, and when stranded on the beaches in large quantities, it creates a nuiance for the tourism (Occhipinti Ambrogi, 2002).

*Aglaothamnion feldmanniae*, previously only recorded once in W Italy (see above) was found in Venice in the beginning of 2000s (Occhipinti Ambrogi, 2002).

According to Andreakis *et al.* (2004) the occurrence of *Asparagopsis armata* in the Strait of Messina has not been recovered, and they even mentioned that it might have been a founder population that has died out since it was first seen there in 1987.

The Lessepsian seagrass *Halophila stipulacea* is occupying shallow soft bottoms, being especially common in harbours (Occhipinti Ambrogi, 2002).

Phanerogams, often old introductions

Taxa occurring close to the sea shore, incl. in low saline estuarine environments (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| Aptenia cordifolia | **<u>Acacia karoo</u>** | **Angelica archangelica** | **Cotula coronopifolia** |
| Carpobrotus acinaciformis | **Acacia longifolia** | **Hydrocotyle bonariensis** | **Matricaria suaveolens** |
| **Carpobrotus edulis** | Eucalyptus gomphocephalus | **Hydrocotyle sibthorpioides** | Senecio inaequidens |
| Drosanthemum hispidum | Eucalyptus resinifer | **<u>Datura stramonium</u>** | ***<u>Elodea canadensis</u>*** |
| **<u>Tetragonia tetragonoides</u>** | Eucalyptus robustus | Dichondria micrantha | *Halophila stipulacea* |
| **<u>Fallopia japonica</u>** | Eucalyptus rudis | **Heliotropium curassavicum** | **<u>Cyperus polystachyos</u>** |
| Ceratostigma plumbaginoides | Eucalyptus robustus | **<u>Ageratina adenophora</u>** | **<u>Cyperus strigosus</u>** |
| Salix viminalis | Eucalyptus rudis | **<u>Ambrosia artemisifolia</u>** | **<u>Fimbristylus annua</u>** |
| Malcolmia flexuosa | **Oenothera glazioviana** | **<u>Ambrosia psilostachya</u>** | **<u>Paspalum distichum</u>** |
| Sedum praealtum | **Oenothera rosea** | **Aster squamatus** | **Paspalum vaginatum** |
| **<u>Acacia cyanophylla</u>** | **Oenothera stricta** | **<u>Centaurea diffusa</u>** | **Stenotaphrum secundatum** |
| **<u>Acacia dealbata</u>** | Euonymus japonicus | **<u>Conyza canadensis</u>** | **Aloe vera** |
| | | | Iris spuria |

### *2.3.3.4 Malta*

New introductions 1991–2002

The red algae *Botryocladia madagaskariensis* and *Chondria pygmaea* were recorded for the first time in 1994 (Cormaci *et al.*, 1997).

*Womersleyella setacea* was recorded for the first time in the area in 1993 (Athanasiadis, 1997 and reference therein). Nothing is known of its present status, but considering the increase and large impact in other areas (see 2.3.3.3), it may well show the same pattern here.

There is, to my knowledge, no reports on *Caulerpa taxifolia* or *C. racemosa* from Malta for that period, although both species occur in Tunisia and southern Italy (Verlaque *et al.*, 2000, Meinesz *et al.*, 2001).

Introduced macroalgae (no years stated), not mentioned above, following Cormaci *et al.* (1997), and Wallentinus (2002).

| Red algae | Brown algae | Green algae |
|---|---|---|
| *Asparagopsis armata* | None reported | None reported |
| *Acanthophora nayadiformis* | | |
| *Lophocladia lallemandii* | | |

Current status of old introductions

There is no available information on the current status of these introductions.

Phanerogams, often old introductions

Taxa occurring close to the sea shore, incl. in low saline estuarine environments (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa

| | | | |
|---|---|---|---|
| Aptenia cordifolia | Carpobrotus acinacifolia | **Carpobrotus edulis** | *Halophila stipulacea* |

### *2.3.3.5 The western Balcan peninsula (excl. Greece)*

There is very little information in the literature on introduced algae from these countries and they were not included in the previous Status report.

New introductions 1991–2002

In 1994, the aquarium strain of the green alga *Caulerpa taxifolia* was first recorded close to a mooring dock at Stari Grad on Hvar Island (43.19°N, 16.63°E), S Croatia, and in 1995 it also turned up at the port of Malinska, Krk Island (ca. 45.2°N, 14.7°E), N Croatia and in 1996 in the Barbat Channel, near Dolin Island (ca. 44.3°N, 14.8°E), Croatia, where boats are frequently moored (Meinesz *et al.*, 2001). They also stated that eradication attempts failed in the long run, and that *C. taxifolia* continued to spread, especially at the first site.

Verlaque *et al.* (2000) did not map any occurrences of *C. racemosa* in this area.

Previously introduced macroalgae (Wallentinus, 2002).

| **Red algae** | **Brown algae** | **Green algae** |
|---|---|---|
| *Chondria pygmea,* Albania <1996 | *Desmarestia viridis,* Croatia 1948[1)] | |

*1) Year according to Occhipinti Ambrogi (2002).*

Current status of old introductions

There is no available information on the current status of these introductions.

Phanerogams, often old introductions

Taxa occurring close to the sea shore, incl. in low saline estuarine environments (Wallentinus, 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| **Carpobrotus edulis** | Euonymus japonicus | **Ambrosia artemisifolia** | ***Matricaria suaveolens*** |
| **Fallopia japonica** | **Angelica archangelica** | **Aster squamatus** | ***Elodea canadensis*** |
| Brassica oleracea | **Datura stramonium** | **Conyza canadensis** | *Halophila stipulacea* |
| **Acacia dealbata** | **Heliotropium curassavicum** | **Helianthus annuus** | **Paspalum distichum** |

### *2.3.3.6 Greece*

New introductions 1991–2002

The red alga *Womersleyella setacea* was first recorded in spring 1992, from Sarti Reef and Pseudokopons on the Sithonia penisula, NE Greece, where it formed 1–2 cm dick carpets in the sublittoral (Athanasiadis, 1997). He also stated that fishermen often visit the area and that it probably had arrived with infested nets. When revisiting the area in summer 1996, *W. setacea* was still there but not forming mats. It has also been reported from Milos Island, S Greece.

Verlaque (1994) did not map any occurrence in Greece of the Lessepsian brown alga *Stypopodium schimperii*, which was later found on the island Milos, SW Aegean Sea, in 1996 (Sartoni and De Biasi, 1999). Studying shallow-water hydrothermal vents off the island of Milos, the Aegean Sea, De Biasi and Aliani (2003) found it to be the most important and conspicuous species, reaching down to 41 m depth, with 25% cover on vent sites, but only 2–5% in non-vent sites.

Introduced macroalgae prior to 1991 (Wallentinus, 2002)

Year of first record follows mainly Athanasiadis (1987).

| **Red algae** | **Brown algae** | **Green algae** |
|---|---|---|
| *Lophocladia lallemandii*, 1908 | (*Chorda filum*?, <1899) | *Codium fragile* ssp. *tomentosoides*[2)] |
| *Acanthophora nayadiformis*, < 1948 | | *Caulerpa racemosa*, 1956[3)] |
| *Hypnea valentiae*, 1960s[1)] | | |
| *Antithamnion decipiens*, 1980 | | |
| *Asparagopsis armata*, < 1981 | | |
| *Chondria polyrhiza*, 1982 | | |
| *Hypnea esperi*, < 1985 | | |
| *Hypnea spinella* | | |
| *Sarconema scinaiodidis* | | |
| (*Polysiphonia fucoides*?, <1968) | | |

1) Propobably a Lessepsian immigrant in the E Mediterranean, see Verlaque, 2001 and references therein, 2) After 1945 according to Zenetos *et al.*, 2002, 3) For first record see below

Current status of old introductions

According to Verlaque *et al.* (2000) *Caulerpa racemosa* was first recorded in 1956 from the Greek island Castellorizo, close to Turkey, and differed in variety from the recently inviding taxon, but was not the same taxon as the specimens first recorded in the Mediterranean. The invasive variety, consistent with a variety endemic to SW Australia (Verlaque *et al.*, 2003), was first seen at Zakynthos Island (ca 37.8°N, 20.9 °E), on the SW coast of Greece in 1993 (Panayotis and Montesanto 1994, Verlaque *et al.*, 2000), growing as small patches in the beds of *Posidonia* at 25–35 m depth between the seagrass plants. Verlaque *et al.* (2000) also stated that the invasive variety was found at Kalimnos Island (ca 37.0 °N, 27.0 °E) in 1997, and at Crete, Salmos Island, and the Gulf of Saronikes in 1998.

There is to my knowledge no report on *Caulerpa taxifolia* from Greece.

According to Zenos *et al.* (2002), *Codium fragile* is now common in the Agean Sea.

Phanerogams, often old introductions

Taxa occurring close to the sea shore, incl. in low saline estuarine environments (Wallentinus 2002). Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa)

| | | | |
|---|---|---|---|
| Aptenia cordifolia | **Acacia cyanophylla** | **Aster squamatus** | *Halophila stipulacea* |
| Carpobrotus acinacifolia | **Datura strammonium** | **Conyza canadensis** | **Fimbrystulus ferruginosa** |
| **Carpobrotus edulis** | **Heliotropum curassavicum** | **Helianthus annuus** | **Paspalum distichum** |
| Lobularia maritima | **Ageratina adenophora** | | **Aloe vera** |

## 2.3.4 North America (incl. also the Pacific coasts)

### *2.3.4.1 Canada*

Since 2001, Canada has a new National Code on intentional introductions and transfers, which is almost unique in the way that also plants are covered (ICES WGITMO, 2002). In 1995, there were two proposals to introduce the Pacific kelp *Macrocystis integrifolia* from British Columbia to the Gulf of St. Lawrence for developing a herring roe-on-kelp fishery, which were denied (ICES WGITMO, 1996).

New introductions 1991–2002

In 1991, the green alga, *Codium fragile* ssp. *tomentosoide*, was recorded in Nova Scotia for the first time (Bird *et al.*, 1993;ICES WGITMO, 1994), the proposed vector being shipping or currents, and later also transfers of shellfish from the US was suspected as a vector (ICES WGITMO, 1996). The first years there seemed to be no dispersal to other costal areas, nor any sign of it being a threat to other subtidal species (ICES WGITMO, 1996). However, in 1996 there were numerous reports of findings in the Gulf of St Lawrence, and it was found attached to American oysters, *Crassostrea virginica*, at Prince Edward Island and further surveys and ecological impact studies were planned (Garbary *et al.*, 1997; ICES WGITMO, 1997). It later became a severe nuissance in oyster cultures at PEI, affecting both the oyster growing areas in up to 2 feet high mats, as well as on the suspended gears, and although large amounts of plants (> 100 000 pounds) were taken ashore, no decline was noted (ICES WGITMO, 1998, 1999, 2002; Chapman, 1999). Treatment of oysters with 4% hydrated lime for 5 minutes, or saturated brine for 15 minutes appeared to kill *Codium*, allowing oyster movements without spreading the alga (ICES WGITMO, 1998). However, it was later detected that the efficiency was not that high and that holdfasts of the alga in crevices on the shells could regrow despite the chemical treatment (ICES WGITMO, 1999, 2000), and that manual removal had no long-term effects. In 2000 a significant number of oysters became buoyant through the algal growth and were washed ashore, and there was severe fouling of aquaculture lines and some epiphytes on *Codium* caused skin irritations. There was also great concern that *C. fragile* would spread to the major oyster producing bays in PEI (ICES WGITMO, 2001). An apparent jump within the PEI region to the southernmost part had occurred during 2001 (ICES WGITMO, 2002).

For farming of the Japanese *Porphyra yezoensis* in New Brunnswick see 2.2.4.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Furcellaria lumbricalis*, late 1800s?[1) ] (Atlantic coast) | *Fucus serratus*, 1800s?[1)] (Atlantic coast) | None reported | *Artemisia stelleriana*, old (Atlantic coast) |
| *Bonnemaisonia hamifera*, 1948 (Atlantic coast) | *Sargassum muticum*, <1941 (Pacific coast) | | *Zostera japonica*, 1969 (Pacific coast) |
| (*Lomentaria orcadensis*)[2)] (Atlantic coast) | *Colpomenia peregrina*, 1960 (Atlantic coast) | | |

1) For references on proposed arrival time see Wallentinus, 1999a, 2) According to Bird and McLachlan (1992: 122) it has only been recorded once and is considered an adventive species in the Maritimes

Introduced macroalgae prior to 1991, but not listed above

Recent studies, using rbcL sequences, have revealed that the red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi* , Guiry *et al.*, 2006) is not of Atlantic origin, but has been introduced from Japan, and can be found from New Foundland and southwards (McIvor *et al.*, 2001).

On the Pacific coast the red alga *Lomentaria hakodatensis* was first recognized as an introduced species in 1967 at the N part of the Gabriola Island (ca 49.2°N, 125.8°W) in the Strait of Georgia, British Columbia (South 1968). He also listed three other localities closeby, where the alga had been collected in 1959 and 1962, as well as two sites on the Washington side of the Strait, and considered that it most probably had arrived there by oyster imports from Japan, and not by dispersal from the S part of North America. In the mid 1980s it had colonized also the W shores of Vancouver Island (Hawkes and Scagel, 1986).

The same vector was supposed to have brought the Japanese red alga *Gelidium vagum* to British Columbia, where it has a restricted distribution in the area around the Hornby-Denman

Islands, an area with many oyster farms, and where it was recognized in the mid 1980s (Renfrew *et al.*, 1989).

Current status of old introductions

In British Columbia there was concern about sightings of *Sargassum muticum* outside the Pendrell Sound, where it had arrived in the late 1970s (ICES WGITMO, 1996). There have been no reports, so far, of any records of this species from the Canadian Atlantic coast, despite temperatures are well within its tolerance range in the southern parts.

Bird and McLachlan (1992) stated that mature gametophytes of *Bonnemaisonia hamifera* are uncommon around Nova Scotia and in the outer Bay of Fundy, and that only young gametophytes have been seen in Gulf of St. Lawrence. Sporophytes, on the other hand, are locally abundant in summer, with tetraspores in autumn, and present all year round down to 20 m depth, but are rare in the inner Bay of Fundy. *Furcellaria lumbricalis* is common in the Gulf of St. Lawrence, and occasionally also in the adjacent outer coasts down to 12 m depth and in the 1970s-1980s storm-cast plants were used as an industrial resource, but drift has since declined, probably due to movement of sand into the algal beds (Bird and McLachlan, 1992).

In Boundary Bay, British Columbia, there was an almost 17-fold increase between 1970 and 1991 in coverage of *Zostera japonica* and it had extensively colonized formerly unvegetated tidal flats, and dramatically altered the habitat structure, covering 60% of the bay's intertidal and shallow subtidal area and occurring mostly from 0 to -1.8 m (Baldwin and Lovvorn, 1994). They also stated that it provides an important feeding habitat for many migratory waterfowl, which could remove 50% and 43% of its above- and below-ground biomass, respectively.

Phanerogams, often old introductions

It has not been possible to list all phanerogams introduced into Canada, which grow or have a potential to grow at or close to the seashore. The tentative list below is mainly summarized from "The flora of Nova Scotia" (Roland and Smith, 1969) and, although the occurrences in other provinces as well as in the US mostly are mentioned, it does not include species only found elsewhere. Furthermore, it is not up to date with the new taxonomy, nor with new species concepts and recent introductions of course are not included. Anyhow, it gives an idea of the quite large number of introductions, several also weeds, and most of them (118) are of European origin, while a few are Asian (5) or South-American (2) plants and some (6) are natives of other parts of the North American continent. That book also had an interesting note saying that the North American species *Elodea canadensis*, since long introduced in most European countries, had been planted in a pond as food for wild fowl. However, I have found no information that this should be an additional vector in Europe. **Bold** denotes weeds, and **Bold + underlined** serious weeds, *Italic* submerged plants

| | | | |
|---|---|---|---|
| Atriplex sabulosa | Sedum accre | Lycium halimifolium | **Cirsium vulgare** |
| **Chenopodium album** | Sedum telephium[2)] | **Solanum dulcamara** | Cnicus benedictus |
| **Chenopodium botrys** | **Filipendula ulmaria** | Solanum nigrum | **Cotula coronopifolia** |
| Chenopodium glaucum | **Potentilla argentea** | Convolvulus arvensis | **Helianthus annuus** |
| Scleranthus annuus | Potentilla reptans | Cynoglossum officinale | **Hieracium spp.** |
| Spergularia rubra | Prunus spinosa | Echium vulgare | **Iva frutescens** |
| **Spergula arvensis** | Rosa canina | Myosotis scorpiodes | **Iva xanhifolia** |
| Arenaria serpyllifolia | Rosa rugosa | Galeopsis bifida | Leontodon autumnalis |
| **Stellaria graminea** | Lathyrus pratensis | **Galeopsis trifida** | **Matricaria maritima**[7)] |
| **Stellaria media** | Lotus corniculatus | **Lamium purpureum** | **Matricaria matricarioides**[8)] |
| **Polygonum arenastrum** | Lotus uliginosus | Lycopus europeus | **Onopordum acanthium** |
| Polygonum rhaii? | Medicago falcata[3)] | **Stachys palustris** | Senecio sylvaticus |

| | | | |
|---|---|---|---|
| Polygonum lapathifolium[1] | Melilotus altissimus | Cymbalaria muralis | Senecio squalidus |
| **Polygonum cuspidatum** | Trifolium repens | **Linaria vulgaris** | **Senecio viscosus** |
| Rumex domesticus | Vicia angustifolium | **Odontites serotina**[6] | **Senecio vulgaris** |
| **Rumex crispus** | Vicia cracca | **Verbascum thapsus** | **Sonchus arvensis** |
| Rumex acetosella | Vicia hirsuta | Veronica longifolia | **Sonchus uliginosus**[9] |
| **Rumex obtusifolius** | Vicia sepium | Veronica officinalis | **Tanacetum vulgare** |
| **Populus alba** | ***Myriophyllum spicatum***[4] | **Plantago major var. intermedia** | **Taraxacum spp.** |
| Salix viminalis | **Lythrum salicaria** | **Plantago lanceolata** | **Tussilago farfara** |
| **Urica urens** | Epilobium hirsutum | **Galium aparine** | Juncus compressus |
| **Cardaria draba** | Erodium cicutarium | Galium verum | ***Zostera japonica***[10] |
| Coronopus procumbens | Linum catharticum | **Acillea millefolium** | Aira praecox |
| Diplotaxis muralis | Millegrana radiola[5] | **Ambrosia psilostachya** | **Eragrostis megastachya** |
| **Erucastrum gallicum** | Conium maculatum | **Anthemis tinctoria** | **Phragmites communis**[11] |
| Lepidium campestre | **Pimpinella saxifraga** | Artemisia absinthium | **Poa annua** |
| **Sisymbrium altissimum** | Viola tricolor | Artemisia stelleriana | Poa pratensis |
| **Thlaspi arvense** | Centaurium umbellatum | **Artemisia vulgaris** | Puccinellia distans |
| **Calluna vulgaris** | **Datura stramonium** | Bellis perennis | **Asparagus officinalis** |
| | | | Iris pseudacorus |

1) Valid name *Persicaria lapathifolia*, 2) Valid name *Hylotelephium telephium*, 3) Valid name *Medicago sativa* var. *falcata*, 4) See also Wallentinus, 1999a, 5) Valid name *Radiola linoides*, 6) Valid name *Odontites littoralis*, 7) Valid name *Tripleurospermum maritimum*, 8) Valid name *Matricaria suaveolens*, 9) Valid name *Sonchus arvensis* var. *glabrescens*, 10) See also above and Wallentinus, 1999a, 11) Valid name *Phragmites australis* often described as cosmopolitic species, but considered to be an old introduction on the North American continent, where there are many recent papers on its impact.

The Atlantic dune grass *Ammophila arenaria* was introduced as a stabilizer on the Pacific coastal dunes in the 1860, now being present from the southern border to N of Vancouver Island, and has lately become a species of concern, since it outcompetes the native species, as well as prevent new sand being brought to the foredunes, which finally will lead to disappearance of the dunes (Wiedemann and Pickart, 1996).

Additionally, it can be mentioned that extremely dense and deep-growing (6.5 m) populations of fanwort, *Cabomba caroliniana*, was found in Lake Kasshabog (44.63°N, 79.97°W), Ontario, probably as a result of someone dumping an aquarium. Other freshwater plants may have spread from gardens or aquaria such as the floating heart, *Nymphoides peltata*, in two lakes near Burlington (ca. 43.3°N, 79.8°W) and the European frog-bit, *Hydrocharis morsus ranae*, in several lakes throughout E Ontario (ICES WGITMO, 1997, 2001).

#### *2.3.4.2 USA (excl. Hawaii)*

New introductions 1991–2002

As mentioned in 2.2.4 the first nets with *Porphyra yezoensis* were released in the sea in Maine during 1992 (ICES WGITMO, 1993). As of 1994 no plants had been detected outside the cultivation area (ICES WGITMO, 1994), but later some few were recorded (ICES WGITMO, 1997), which did not survive the winter (see also 2.2.4). West *et al.* (2005), reported records of *Pophyra yezoensis* from Dover Point in New Hamshire, but it is not clear if this occurrence has anything to do with the farming in Maine (*P. yezoensis* U51). The species was identified by using ITS1 and rbcL sequences, and when comparing with data in GenBank, it was found to be identical to *P. yezoensis* forma *narawaensis* cultivar F-6 and strain NA4, which were not listed among those of interest for culturing in Maine (ICES WGITMO, 1996). For more on the farming of the Japanese *Porphyra yezoensis* in Maine, see 2.2.4.

The Pacific red alga *Grateloupia doryphora* (valid name *G. turuturu*, Gavio and Fredriqs, 2002), previously introduced in several European countries, was first recognized in large amounts in the outmost parts of Narragansett Bay, Rhode Island, in 1996, and further studies were undertaken (ICES WGITMO, 1997; Villalard-Bohnsack and Harlin, 1997). Later studies showed, however, that the species was in fact present already 1994 (Harlin and Villalard-Bohnsack, 2001; Villalard-Bohnsack and Harlin, 2001). It is supposed to have arrived by shipping, although it is not possible to say from where. In 1997 it was well established in Narragansett Bay, harbouring large number of the native grazing snail *Lactuna vincta*. The species was expected to spread further south through Long Island Sound (ICES WGITMO, 1998) and its seasonal dynamics, strategies and further dispersal in the area were studied (Harlin and Villalard-Bohnsack, 2001; Villalard-Bohnsack and Harlin, 2001), the latter study revealing that it by 1999 had spread north, east and west in Narragansett Bay, and south along the open coast of Rhode Island Sound.

In 2000 the noxious aquaria strain of *Caulerpa taxifolia* was detected in S California in Aqua Heionda Lagoon at Carlsbad (33.20°N, 117.35°W) and in Huntington Harbor (33.67°N, 118.0° W) (Jousson *et al.*, 2000; Kaiser, 2000; ICES WGITMO, 2001, 2002; Williams and Grosholz, 2002), the possible vector being aquaria releases. The authorities and private entities responded very quickly (e.g. Anderson, 2005) and after less than three weeks an eradicating programme with chemical treatment with chlorine injected under PVS mats started.

The first record of the Japanese kelp, *Undaria pinnatifida*, was detected in Los Angeles Harbor in 2000 (Silva *et al.*, 2002), and was later found at several sites in S California. In 2001 it had been established at Santa Barbara Harbor (34.40 °N, 120.68°W), Cabrillo Beach at San Pedro (33.73° N, 118.27°W) and at Channel Islands Harbor at Oxnard (34.15°N, 119.20°W) and as far north as Monterey Bay (36.60 °N, 121.89°W), there growing down to 25 m depth (ICES WGITMO, 2002; Silva *et al.*, 2002). It probably had arrived with shipping. See also 2.2.1 and Wallentinus (submitted).

The non-native, Indo-Pacific green alga *Caulerpa brachypus* was first recognized in SE Florida in 2001, creating extensive mats overgrowing or displacing the native flora (Florida Sea Grant College Program quoted by Walters *et al.*, 2006).

Mats of free-living Atlantic knotted wrack (*Ascophyllum nodosum* ecad *mackayi*) were found in San Fransisco Bay during a survey in 2001–2002. The presumed vector was as packing material, either around bait worms or seafood. Since fertile plants were seen, and it also can propagate by fragmentation, the small population was eradicated manually later that autumn (Miller *et al.*, 2004), and the success has been monitored further.

Previously established (Wallentinus, 1999a)

| **Red algae** | **Brown algae** | **Green algae** | **Phanerogams** |
|---|---|---|---|
| *Bonnemaisonia hamifera*, 1927 (Atlantic coast) | *Sargassum muticum*, <1947 (Pacific coast) | *Codium fragile* ssp. *tomentosoides*, 1957 | *Artemisia stellariana*, old (Atlantic coast) |
| *Lomentaria clavellosa*, 1960s (Atlantic coast) | | (Atlantic coast) | *Myriophyllum spicatum* (Atlantic coast, late 18th century) |
| *Porphyra yezoensis* (farmed in sea, Pacific coast ≥1984; Atlantic coast≥1992) | | | *Zostera japonica*, <1957 (Pacific coast) |
| *Polysiphonia* cf. *breviarticulata*, 1982 | | | |

Introduced macroalgae prior to 1991, but not listed above

The Japanese red alga *Antithamnion nipponicum* (valid name, and according to Cho *et al.* (2005) *A. pectinatum* is not correct) was discovered in Long Island Sound, Connecticut/New York, during the 1980s (ICES WGITMO, 1993).

The records of *Polysiphonia harveyi* from Massachusetts and Rhode Island in 2000 were mentioned as an introduction (ICES WGITMO, 2002). Since the species was originally described from Connecticut in 1848, eastern USA (Maggs and Stegenga 1999 and references therein) this was astonishing. However, recent studies using rbcL sequences have revealed that *P. harveyi* is not of Atlantic origin, but has been introduced from Japan and most of the populations are the same as in Europe, while samples from North Carolina are the same haplotype as those having invaded New Zealand and California (McIvor *et al.,* 2001). The species has been proposed to be removed from the genus *Polysiphonia* to the newly erected genus *Neosiphonia* (Choi *et al.,* 2001), which now is the valid name (Guiry *et al.,* 2006). Duffy and Harvilicz (2001) demonstrated experimentally its different sensitivity to different grazers. Whereas grazer-free eelgrass became heavily fouled with periphyton and tunicates, eelgrass exposed to the amphipod *Gammarus mucronatus* alone was overgrown by the red alga *Neosiphonia* (*Polysiphonia*) *harveyi*, which reached a biomass equal to the total fouling mass of grazer-free controls, but that it was nearly absent from all other treatments including grazing by amphithoids.

According to Silva *et al.* (2002) the Japanese red alga *Gelidium vagum* has been recorded in Tomales Bay, California and probably had been brought there with Japanese oysters from British Columbia or Washington, where it previously had been introduced (Renfrew *et al.,* 1989).

The Japanese red alga *Lomentaria hakodatensis* was first recognized as an introduced species in the late 1960s at two sites on the Washington side of the Strait of Georgia (South, 1968), and he considered that it most probably had arrived there by oyster imports from Japan, and not by dispersal from the S part of North America. In the mid 1980s it had colonized also the S part of San Juan Islands (Hawkes and Scagel, 1986).

Ní Chualáin *et al.* (2005) suggested that the red alga *Asparagopsis armata* might be a relatively "recent" introduction to San Diego, California, since it is apparently the only known site on the American west coast, but having been there since the early 1900 hundreds.

The following seaweeds (incl. year for the first record) were described as introduced in San Fransisco Bay by Cohen and Carlton (1995): the green algae *Codium fragile* ssp. *tomentosoides* (1977, common on rocks, pontoons etc.), *Bryopsis* sp. (1951, asexual reproduction only, cast ashore in large amounts); the brown alga *Sargassum muticum* (1973, common in low intertidal on pilings etc.); the red algae *Callithamnion byssoides* (between 1978–1983, frequent or less on rocks), *Polysiphonia denudata* (between 1978–1983, common in drift or as epiphytes).

Current status of old introductions

The green alga *Codium fragile* ssp. *tomentosoides* has expanded in many areas. Mathieson *et al.* (2003) described it as the dominant canopy species in several places in southern Maine and New Hampshire, occuring both at disturbed sites after sea urchin grazing, as well as in kelpbeds. They also reported that the Asiatic red alga *Neosphonia (*as *Polysiphonia*) *harveyi,* which is the dominant epiphyte on *Codium* has had almost the same rapid expansion.

In 1989 *Zostera japonica* was the most abundant seagrass in the Padilla Bay, Washington, covering about 2900 ha in the mid and lower intertidal flats of a total of 3200 ha of seagrass beds (Bulthuis, 1995).

Since the exotic Eurasian milfoil *Myriophyllum spicatum* (L.) was first reported in the Lake Pontchartrain estuary in 1978, it had in the early 1990s become established as a dominant species of submerged macrophyte, but its distribution and abundance had varied considerably (Duffy and Baltz, 1998). They compared common littoral fish assemblages between two native macrophytes, *Vallisneria americana* and *Ruppia maritima* habitats ,with those of *M.*

*spicatum* and unvegetated substratum to determine if milfoil influenced assemblage structure and microhabitat use by fishes. Community diversity was highest in *V. americana*, intermediate in unvegetated areas, and lowest in *R. maritima* and *M. spicatum*, while total abundances were higher in *M. spicatum* and *R. maritima* than in *V. americana*. They thought *M. spicatum* may not have had a detectable influence on fish assemblages or abundances relative to the native macrophytes, because the high wave energy in the open system may prevent it from growing densely enough to strongly alter microhabitat characteristics.

Phanerogams, often old introductions

It has not been possible to list all phanerogams introduced into the country, growing or with a potential grow at or close to the seashore. The tentative list below is mainly summarized from "The flora of Nova Scotia" (Roland and Smith, 1969) where occurrences in the US mostly are mentioned. However, it does not include species introduced elsewhere, but not found in Nova Scotia. Furthermore, the book is not up to date with the new taxonomy, nor with new species concepts and recent introductions of course are not included. Anyhow, it gives an idea of the quite large number of introductions, several also weeds, and most of them (115) being of European origin while a few are Asian (5) or South-American (2) plants and some (2) are natives of other parts of the North American continent. **Bold** denotes weeds, and **Bold + underlined** serious weeds, *Italic* submerged plants. For species marked with ? it was not clearly stated if they also were introduced in the US, but it seems likely they also may occur at least in the NE States.

| | | | |
|---|---|---|---|
| Fumaria officinalis? | Anagallis arvensis | Hyoscyamus niger | Bellis perennis? |
| **Chenopodium album** | Sedum accre | Lycium halimifolium | **Cirsium arvense**? |
| **Chenopodium botrys** | Sedum telephium[2)] | **Solanum dulcamara** | **Cirsium vulgare**? |
| Chenopodium glaucum | **Filipendula ulmaria?** | Solanum nigrum | Cnicus benedictus |
| Scleranthus annuus | **Potentilla argentea** | Convolvulus arvensis | **Cotula coronopifolia**? |
| Spergularia rubra | Potentilla reptans | Cynoglossum officinale? | **Hieracium spp.** |
| **Spergula arvensis** | Prunus spinosa? | Echium vulgare? | **Iva xanhifolia** |
| Arenaria serpyllifolia | Rosa canina | Myosotis scorpiodes | Leontodon autumnalis |
| **Stellaria graminea** | Rosa rugosa? | Galeopsis bifida | **Matricaria maritima**[6)] |
| **Stellaria media** | Lathyrus pratensis | **Galeopsis trifida** | **Matricaria matricarioides**[7)] |
| **Polygonum arenastrum** | Lotus corniculatus | **Lamium purpureum** | **Onopordum acanthium**? |
| Polygonum rhaii? | Lotus uliginosus? | Lycopus europeus | Senecio sylvaticus |
| Polygonum lapathifolium[1)] | Medicago falcata[3)] | **Stachys palustris** | **Senecio viscosus**? |
| **Polygonum cuspidatum**? | Melilotus altissimus | Cymbalaria muralis | **Senecio vulgaris** |
| Rumex domesticus | Trifolium repens? | **Linaria vulgaris** | **Sonchus arvensis** |
| **Rumex crispus** | Vicia angustifolium | **Odontites serotina**[5)] | **Sonchus uliginosus**[8)] |
| Rumex acetosella | Vicia cracca? | **Verbascum thapsus** | **Tanacetum vulgare** |
| **Rumex obtusifolius** | Vicia hirsuta? | Veronica longifolia | **Taraxacum spp.** |
| **Populus alba**? | Vicia sepium | Veronica officinalis? | **Tussilago farfara** |
| Salix viminalis | ***Myriophyllum spicatum***[4)] | **Plantago major var. intermedia** | Juncus compressus? |
| **Urica urens**? | **Lythrum salicaria** | **Plantago lanceolata** | ***Zostera japonica***[9)] |
| **Cardaria draba** | Epilobium hirsutum | **Galium aparine** | Aira praecox |
| Coronopus procumbens | Erodium cicutarium? | Galium verum | **Eragrostis megastachya**? |
| Diplotaxis muralis | Linum catharticum | **Acillea millefolium** | **Phragmites communis**[10)] |
| **Erucastrum gallicum** | Conium maculatum? | **Anthemis tinctoria**? | **Poa annua** |
| Lepidium campestre | **Pimpinella saxifraga** | Artemisia absinthium | Poa pratensis? |
| **Sisymbrium altissimum** | Viola tricolor? | Artemisia stelleriana | Puccinellia distans |

| | | | |
|---|---|---|---|
| **Thlaspi arvense** | Centaurium umbellatum | **Artemisia vulgaris** | **Asparagus officinalis**? |
| **Calluna vulgaris** | | | Iris pseudacorus |

1) Valid name *Persicaria lapathifolia*, 2) Valid name *Hylotelephium telephium*, 3) Valid name *Medicago sativa* var. *falcata*, 4) See also Wallentinus, 1999a, 5) Valid name *Odontites littoralis*, 6) Valid name *Tripleurospermum maritimum*, 7) Valid name *Matricaria suaveolens*, 8) Valid name *Sonchus arvensis* var. *glabrescens*, 9) See also above and Wallentinus, 1999a, 10) Valid name *Phragmites australis* often described as a cosmopolitic species, but considered to be an old introduction on the North American continent, where there are many recent papers on its impact.

The following higher plants, many old introductions, were described by Cohen and Carlton (1995) as introduced in San Fransisco Bay or the delta area further inland (type of habitat given): *Chenopodium macrospermum* (in marshes), *Cotula coronopifolia* (salt and freshwater marshes), *Lepidium latifolium* (beaches, tidal shores and invasive in high tidal marshes and ponds), *Limosella subulata* (intertidal flats), *Lythrum salicaria* (marshes etc., often noxious weed), *Myriophyllum aquaticum* (mostly freshwater but also tidal marshes), *Myriophyllum spicatum* (mainly freshwater in this area), *Polygonum patulum* (uncommon in saltmarshes), *Rorippa nasturtium-aquaticum* (freshwater only), *Salsola kali* (saltmarshes and mudflats), *Spergularia media* (common in tidal marshes, flats and beaches), *Egria densa* (only freshwater, there highly invasive), *Eichhornia crassipes* (serious problem in freshwater), *Iris pseudacorus* (banks in delta), *Polypogon elongatus* (salt marshes), *Potamogeton crispus* (mainly freshwater), *Spartina alterniflora* (salt marshes and mud flats, increasing and eradication programmes), *S. anglica* (salt marshes, less invasive than elsewhere), *S. densiflora* (salt marshes), *S. patens* (marsh, not spreading) and *Typha angustifolia* (brackish marshes, often hybrids with the native *T. latifolia*).

The Atlantic dune grass *Ammophila arenaria* was introduced as a stabilizer on the Pacific coastal dunes in the 1860, now being present in all western states. It has lately become a species of concern, since it outcompetes the native species, as well as prevent new sand being brought to the foredunes, which finally will lead to disappearance of the dunes (Wiedemann and Pickart, 1996).

Among the more noteworthy introduced phanerogams, not included above, are the in western US since long time ago established South American *Carpobrotus chilensis*, which now is threatened by the much later introduced *Carpobrotus edulis*, which also forms vigorous hybrids with the former making the threat worse (e.g. Weber and D'Antonio, 1999). Likewise, within the cordgrass genus *Spartina*, hybridization is said to constitute a threat to the shores of California, since both introduced species (e.g. the North-American *S. alterniflora* and S. *densiflora* from Chile, Daehler and Strong, 1997; Kittelson and Boyd, 1997), and the hybrid may occupy other zones than the native species (e.g. Anttila *et al.*, 1998).

A more unusual introduction is that of Asiatic sand sedge *Carex kobomugi*, which was accidentally introduced about 100 years ago when a ship with porcelain, wrapped in this sedge, stranded on the North American east coast in New Jersey (Wootton *et al.*, 2005). The sedge became established, and was later intentionally planted in dune systems all along the east coast, because of its disease- and trampling-resistant properties. There it expanded rapidly, leading to eradication programmes having to be undertaken (Standley, 1983; Wootton *et al.*, 2005; several www.pages).

## 2.4 Phytoplankton

The occurrence of new phytoplankton species in a sea area is even more difficult to relate to events of introductions than is the case for macrophytes, since especially small organisms have often been neglected or not sampled in previous surveys. Furthermore, their taxonomic affinities often have been obscure and the natural distribution of many species thus is poorly known (cf. Elbrächter, 1999). Due to time limits all literature on phytoplankton species has not been reviewed for new introductions, and the reports of new species are mainly based on the ICES WGITMO, reports during the period 1992–2002.

Current status of old introductions

Due to time limits it has not been possible to follow up the current status of these species. Many of them, however, have become permanent members of the phytoplankton assemblages, and some also frequently build up nuisant or toxic blooms. Some information on their present status in the North Sea was given by Elbrächter (1999).

### 2.4.1 The eastern Atlantic (incl. the North Sea, the Skagerrak, the Kattegat and Öresund)

New introductions 1991–2002

Rhaphidophyceae: The potentially ichtyotoxic rhapidophycean alga, *Fibrocapsa japonica*, was first seen in samples from off the coast of Normandy, N France, in October 1991 (Billard, 1992). Later the same year it was also found in Dutch waters, and the following year off Sylt on the German W coast (Elbrächter, 1999 and references therein) and is now a regular component in the North Sea coastal waters. Ribosomal DNA ITS markers were used to compare 16 different populations of the species from different parts of the world, and the North Sea did have the highest polymorphism, which could be explained by e.g. recent ballast-water-mediated mixing of previously isolated populations (Kooistra *et al.*, 2001; de Boer *et al.*, 2002).

Two other species of the genus *Chattonella*, *Ch. antiqua* and *Ch. marina* were also recorded in Dutch waters in 1991 (Elbrächter, 1999 and reference therein), the first described from Japanese waters, the second from the Indian Ocean.

In April-May 1998 a bloom of *Chattonella* cf. *verruculosa* (two morphological forms were seen) occurred along the Kattegat, the Skagerrak and the inner North Sea coasts. The highest cell concentrations with up to 24 million cells per litre were found W of Jutland in May (e.g. Backe-Hansen *et al.*, 2001) and fish kills were reported from several areas. *C. verruculosa* was previously known only from Japan, and thus transportations from other areas cannot be ruled out (ICES WGITMO, 1999). It was found also during spring 1999 in small amounts, but did not bloom, at the Swedish west coast and E of Jutland (ICES WGITMO, 2000). In 2000 it bloomed along the Danish coast, but was only seen in small amounts on the Swedish west coast (ICES WGITMO, 2001). However, in 2001 it did bloom in March-April on the Swedish west coast and on the Norwegian south coast, and nearly 1000 tonnes of farmed fish was killed. It was also realized by retrospective analyses that it had occurred in small amounts earlier than previously noted during the 1990s (Mats Kuylenstierna pers. comm.). A study (Tomas *et al.*, 2002), based on fine structure, pigments and toxicity, considered Japanese and North Sea isolates to be closely related, while the American indigineous isolate *Chattnella* cf. *verruculosa* indicated another ichtyotoxic species in the genus.

Dinophyceae:

The reported cysts of *Gymnodinium catenatum* from North European waters in the mid 1990s were based on misidentification of a very similar, native species (see further below).

In the 1990s, it was conisdered to be a direct relationship between the occurrence of *Gymnodinium catenatum* in western Spain and ships arriving at the same time to Rochefort harbour, as well as those coming from Portugal in 1994 and 1995 ((ICES/IMO/IOC SGBOSV, 2000).

The non-toxic *Alexandrium leei*, occurring in the W Pacific and N Indian Ocean, was first recorded in Dutch waters in 1995 (Elbrächter, 1999 and reference therein). So far it has not formed any extensive blooms.

*Alexandrium taylori*, which may cause PSP (but cf. Hallegraeff *et al.*, 2003), was found in Arcachon, France in 1994 (ICES WGITMO, 2001).

The potential PSP-producer *Alexandrium minutum* was first recorded in phytoplankton samples from the Swedish west coast in June 1996, when it was abundant (ICES WGITMO, 1997), and was again abundant in June 1997 (ICES WGITMO, 1998). It was previously not recorded from the North Sea/Skagerrak area, the closest being Brittany, France, while live cysts of the same species occurred in several sediment samples from Bohulän collected in 1995 (ICES WGITMO, 1997). Elbrächter (1999) considered it to be a species distributed to these northern areas by currents from the Atlantic oasts of France, Spain and Portugal. At a meeting in 2000 (ICES/IMO/IOC SGBOSV, 2000) it was, however, reported as new for the coast north of Brittany, France.

Since 1997 the following new dinoflagellates have been found on the Swedish west coast: *Alexandrium angustitabulatum* (known from New Zealand), *Discroerisma psilonereiella* (known from Kamchatka and British Columbia) and *Gyrodinium corallinum* (known from California). Whether they were new introductions, or previously have been overlooked, was not known, nor the vector in case they have been introduced. *Alexandrium angustitabulatum* is a small, potentially toxic species difficult to separate from *A. minutum*, while *Discroerisma psilonereiella* is relatively rare, but quite easy to recognize with the internal skeleton and *Gyrodinium corallinum* is quite a large species (ICES WGITMO, 2001).

Cysts of the subtropical-tropical species *Pyrodinium bahamense* were found in Portugal in the 1990s and are the first record from a European coast (Amorim and Dale, 1998).

For *Pfiesteria* spp. see 2.2.4

Previously established (Wallentinus, 1999a). Clearly non-introduced taxa, as well as rang extensions excluded

| **Diatoms** | **Rhaphidophyceans** | **Dinoflagellates** |
|---|---|---|
| *Odonthella sinensis*, 1903 | (*Olisthodiscus luteus*[1], 1964) | *Gymnodinium* cf. *aureolum*[3], 1966 |
| *Thalassiosira tealata*, 1950 | (*Heterosigma akashiwo*[2], late 1970s | *Gymnodinium catenatum*[4], 1976 |
| *Pleurosigma planctonicum*[6], 1966 | | (*Prorocentrum minimum*[5], 1976) |
| *Coscinodiscus wailesii*, 1977 | | *Ptychodiscus brevis*[7] ? |
| *Thalassiosira punctigera*, 1978 | | |

1) According to Elbrächter (1999) conspecific with *Heterosigma akashiwo* and not an introduced species, 2) According to Elbrächter (1999) not an introduced species, 3) Valid name *Karenia mikimotoi*, 4) In northern European waters records of this species are based on misidentifications of the recently described species *G. nolleri* (see further below), 5) According to Elbrächter (1999) this is a “pseudo-exotic” species, being known earlier from the North Sea area under other names, 6) Valid name *P. simonsenii*, 7) valid name *Karenia brevis*

Introduced microalgae prior to 1991, but not listed above

Blooms of the dinoflagellate *Prorocentrum redfieldii* has occurred in the Dutch coastal area since 1961, and sometimes also along the North Frisian coast, and might represent a new introduction from the North American Atlantic coast (Elbrächter, 1999). In the same paper it was also mentioned that it might be conspecific with *P. triesinum*, a species recorded worldwide in coastal waters, and in that case probably not introduced.

Reports concerning native, mainly potentially toxic species

In the National report from Norway (ICES WGITMO, 1992, 1993) an exceptional bloom in 1991 in Sørfjorden of the dinoflagellate *Dinophysis acuta*, a potential DSP-producer, was reported to have been caused by ballast discharges originating from the UK. It should be pointed out, however, that this is a species native to the area.

In 1993 (ICES WGITMO, 1993) there was concern of transfers of toxic dinoflagellate cysts from France to Ireland with the movements of *Crassostrea gigas*. That risk had also been pointed out by Dijkema (1992) for movements to the Netherlands.

Recently, there have been several reports of Azaspiracid shellfish toxins (AZP), which also were discussed by WGITMO (ICES WGITMO, 2000: Irish National report). The poisoning occurred for the first time in the Netherlands in 1995, after consumption of Irish mussels from Killary Harbour, and analyses of the toxin and its analogues have later shown the native dinoflagellate *Protoperidinium crassipes* to be the organisms causing AZP (Yasumoto *et al.*, 2002). The toxins have also been identified in mussels from Craster, NE England, and Søgnefjord, SW Norway (James *et al.*, 2002) and those authors did not see it unlikely that the toxins occur also elsewhere in N Europe.

In Sweden, high levels of PST was found in mussels in May 1997, coinciding with high levels of the dinoflagellates *Alexandrium ostenfeldii* and *A. tamarense* (ICES WGITMO, 1998). In Nova Scotia, E Canada, *A. ostenfeldii* was found not to cause PSP, but to be the organism producing a new group of fast-acting, macrocyclic imine toxins called spirolides (e.g. Cembella *et al.*, 2000, 2002) which has also been found in algae from Limfjorden, Denmark, (MacKinnon *et al.*, 2002) and from the Scottish east coast (Rühl *et al.*, 2002).

At the end of 1999, Amnesic Shellfish Toxin, caused by diatoms of the genus *Pseudonitschzia*, was detected in *Pecten maximus* around the Irish west coast, some harvest areas being closed for months, and the same also occurred on the west coast of Scotland, the most intense and extensive bloom seen there (ICES WGITMO, 2000). These species, however, are native in Europe.

The reports of cysts (no motile cells seen *in situ*) of the dinoflagellate *Gymnodinium catenatum*, a potential PSP-producer, from Scandinavian and German waters (ICES WGITMO, 1994, 1995, 1996, 1997) were based on misidentifications of cysts having almost the same morphologies. The species in question was later described as *Gymnodimium nolleri* Ellegaard et Moestrup sp. nov. (Ellegaard and Moestrup, 1999; ICES WGITMO, 1999) and does not produce PSP (ICES WGITMO, 1996 and reference therein, 1999; Ellegaard *et al.*, 1998).

### 2.4.2 The Baltic Sea (inside the Kattegat and the Belt sea areas)

New introductions 1991–2002

The potentail PST-producing dinoflagellate *Alexandrium ostenfeldi* was recorded for the first time from the Baltic proper in a dense bloom outside the island of Öland in September 1997 (ICES WGITMO, 1999).

Previously established (Wallentinus, 1999a).

| **Diatoms** | **Rhaphidophyceans** | **Dinoflagellates** |
|---|---|---|
| *Odonthella sinensis*, early 20th century | | *Prorocentrum minimum*, 1983 |

Introduced microalgae prior to 1991, but not listed above

In 1992 there was a considerable bloom of the potentially toxic dinoflagellate *Prorocentrum minimum* in the NW Baltic proper, the species first recorded there in 1984 (ICES WGITMO, 1994). It has later been questioned if it has been introduced to the Baltic Sea (cf. Hajdu *et al.*, 2000), and thus it may be considered cryptogenic. It occurred sparsely until 1998 (ICES WGITMO, 1999).

### 2.4.3 The Mediterranean Sea

New introductions 1991–2002

Rhaphidophyceae: The Pacific, potentially toxic, species *Fibrocapsa japonica* was blooming along the Latium coast of Italy, Middle Thyrrhenian Sea, in summer 1999, discolouring the water brown close to shore (Bianco *et al.*, 2002). The vector was not discussed.

Dinophyceae: Recurrent blooms of the dinoflagellate *Alexandrium taylori*, which may cause PSP (but cf. Hallegraeff *et al.*, 2003), occurred in the late 1990s off the Catalonian coast, Spain and off Siciliy (ICES WGITMO, 2001).

The potential PST-producer *Alexandrium catennella* has caused toxic blooms in central Catalonia, E Spain, first recorded in Barcelona harbour in 1996 and expanding (Vila *et al.*, 2001), in the Thau lagoon, S France, since 1998 (Laabir *et al.*, 2002). It has also been found off Sardinia, Italy, (Lugliè *et al.*, 2002), where it was suggested to have been introduced by either ballast or mussel movements.

*Alexandrium andersoni* was seen in Italy for the first time in the late 1990s (Montresor *et al.*, 1998; Montresor *et al.*, 2000).

In Thau lagoon, S France, *Alexandrium tamarense* was reported as new for the area, causing a significant bloom and was presumed to be an Asiatic strain (ICES/IMO/IOC SGBOSV, 2000).

Previously established (Wallentinus, 1999a)

| **Diatoms** | **Rhaphidophyceans** | **Dinoflagellates** |
|---|---|---|
| | | *Ptychodiscus brevis*[1)], 1972 |

1) Valid name *Karenia brevis*

Introduced microalgae prior to 1991, but not listed above

Dinoflagellates: The potential PST-producer *Alexandrium tamarense* was first seen in the Adriatic Sea in August 1982 and *A. pseudogonyaulax* and *A. lusitanicum* in 1987. Since phytoplankton composition has been followed there for over hundred years, they were believed to have arrived quite recently, either through ballast discharges or mussel importations and have been intensely monitored (ICES WGITMO, 2000, 2001; Occhipinti Ambrogi 2002).

The potential PST-producer *Alexandrium minutum* was first found in Italy, off the coast of Sicily, in April 1990 (Giacobbe and Maimone, 1994), but is widely spread in other parts of the Mediterranean.

Motile cells of *Gonyaulax grindley* (=*Protoceratium reticulatum*) were first seen in small amounts in the early 1990s, while cysts have been found in sediment cores dating back 10 000 yrs BP.

### 2.4.4 Canadian and US coasts

Only the species mentioned in the National reports are listed here, since time did not allow a literature review.

New introductions 1991–2002

In July 1999, on the Canadian west coast, W of Vancover Island, the dinoflagellate *Cochliodinium polykrikoides* caused a dense bloom for the first time, while previously only having been rarely encountered. The bloom caused death of farmed fish and, since the survey found the highest concentrations close to inlets, where cargo ships from Korea (where the species frequently causes blooms) take on cargo, the bloom could have resulted from discharge of ballast of either water or resuspended sediment containing cysts. There was great concern that the species might cause more blooms in the future (ICES WGITMO, 2001).

Reports concerning native, mainly toxic species

There has been great concern of some "new" phytoplankton blooms in the US caused by the APS producer *Pseudonitzschia australis* on the Pacific coast, on the *Pfiesteria piscicida* in North Carolina and the Chesapeake Bay system, and the small brown tide species *Aureococcus anophagefferens* (Pelagophyceae) on the Atlantic coast (ICES WGITMO, 1993). However, these species are probably not introduced. The latter was also mentioned, as a native species in the previous Status report (Wallentinus, 1999a).

## 2.5 References

Amorim, A., Dale, B. 1998. Distribution of cysts from toxic or potentially toxic dinoflagellates along the Portuguese coast. *In*: Reguera B, Blanco J, Fernández ML, Wyatt T (eds) *Harmful Algae*, pp 64–65. Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Vigo and Paris

Anderson, L.W. 2005. California's reaction to *Caulerpa taxifolia*: A model for invasive species rapid response. Biological Invasions, 7(6): 1003–1016

Andreakis, N., Procaccini, G., Kooistra, W. 2004. *Asparagopsis taxiformis* and *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta): genetic and morphological identification of Mediterranean populations. European Journal of Phycology, 39: 273–283

Andrew, N.L., Viejo, R.M. 1998. Ecological limits to the invasion of *Sargassum muticum* in northern Spain. Aquatic Botany, 60: 251–263

Anon. 1997. Dynamique d'espèces marine invasives: application à l'expansion de Caulerpa taxifolia en Mediterranée. Actes de Colloques Septembre 1997, Académie des Sciences, Lavoiser Technique & Documentation, Paris, 382 pp

Anttila, C.K., Daehler, C.C., Rank, N.E., Strong, D.R. 1998. Greater male fitness of a rare invader (*Spartina alterniflora*, Poaceae) threatens a common native (*Spartina foliosa*) with hybridization. American Journal of Botany, 85: 1597–1601

Araujo, R., Barabara, I., Santos, G., Oliviera, M., Pereira, R., Sousa Pinto, I. 2003. Discovery of seven new seaweed records for the Portuguese coastline. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P5–13, p 89

Aronsson, M., Hallingbäck, T., Mattsson, J.E. [eds] 1995. Rödlistade växter i Sverige. ArtDatabanken, SLU, Uppsala (In Swedish)

Athanasiadis, A. 1987. A survey of the seaweeds of the Aegean Sea with taxonomic studies on species of the tribe Antithamnieae (Rhodophyta). PhD thesis, Department of Marine Botany, Göteborg University, 224 pp

Athanasiadis, A. 1996a. Taxonomisk litteratur och biogeografi av Skandinaviska rödalger och brunalger. Algologia, Göteborg, 280 pp

Athanasiadis, A. 1996b. Morphology and classification of the Ceramioideae (Rhodophyta) based on phylogenetic principles. Opera Botanica, 128: 1–216

Athanasiadis, A. 1997. North Aegean marine algae. IV. *Womersleyella setacea* (Hollenberg) R.E. Norris (Rhodophyta, Ceramiales). Botanica Marina, 40: 473–476

Athanasiadis, A., Tittley, I. 1994. Antithamnioid algae (Rhodophyta, Ceramiaceae) newly recorded from the Azores. Phycologia, 33: 77–80

Axelius, B. and Karlsson, J. 2004. Japanplym, ny rödalg för Sverige (*Heterosiphonia japonica* new for Sweden). Svensk Botanisk Tidskrift, 98(5): 268–273 (In Swedish with English legends)

Baldwin, J.R., Lovvorn, J.R. 1994. Expansion of seagrass habitat by the exotic *Zostera japonica*, and its use by dabbling ducks and brant in Boundary Bay, British Columbia. Marine Ecology Progress Series, 103: 119–127

Bárbara, I., Cremades, J. 1996. Seaweeds of the Ría de A Coruna (NW Iberian Penisula, Spain). Botanica Marina, 39: 371–388

Barone, R., Di Martino, V., Mannino, A.M. 2003. *Asparagopsis taxiformis* (DeLile) Trevisan in Italy: distribution and reproductive strategies. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P5–10, p 88

Bartsch, I., Kuhlenkamp, R. 2000. The marine macroalgae of Helgoland (North Sea): an annotated list of records between 1845 and 1999. Helgoland Marine Research, 54: 160–189

Berry, J.P., Reece, K.S., Baden, D.G., Haas, L.W., Ribeiro, W.L., Shields, J.D., Snyder, R.V., Vogelbein, W.K., Gawley, R.E. 2002. Are *Pfiesteria* species toxicogenic? Evidence against producton of ichtyotoxins by *Pfiesteria shumwayae*. Proceedings of the National Academy of Sciences of the United States of America, 99: 10970–10975

Bianco, I., Congestri, R., Albertano, P. 2002. Toxic armored dinoflagellates of the Latium coastal waters, Italy (Middle Tyrrhenian Sea). Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 29

Bird, C.J., Dadswell, M.J., Grund, D.W. 1993. First record of the potential nuisance alga *Codium fragile* ssp. *tomentosoides* (Chlorophyta, Caulerpales) in Atlantic Canada. Proc. N.S. Inst. Sci., 40: 11–17

Bird, C.J., McLachlan, J.L. 1992. Seaweed flora of the maritimes. 1. Rhodophyta – the red algae. Biopress Ltd, Bristol, 177 pp.

Billard, C. 1992. *Fibrocapsa japonica* (Rhaphidophyceae), planktonic marine alga reported for the first time in France. Cryptogamie Algologie, 13: 225–231 (in French)

Bischof, K., Kräbs, G., Hanelt, Wiencke, C. (2000) Photosynthetic characteristics and myosporine-like amino acids under UV radiation: a competitive advantage of *Mastocarpus stellatus* over *Chondrus crispus* at the Helgoland shoreline. Helgoland Marine Research, 54: 47–52

Bjærke, M.R., Rueness, J. 2004a. The introduced red alga *Heterosiphonia japonica* (Ceramiales, Rhodophyta) in the eastern North Atlantic: an investigation of genetic variation with focus on ALFP fingerprinting. *In* Bjærke MR, Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. Ph D Thesis, University of Oslo, Paper I

Bjærke, M.R., Rueness, J. 2004b. RbcL sequences provide information on origin and distribution of *Neosiphonia harveyi* (Ceramiales, Rhodophyta) in Norwegian waters *In* Bjærke MR, Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. Ph D Thesis, University of Oslo, Paper III

Bjærke, M.R., Rueness, J. 2004c. *Aglaothamnion halliae* (Ceramiales, Rhodophyta) in Scandinavian waters: Field observations and molecular data suggest a recent introduction. *In* Bjærke MR, Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. Ph D Thesis, University of Oslo, Paper II

Blackburn. S.I., Bolch, C.J.S., Haskard, K.A., Hallegraeff, G.M. 2001. Reproductive compatibility among four global populations of the toxic dinoflagellate *Gymnodinium catenatum* (Dinophyceae). Phycologia, 40: 78–87

Boaden, P.J.S. 1995. The adventive seaweed *Sargassum muticum* (Yendo) Fensholt in Strangford Lough, Northern Ireland. Irish Naturalists' Journal, 25: 111–113

Boudouresque, C.F., Verlaque, M. 2002. Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. Marine Pollution Bulletin, 44: 32–38

Boudouresque, C.F., Meinesz, A., Verlaque, M., Knoepffler-Peguy, M. 1992. The expansion of the tropical alga *Caulerpa taxifolia* (Chlorophyta) in the Mediterranean, Cryptogamie Algologie, 13: 144–145.

Bulthuis, D.A. 1995. Distribution of seagrasses in a north Puget- Sound Estuary – Padilla Bay, Washington, USA. Aquatic Botany, 50: 99–105

Burkholder, J.M., Glasgow, H.B. 2002. The life cycle and toxicity of *Pfiesteria piscicida* revisited. Journal of Phycology, 38: 1261–1267

Burkholder, J.M., Glasgow, H.B., Hobbs, C.W. 1995. Fish kills linked to a toxic ambush-predator dinoflagellate – distribution and environmental-conditions. Marine Ecology Progress Series, 124: 43–61

Cabioch, J., Castric-Fey, A., L'Hardy Halos, M.T., Rio, A. 1997. *Grateloupia doryphora* and *Grateloupia filicina* var. *luxurians* (Rhodophyta, Halymeniaceae) from the coasts of Brittany (France). Cryptogamie Algologie, 18: 117–137 (in French with English abstract).

Castric-Fey, A., Girard, A., L'Hardy-Halos, M.T. 1993. The distribution of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the coast of St Malo (Brittany, France). Botanica Marina, 36: 351–358

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., L'Hardy-Halos, M.T. 1999a. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Morphology and growth of the sporophyte. Botanica Marina, 42: 71–82

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., L'Hardy-Halos, M.T. 1999b. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Growth rate and longivity of the sporophyte. Botanica Marina, 42: 83–96

Ceccherelli, G., Cinelli, F. 1999. The role of vegetative fragmentation in dispersal of the invasive alga *Caulerpa taxifolia* in the Mediterranean. Marine Ecology Progress Series, 182: 299–303

Ceccherelli, G., Piazzi, L. 2001. Dispersal of *Caulerpa racemosa* fragments in the Mediterranean: Lack of detachment time effect on establishment. Botanica Marina, 44: 209–213

Cecere, E., Petrocelli, A., Verlaque, M. 2004. Morphology and vegetative reproduction of the introduced species *Hypnea cor*nuta (Rhodophyta, Gigartinales) in the Mar Piccolo of Taranto (Italy), Mediterranean Sea. Botanica Marina, 47: 381–388.

Cembella, A.D., Lewis, N.I., Quilliam, M.A. 2000. The marine dinoflagellate *Alexandrium ostenfeldii* (Dinophyceae) as the causative organism of spirolide shellfish toxins. Phycologia, 39: 67–74

Cembella, A.D., John, U., Elbrächter, M., Quilliam, M.A., Hummert, C., Luckas, B., Medlin, L. 2002. Biogeography of *Alexandrium ostenfeldii* and spirolide toxin composition in natural compositions. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 47

Chapman, A.S. 1999. From introduced species to invader: what determines variation in the success of *Codium fragile* ssp. *tomentosoides* (Chlorophyta) in the North Atlantic Ocean. Helgoländer Meeresuntersuchungen, 52: 277–289

Cho, T.O., Boo, Y.W., Fredericq, S. 2005. *Antithamnion nipponicum* (Ceramiaceae, Rhodophyta), incorrectly known as *A. pectinatum* in western Europe, is a recent introduction along the North Carolina and Pacific coasts of North America. European Journal of Phycology, 40: 323–335

Choi, H.-G., Kim, M.-S., Guiry, M.D., Saunders, G.W. 2001. Phylogenetic relationships of *Polysiphonia* (Rhodomelaceae, Rhodophyta) and its relatives based on anatomical and nuclear small-subunits rDNA sequence data. Canadian Journal of Botany, 79: 1465–1476

Cohen, A.N., Carlton, J.T. 1995. Nonindiginenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and Delta. United States Fish and Wildlife Service, Washington D.C., 26 pp + 5 App

Cormaci, M., Furnari, G., Alongi, G., Dinaro, R., Pizzuto, F. 1992. On the occurrence in Sicily of three Florideophyceae new to the Mediterranean Sea. Botanica Marina, 35: 447–449

Cormaci, M., Lanfranco, E., Borg, J.A., Buttigieg, S., Furnari, G., Micallef, S.A., Mifsud, C., Pizzuto, F., Scammacca, B., Serio, D. 1997. Contribution to the knowledge of the benthic marine algae on rocky substrata of the Maltese Islands. Botanica Marina, 40: 203–215

Cosson, J. 1999. On the progressive disappearance of *Laminaria digitata* on the coasts of Calvados (France). Cryptogamie Algologie, 20: 35–42 (in French)

Coyer, J.A., Peters, A.F., Hoarau, G., Stam, W.T., Olsen, J.L. 2002. Hybridization of the marine seaweeds, *Fucus serratus* and *Fucus evanescens* (Heterokontophyta: Phaeophyceae) in a 100-year-old zone of secondary contact. Proceedings of the Royal Society London Series B-Biological Sciences, 269(1502): 1829–1834

Critchley, A.T., Farnham, F.W., Morrel, S.L. 1986. An account of the attempted control of an introduced marine alga, *Sargassum muticum*, in southern England. Biological Conservation, 35: 313–332

Curiel, D., Marzocchi, M., Bellemo, G. 1996. First report of fertile *Antithamnion pectinatum* (Ceramiales, Rhodophyceae) in the North Adriatic Sea (Lagoon of Venice, Italy). Botanica Marina, 39:19–22

Curiel, D., Bellemo, G., Marzocchi, M., Scattolin, M., Parisi, G. 1998. Distribution of introduced Japanese macroalgae *Undaria pinnatifida*, *Sargassum muticum* (Phaeophyta) and *Antithamnion pectinatum* (Rhodophyta) in the Lagoon of Venice. Hydrobiologia, 385: 17–22

Curiel, D., Bellemo, G., Iuri, M., Marzocchi, R., Scattolin N (1999) First report of the genus *Sorocarpus* Pringsheim (Fucophyceae, Ectocarpaceae) in the Mediterranean. Botanica Marina, 42 (1): 7–10

Curiel, D., Bellemo, G., La Rocca, B., Scattolin, M., Marzocchi, M. 2002. First report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea. Botanica Marina, 45: 66–70

Daehler, C.C., Strong, D.R. 1997. Hybridization between introduced smooth cordgrass (*Spartina alterniflora*; Poaceae) and native California cordgrass (*S. foliosa*) in San Francisco Bay, California, USA. American Journal of Botany, 84(5): 607–611

Daguin, C., Voisin, M., Engel, C., Viard, F. 2005. Microsatellites isolation and polymorphism in introduced populations of the cultivated seaweed *Undaria pinnatifida* (Phaeophyceae, Laminariales) Conservation Genetics, 6(4): 647–650

De Biasi, A.M., Aliani, S. 2003. Shallow-water hydrothermal vents in the Mediterranean Sea: stepping stones for Lessepsian migration? Hydrobiologia, 503: 37–44

De Boer, M.K., Koolmees, E.M., Gieskes, W.W.C., Vrieling, E.G., Breeman, A.M., van Rijssel, M. 2002. Evidence for recent introduction of the toxic microalga *Fibrocapsa japonica* (Raphidophyceae) in the North Sea / Wadden Sea. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 66

Devillele, X., Verlaque, M. 1995. Changes and degradation in a *Posidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the north-western Mediterranean. Botanica Marina, 38: 79–87

den Hartog, C. 1997. Is *Sargassum muticum* a threat to eelgrass beds? Aquatic Botany, 58: 37–41

Díez, I., Santolaria, A., Gorostiaga, J.M. 2003. The relationship of environmental factors to the structure and distribution of subtidal seaweed vegetation of the western Basque coast (N Spain). Estuarine Coastal and Shelf Science, 56: 1041–1054

Dijkema, R. 1992. The risk of provoking toxic dinoflagellate blooms in the Dutch coastal waters through immersion of imported bivalves, originating from red tide areas. ICES CM 1992/K:48.

Doblin, M.A., Drake, L.A., Coyne, K.J., Rublee, P.A., Dobbs, F.C. 2002. *Pfiesteria* species identified in ballast water and residuals: a possible vector for introductions to coastal areas. Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 74

Duffy, K.C., Baltz, D.M. 1998. Comparison of fish assemblages associated with native and exotic submerged macrophytes in the Lake Pontchartrain estuary, USA. Journal of Experimental Marine Biology and Ecology, 223: 199–221

Duffy, J.E., Harvilicz, A.M. 2001. Species–specific impacts of grazing, amphipods in an eelgrass–bed community. Marine Ecology Progress Series, 223: 201–211

Elbrächter, M.. 1999. Exotic flagellates of coastal North Sea waters. Helgoländer Meeresuntersuchungen, 52: 235–242

Ellegaard, M., Moestrup, O. 1999. Fine structure of the flagellar apparatus and morphological details of *Gymnodinium nolleri* sp. nov. (Dinophyceae), an unarmored dinoflagellate producing a microreticulate cyst. Phycologia, 38: 289–300

Ellegaard, M., Kulis, D.M., Anderson, D.M. 1998. Cysts of Danish *Gymnodinium nolleri* Ellegaard et Moestrup sp. ined. (Dinophyceae): studies on encystment, excystment and toxicity. Journal of Plankton Research, 20: 1743–1755

Engel, C., Voisin, N., Viard, F. 2003. Tracing an exotic species' migration routes: dispersal patterns of the pandemically introduced brown alga *Undaria pinnatifida*, Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P1–9, p 67

Engelen, A., Santos, R., Alves, C. 2003. Demography of the alien species *Sargassum muticum* at its southern European distribution limit. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, M8–2, p 48

Farnham, W.F. 1997. Invasive species on the English Channel and Atlantic coasts. In: Dynamics of Invasive Marine Species: Application to the Expansion of Caulerpa taxifolia in the Mediterranean. Actes de Colloques Septembre 1997, Académie des Sciences, pp 15–35. Lavoiser Technique & Documentation, Paris

Fletcher, R.L., Farell, P. 1999. Introduced brown algae in the North East Atlantic with particular respect to *Undaria pinnatifida* (Harvey) Suringar. Helgoländer Meeresuntersuchungen, 52: 259–275

Fletcher, R.L., Manfredi, C. 1995. The occurrence of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the south coast of England. Botanica Marina, 38: 355–358

Flagella, M.M., Guala, I., Esposito, A., Lorenti, M., Buia, M.C. 2003. *Asparagopsis taxiformis* and *Caulerpa racemosa*: ecophysiological traits and interactions with native algal communities. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, M3–8, p 37

Floc'h, J.-Y., Pajot, R., Wallentinus, I. 1991. The Japanese brown alga *Undaria pinnatifida* on the coast of France and its possible establishment in European waters. J. Cons. int. Explor. Mer, 47: 379–390

Floc'h, J.-Y., Pajot, R., Mouret, V. 1996. *Undaria pinnatifida* (Laminariales, Phaeophyta) 12 years after its introduction into the Atlantic. Hydrobiologia, 326–327: 217–222

Gallagher, A.M., Loughnane, C.J., Keane, S., Stengel, D.B. 2003. Productivity of *Sargassum muticum* (Yendo) Fensholt (Phaeophyta), recently introduced to Ireland, in relation to temperature, irradiance and habitat. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P1–7, p 67

Garbary, D.J., Vandermeulen, H., Kim, K.Y. 1997. *Codium fragile* ssp. *tomentosoides* (Chlorophyta) invades the Gulf of St Lawrence, Atlantic Canada. Botanica Marina, 40: 537–540

Gärdenfors, U. [ed.] 2000. The 2000 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala, 397 pp

Gavio, B., Fredericq, S. 2002. *Grateloupia turuturu* (Halymeniaceae, Rhodophyta) is the correct name of the non-native species in the Atlantic known as *Grateloupia doryphora*. European Journal of Phycology, 37: 349–359

Glasgow, H.B., Burkholder, J.M., Morton, S.L., Springer, J. 2001. A second species of ichtyotoxic *Pfiesteria* (Dinamoebales, Dinophyceae)

Goulletquer, P., Bachelet, G., Sauriau, P.G., Noel, P. 2002. Open Atlantic coast of Europe – a century of introduced species into French waters. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 276–290

Gravez, V., Boudouresque, C.-F., Meinesz, A., Scabbia, G. [eds] 2001. Fourth International Workshop on Caulerpa taxifolia, Lerici, 1–2 february *1999*. GIS Posidonie, Marseille

Guiry, M.D., Rindi, F., Guiry, G.M. 2006. AlgaeBase version 4.0. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org

Hajdu, S., Edler, L., Olenina, I., Witek, B. 2000. Spreading and establishment of the potentially toxic dinoflagellate Prorocentrum minimum in the Baltic Sea. International Review of Hydrobiology, 85: 561–575

Hales, J.M., Fletcher, R.L. 1989. Studies on the recently introduced brown alga *Sargassum muticum* (Yendo) Fensholt. V. Receptacle initiation and growth, and gamete release in laboratory culture. Botanica Marina, 33: 241–249.

Hallegraeff, G., Anderson, D.M., Cembella, A.D. [eds] 2003. Manual on Harmful Marine Microalgae. UNESCO Publishing, Paris

Harlin, M.M., Villalard-Bohnsack, M. 2001. Seasonal dynamics and recruitment strategies of the invasive seaweed *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) in Narragansett Bay and Rhode Island Sound, Rhode Island, USA. Phycologia, 40: 468–474

Hawkes, M.W., Scagel, R.F. 1986. The marine algae of British Columbia and northern Washington: division Rhodophyta (red algae), class Rhodophyceae, order Rhodomeniales. Canadian Journal of Botany, 64: 1549–1580

Hay, C.H., Villouta, E. 1993. Seasonality of the adventive Asian kelp *Undaria pinnatifida* in New Zealand. Botanica Marina, 36: 461–476

Hitchcock, A.S. 1950. Manual of the grasses of the United States. US Dept of Agriculture 200: 1–1051.

Hopkins, C.C.E. 2002. Introduced marine organisms in Norwegian waters, including Svalbard *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 240–252.

ICES/IMO/IOC. 2000. Report of the Study Group on Ballast and Other Ship Vectors, By Correspondance. ICES CM 2000/ACME:08.

ICES SGMBIS. 1997. Report of the Study Group on Marine Biocontrol and Invasive Species.

ICES WGITMO. 1987. Report of the Working Group on Introductions and Transfers of Marine Organisms, Brest, France, June 10–12, 1987. ICES CM 1987/F: 35.

ICES WGITMO. 1990. Report of the Working Group on Introductions and Transfers of Marine Organisms, Halifax, Canada, June 6–8, 1990. ICES CM 1990/F: 14.

ICES WGITMO. 1992 Report of the Working Group on Introductions and Transfers of Marine Organisms, Lisbon, Portugal, April 14–17, 1992. ICES CM 1992/POLL: 3.

ICES WGITMO. 1993. Report of the Working Group of Introductions and Transfers of Marine Organisms, Aberdeen, Scotland 26–28 April 1993. ICES CM 1993/ENV: 7.

ICES WGITMO. 1994. Report of the Working Group of Introductions and Transfers of Marine Organisms, Mystic, Connecticut, 20–22 April 1994. ICES CM 1994/ENV: 7.

ICES WGITMO. 1995. Report of the Working Group of Introductions and Transfers of Marine Organisms, Kiel, Germany, 10–13 April 1995. ICES CM 1995/ENV: 9.

ICES WGITMO. 1996. Report of the Working Group of Introductions and Transfers of Marine Organisms, Gdynia, Poland, 22–26 April 1996. ICES CM 1996/ENV: 8.

ICES WGITMO. 1997. Report of the Working Group of Introductions and Transfers of Marine Organisms, La Tremblade, France, 22–25 April 1997. ICES CM 1997/Env: 6.

ICES WGITMO. 1998. Report of the Working Group of Introductions and Transfers of Marine Organisms, The Hague, Netherlands, 25–27 March 1998. ICES CM 1998/ACME: 4.

ICES WGITMO. 1999. Report of the Working Group of Introductions and Transfers of Marine Organisms, Conwy, United Kingdom, 14–16 April 1999. ICES CM 1999/ACME: 1.

ICES WGITMO. 2000. Report of the Working Group of Introductions and Transfers of Marine Organisms, Parnu, Estonia, 27–29 March 2000. ICES CM 2000/ACME:07.

ICES WGITMO. 2001. Report of the Working Group of Introductions and Transfers of Marine Organisms, Barcelona, Spain, 21–23 March 2001. ICES CM 2001/ACME: 08. (available at: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO)

ICES WGITMO. 2002 Report of the Working Group of Introductions and Transfers of Marine Organisms, Gothenburg, Sweden, 20–22 March 2002. ICES CM 2002/ACME: 06. (available at: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO)

Jakobsen, K.S., Tengs, T., Vatne, A., Bowers, H.A., Oldach, D.W., Burkholder, J.M., Glasgow, H.B., Rublee, P.A., Klaveness, D. 2002. Discovery of the toxic dinoflagellate *Pfiesteria* in northern European waters. Proceedings of the Royal Society of London Series B-Biological Sciences, 269 (1487): 211–214.

James, K.J., Furey, A., Lehane, M., Ramstad, H., Aune, T., Hovgaard, P., Morris, S., Higman, W., Satake, M., Yazumoto, T. 2002 First evidence of an extensive northern European distribution of azaspiracid posioning (AZP) toxins in shellfish. Toxicon, 40: 909–915.

Jansson, K. 1994. Alien species in the marine environment. Introductions to the Baltic Sea and the Swedish west coast. Swedish Environmental Protectection Agency Report, 4357: 1–68.

Jousson, O., Pawlowski, J., Zaninetti, L., Zechman, F.W., Dini, F., Di Guiseppe, G., Woodfield, R., Millar, A., Meinesz, A. 2000. Invasive alga reaches California – The alga has been identified that threatens to smother Californian coastal ecosystems. Nature, 408 (6809): 157–158.

Kaiser, J. 2000. Ecology – California algae may be feared European species. Science, 289 (5477): 222–223.

Karlsson, J., Loo, L.-O. 1999. On the distribution and the continuous expansion of the Japanese seaweed – *Sargassum muticum* – in Sweden. Botanica Marina, 42: 285–294.

Karlsson, J., Kuylenstierna, M., Åberg, P. 1992. Contributions to the seaweed flora of Sweden: New or otherwise interesting records from the west coast. Acta Phytogeographica Suecica, 78: 49–63.

Kask, M., Vaga, A. [eds] 1966. *Eesti taimede määraja*. Kirjastus “Valgus”, Tallinn, 1187 pp.

Kittelson, P.M., Boyd, M.J. 1997. Mechanisms of expansion for an introduced species of cordgrass, *Spartina densiflora,* in Humboldt Bay, California. Estuaries, 20 (4): 770–778.

Klein, J., Verlaque, M. 2005. *Laurencia caduciramulosa* Masuda et Kawaguchi (Ceramiales, Rhodophyceae), first record on the Mediterranean coast of France. Cryptogamie Algologie, 26 (2): 209–216.

Køie, M., Kristiansen, A., Weitemeyer, S. 2000. Havets dyr og planter. Gads Forlag, København, 351 pp (In Danish).

Kooistra, W.H.C.F., de Boer, M.K., Vrieling, E.G., Connell, L.B., Gieskes, W.W.C. 2001 Variations along ITS markers across strains of *Fibrocapsa japonica* (Rhaphidophyceae) suggests hybridisation events and recent range expansion. Journal of Sea Research, 46: 213–222.

Kornmann, P., Sahling, P.-H. 1983. Meeeresalgen von Helgoland: Ergänzung. Helgoländer Meeresuntersuchungen, 36: 1–65.

Kraan, S., Barrington, K.A. 2005. Commercial farming of *Asparagopsis armata* (Bonnemaisoniceae, Rhodophyta) in Ireland, maintenance of an introduced species? Journal of Applied Phycology, 17: 103–110.

Kylin, H. 1944. Die Rhodophyceen der schwedischen Westküste. Lunds Universitets Årsskrift N.F. Avd. 2 Bd 40(2): 1–104 + 32 Plates.

Laabir, M., Génovési-Giunti, B., Barré, N., Vaquer, A., Collos, Y., Cecchi, P., Pons, V., Bibent, B. 2002. Study on the biology of *Alexandrium catenella*, a toxic dinoflagellate species colonising Thau lagoon (French Mediterranean coast). Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 159.

Lein, T.E. 1999. A newly immigrated red alga ('*Dasysiphonia*', Dasyaceae, Rhodophyta) to the Norwegian coast. Sarsia, 84: 85–88.

Litaker, R.W., Vandersea, M.W., Kibler, S.R., Madden, V.J., Noga, E.J., Tester, P.A. 2002a. Life cycle of the heterotrophic dinoflagellate *Pfiesteria piscicida* (Dinophyceae). Journal of Phycology, 38: 442–463.

Litaker, R.W., Vandersea, M.W., Kibler, S.R., Noga, E.J., Tester, P.A. 2002b. Reply to comment on the life cycle and toxicity of *Pfiesteria piscicida* revisited. Journal of Phycology, 38: 1268–1272.

Litaker, R.W., Steidinger, K.A., Mason, P.L., Landsberg, J.H., Shields, J.D., Reece, K.S., Haas, L.W., Vogelbein, W.K., Vandersea, M.W., Kibler, S.R., Tester, P.A. 2005. The reclassification of Pfiesteria shumwayae (Dinophyceae): Pseudopfiesteria, gen. nov. Journal of Phycology, 41 (3): 643–651.

Publiè, A., Giacobbe, M., Fiocca, F., Sannio, A., Sechi, N. 2002. The geographical distribution of *Alexandrium catenella* is extending to Italy! First evidences from the Tyrrhenien Sea. Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 177.

Luther, H. 1979 *Chara connivens* in the Baltic Sea area. Annales Botanici Fennici, 16:141–150.

MacKinnon, S.L., Cembella, A.D., Quilliam, M.A., LeBlanc, P., Lewis, N., Hardstaff, W.R., Burton, I.W., Walter, J.A. 2002. The characterization of two new spiroldes isolated from Danish strains of the toxigenic dinoflagellate *Alexandrium ostenfeldii*. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 180.

Maggs, C.A., Hommersand, M.H. 1993. Seaweeds of the British Isles Vol.1 Rhodophyta, Part 3A Ceramiales. HMSO, London, 444 pp.

Maggs, C.A., Stegenga, H. 1999. Red algal exotics on North Sea coasts. Helgoländer Meeresuntersuchungen, 52: 243–258.

Magne, F. 1992. *Goniotrichopsis* (Rhodophyceae, Porphyridiales) in Europe. Cryptogamie Algologie, 13: 109–112.

Mathieson, A.C., Dawes, C.J., Harris, L.G., Hehre, E.J. 2003. Expansion of the Asiatic green alga Codium fragile subsp tomentosoides in the Gulf of Maine. Rhodora, 105(921): 1–53.

McIvor, L., Maggs, C.A., Provan, J., Stanhope, M.J. 2001. *rbc*L sequences reveal multiple cryptic introductions of the Japanese red alga *Polysiphonia harveyi*. Molecular Ecology, 10: 911–919.

Meinesz, A. 1997. The use of Ascoglossan as a biological control of *Caulerpa taxifolia* in the Mediterranean Sea. In: Dynamics of Invasive Marine Species: Application to the Expansion of Caulerpa taxifolia in the Mediterranean. Actes de Colloques, Septembre 1997, Académie des Sciences, pp 291–300. Lavoiser Technique & Documentation, Paris (in French)

Meinesz, A., Belsher, T., Thibaut, T., Antolic, B., Ben Mustapha, K., Boudouresque, C.-F., Chiaverini, D., Cinelli, F., Cottalorda, J.-M., Djellouli, A., El Abed, A., Orestano, C., Grau, A.M., Ivesa, L., Jaklin, A., Langar, H., Massuti-Pascual, E., Peirano, A., Tunesi, L., de Vaugelas, J., Zavodnik, N., Zuljevic, A. 2001. The introduced green alga *Caulerpa taxifolia* continues to spread in the Mediterranean. Biological Invasions, 3: 201–210.

Miller, A.W., Chang, A.L., Cosentino-Manning, N., Ruiz, G.M. 2004. A new record and eradication of the Northern Atlantic alga *Ascophyllum nodosum* (Phaeophyceae) from San Francisco Bay, California, USA. Journal of Phycology, 40: 1028–1031.

Montresor, M., Zingone, A., Sarno, D. 1998. Dinoflagellate cyst production at a coastal Mediterranean site. Journal of Plankton Research, 20 (12): 2291–2312.

Montresor, M., Sarno, D. and Zingone, A. 2000. Can we peacefully live together with harmful phytoplankton? The case of the Gulf of Naples. 9th International Conference on Harmful Algal Blooms, Tasmania, Australia, 7–11 February 2000, p 182. Univ. of Tasmania, Hobart (abstract).

Nií Chualáin, F., Maggs, C.A., Saunders, G.W., Guiry, M.D. 2004. The invasive genus *Asparagopsis* (Bonnemaisoniaceae, Rhodophyta): Molecular systematics, morphology, and ecophysiology of *Falkenbergia* isolates. Journal of Phycology, 40: 1112–1126.

Nielsen, R. 2002. Danish seaweeds. Available at: www.nathimus.ku.dk/BOT/DIV/distribution-index.pdf

Occhipinti Ambrogi, A. 2002. Current status of aquatic introductions in Italy. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 311–324.

Panayotis, P., Montesanto, B. 1994. *Caulerpa racemosa* (Chlorophyta) on the Greek coasts. Cryptogamie Algologie, 15: 159–161.

Parente, M.I., Neto, A.I., Fletcher, R.L. 2003. Morphology and life history studies of *Endarachne binghamiae* (Scytosiphonaceae, Phaeophyta) from the Azores. Aquatic Botany, 76: 109–116.

Pena, V., Bárbara, I. 2003. Seaweeds of A Coruña harbour (N.W. Spain). Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P5–15, p 90.

Peters, A.F., Kawai, H., Novaczek, I. 1993. Intraspecific sterility barrier confirms that introduction of *Sphaerotrichia divaricata* (Phaeophyceae, Chordariales) into the Mediterranean was from Japan. Hydrobiologia, 260/261: 31–36.

Piazzi, L., Cinelli, F. 2003. Evaluation of benthic macroalgal invasion in a harbour area of the western Mediterranean Sea. European Journal of Phycology, 38: 223–231.

Piazzi, L., Balata, D., Ceccherelli, G., Cinelli, F. 2001. Comparative study the growth of two co-occurring introduced green algae *Caulerpa taxifolia* and *Caulerpa racemosa* along the Tuscan coast (Italy, western Mediterranean). Cryptogamie Algologie, 22: 459–466.

Piazzi, L., Balata, D., Cinelli, F. 2002. Epiphytic macroalgal assemblages of *Posidonia oceanica* rhizomes in the western Mediterranean. European Journal of Phycology, 37: 69–76.

Piazzi, L., Meinesz, A., Verlaque, M., Akcali, B., Antolic, B., Argyrou, M., Balata, D., Ballesteros, E., Calvo, S., Cinelli, F., Cirik, S., Cossu, A., D'Archino, R., Djellouli, A.S., Javel, F., Lanfranco, E., Mifsud, C., Pala, D., Panayotidis, P., Peirano, A., Pergent, G., Petrocelli, A., Ruitton, S., Zuljevic, A., Ceccherelli, G. 2005. Invasion of *Caulerpa racemosa* var. *cylindracea* (Caulerpales, Chlorophyta) in the Mediterranean Sea: an assessment of the spread. Cryptogamie Algologie, 26: 189–202.

Renfrew, D.E., Gabrielson, P.W., Scagel, R.F. 1989. The marine algae of British Columbia, northern Washington, and southeast Alaska – division Rhodophyta (red algae), class Rhodophyceae, order Gelidiales. Canadian Journal of Botany, 67: 3295–3314.

Rhodes, L.L., Burkholder, J.M., Glasgow, H.B., Rublee, P.A., Allen, C., Adamson, J.E. 2002. *Pfiesteria shumwayae* (Pfiesteriaceae) in New Zealand. New Zealand Journal of Marine and Freshwater Research, 36: 621–630.

Ribera Siguan, M.A. 2002. Review of non-native marine plants in the Mediterranean Sea. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 291–310.

Ribera, M.A., Ballesteros, E., Boudouresque, C.-F., Gómez, A., Gravez, V. [eds] 1996. Second International Workshop on *Caulerpa taxifolia*, Barcelona, Spain, 15–17 December 1994. Univ.de Barcelona.

Rico, J., Fernández, C. 1997. Ecology of *Sargassum muticum* on the north coast of Spain. II. Physiological differences between *Sargassum muticum* and *Cystoseira nodicaulis.* Botanica Msarina, 40: 405–410.

Rindi, F., Papi, I., Cinelli, F. 1996. New records of Ceramiales (Rhodophyta) for the North-Western Mediterranean. Cryptogamie Algologie, 17 (4): 223–238.

Rindi, F., Sartoni, G., Cinelli, F. 2002. A floristic account of the benthic marine algae of Tuscany (Western Mediterranean Sea). Nova Hedwigia, 74: 201–250.

Rojas-Gonzáles, B., Afonso-Carillo, B.J., Ibeas, C. 1994. New records of Rhodomelaceae (Rhodophyta) from the Canary Islands. Botanica Marina, 37: 133–138.

Roland, A.E., Smith, E.C. 1969. The Flora of Nova Scotia. The Nova Scotia Museum, Halifax, 704 pp.

Rosenvinge, L.K. 1920. Om nogle i nyere tid indvandrede havalger i de danske farvande. Botanisk Tidskrift 37: 125–135 (In Danish with English abstract).

Rublee, P.A., Allen, C., Schaefer, E., Rhodes, L., Adamson, J., Lapworth, C., Burkholder, J., Glasgow, H. 2002. Global distribution of toxic *Pfiesteria* complex species. Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 246.

Rueness, J. 1997. A culture study of *Caulacanthus ustulatus* (Caulacanthaceae, Gigartinales, Rhodophyta) from Europe and Asia. Cryptogamie Algologie, 18: 175–185.

Rueness, J. 1998. Alger i farger – En felthåndbok om kystens makroalger. Almater Forlag AS, Oslo, 136 pp (In Norwegian)

Rueness, J. 2005. Life history and molecular sequences of *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta), a new introduction to European waters. Phycologia, 44: 120–128.

Rueness, J., L'Hardy-Halos, M.T. 1991. *Aglaothamnion westbrookiae* sp. nov. (Rhodophyta), a species previously confused under the name *Callithamnion byssoides*. Journal of Phycology, 27: 649–652.

Rueness, J., Rueness, E.K. 2000. *Caulacanthus ustulatus* (Gigartinales, Rhodophyta) from Brittany (France) is an introduction from the Pacific Ocean. Cryptogamie Algologie, 21: 355–363.

Rühl, A., Hummert, C., Gerdts, G., Luckas, B. 2002. Spirolides (algal neurotoxins) found near the Scottish east coast. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 246.

Ruperez, P., Saura-Calixto, F. 2001. Dietary fibre and physochemical properties of edible Spanish seaweeds. European Food research and Technology, 212: 349–354.

Sanchez, I., Fernandez, C., Arenas, F. 2003. Survival rates of *Sargassum muticum* in rockweed communities. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P1–6, p 66–67.

SanLeón, D.G., Izco, J., Sánchez, J.M. 1999 *Spartina patens* as a weed in Galician saltmarshes (NW Iberian Peninsula). Hydrobiologia, 415: 213–222.

Sansón, M., Reyes, J. 1995. Morphological and geographical observations on four species of Ceramiaceae (Rhodophyta) new to Canary Islands. Botanica Marina, 38: 89–95.

Sanson, M., Reyes, J., Afonso-Carrillo, J., Munoz, E. 2002. Sublittoral and deep-water red and brown algae new from the Canary Islands. Botanica Marina, 45: 35–49.

Sartoni, G., De Biasi, A.M. 1999. A survey of marine algae of Milos Island, Greece. Cryptogamie Algologie, 20: 271–283.

Sartoni, G., Boddi, S. 1993. *Apoglossum gregarium* (Delesseriaceae, Rhodophyta), a new record for Mediterranean algal flora. Botanica Marina, 36: 297–302.

Schaffelke, B., Evers, D., Walhorn, A. 1995. Selective grazing of the isopod *Idotea baltica* between *Fucus evanescens* and *F. vesiculosus* from Kiel Fjord (western Baltic). Marine Biology, 124: 215–218.

Schories, D., Albrecht, A., Lotze, H. 1997. Historical changes and inventory of macroalgae from Königshafen Bay in the northern Wadden Sea. Helgoländer Meeresuntersuchungen, 51: 321–341.

Shumway, S.E., Lewitus, A., Coen, A., Burkholder, J.M. 2002. Shellfish transfer and transplantation as vectors for introduction and establishment of harmful algal blooms via dinoflagellate cells and cysts: potential or imaginary risk? Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 259.

Silva, P.C., Woodfield, R.A., Cohen, A.N., Harris, L.H., Goddard, J.H.R. 2002. First report of the Asian kelp *Undaria pinnatifida* in the northeastern Pacific Ocean. Biological Invasions, 4: 333–338.

Simon, C., Gall, E.A., Deslandes, E. 2001. Expansion of the red alga Grateloupia doryphora along the coasts of Brittany (France). Hydrobiologia, 443: 23–29.

Soto Moreno, J., Conde Poyales, F. 1993. Datos sobre la flora algal betonica de la isla de Albaran (Mar de Alboran, Mediterrano occidental). Cryptogamie Algologie, 14: 183–190.

South, G.R. 1968. Observations on the occurrence of a species of *Lomentaria* in southern British Columbia and northern Washington. Canadian Journal of Botany, 46: 727–732.

Springer, J.J., Shumway, S.E., Burkholder, J.M., Glasgow, H.B. 2002. Interactions between the toxic estuarine dinoflagellate *Pfieasteria piscicida* and two species of bivalve molluscs. Marine Ecology Progress Series, 245: 1–10.

Staehr, P.A., Pedersen, M.F., Thomsen, M.S., Wernberg, T., Krause-Jensen, D. 2000. Invasion of *Sargassum muticum* in Limfjorden (Denmark) and its possible impact on the indigenous macroalgal community. Marine Ecology Progress Series, 207: 79–88.

Standley, L.A. 1983. *Caarex kobomugi* Owhi an adventive sedge new to New England. Rhodora, 85:265–269.

Steidinger, K.A., Burkholder, J.M., Glasgow, H.B., Hobbs, C.W., Garrett, J.K., Truby, E.W., Noga, E.J., Smith, S.A. 1996. *Pfiesteria piscicida* gen et sp nov (Pfiesteriaceae fam nov), a new toxic dinoflagellate with a complex life cycle and behavior. Journal of Phycology, 32: 157–164.

Steidinger, K., Landsberg, J., Richardson, R.W., Truby, E., Blakesley, B., Scott, P., Tester, P., Tengs, T., Mason, P., Morton, S., Seaborn, D., Litaker, W., Reece, K., Oldach, D., Haas, L., Vasta, G. 2001. Classification and identification of *Pfiesteria* and *Pfiesteria*-like species. Environmental Health Perspectives, 109 Suppl.5: 661–665.

Stiger, V., Jechoux, G., Le Berre, S., Plouguerne, E., Trepos, R., Deslandes, E. 2003. Comparison of some biological characteristics of two introduced species in French Brittany, *Sargassum muticum* (Fucales, Phaeophyceae) and *Grateloupia doryphora* (Cryptonemiales, Rhodophyceae): preliminary results. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts, P1–8, p 67.

Talley, T.S., Levin, L.A. 2001. Modification of sediments and macrofauna by an invasive marsh plant. Biological Invasions, 3: 51–68.

Thomsen, M.S., McGlathery, K. 2006. Effects of accumulations of sediments and drift algae on recruitment of sessile organisms associated with oyster reefs. Journal of Experimental Marine Biology and Ecology.

Thomsen, M.S., Gurgel, C.F.D., Fredericq, S., McGlathery, K.J. 2006. *Gracilaria vermiculophylla* (Rhodophyta, Gracilariales) in Hog Island Bay, Virginia: A cryptic alien and invasive macroalga and taxonomic correction. Journal of Phycology, 42: 139–141.

Tittley, I., Neto, A.I. 2005. The marine algal (seaweed) flora of the Azores: additions and amendments. Botanica Marina, 48: 248–255.

Tognetto, L., Bellato, S., Moro, I., Andreoli, C. 1995. Occurrence of *Ostreopsis ovata* (Dinophyceae) in the Tyrrhenian Sea during summer 1994. Botanica Marina, 38: 291–295.

Tomas, C.R., Ono, C., Yoshimatsu, S., Goebel, J. 2002. *Chattonella verriculosa* and related species from Japan, Europe (North Sea) and US coastal waters: cases of mistaken identity? Xth Intern. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 282.

Torn, K., Martin, G. 2003. Changes in the distribution of charophyte species in enclosed seabays of western Estonia. Proceedings of the Estonian Academy of Sciences, Biology and Ecology, 2003: 134–140.

Torn, K., Martin, G., Kukk, H., Trei, T. 2003. Distribution of charophyte species in Estonian coastal water (NE Baltic Sea). Scientia Marina, 67 (Suppl. 3).

Trowbridge, C.D. 2001. Coexistence of introduced and native congeneric algae: *Codium fragile* and *C tomentosum* on Irish rocky intertidal shores. Journal of the Marine Biological Association of the United Kingdom, 81: 931–937.

Trowbridge, C.D., Farnham, W.F., White, L. 2003. Thriving populations of the native macroalga *Codium tomentosum* on Guernsey rocky shores. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programe and Book of abstracts P1–4, p 66.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A. (eds) 1972. Flora Europaea. Vol. 3. Diapensiaceae to Myoporaceae. Cambridge University Press, Cambridge, 370 pp.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A. (eds) 1980. Flora Europaea. Vol. 5. Alismataceae to Orchidaceae *(Monocotyledones).* Cambridge University Press, Cambridge, 452 pp.

van der Velde, G., Nagelkerken, I., Rajagopal, S., bij de Vaate, A. 2002. Invasions by alien species in inland freshwater bodies in western Europe: the Rhine delta. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 360–372.

Verlaque, M. 1994. Inventaire des plantes introduites en Méditerranée: origines et répercussions sur l'environment et les activités humaines. Oceanologica Acta, 17: 1–22.

Verlaque, M. 2001. Checklist of the macroalgae of Thau Lagoon (Hérault, France), a hot spot of marine species introduction in Europe. Oceanologica Acta, 24: 29–49.

Verlaque, M. 2002. Morphology and reproduction of *Dasya sessilis* (Ceramiales, Rhodophyta) – an introduced Asiatic species thriving in Thau Lagoon (France, Mediterranean Sea). Phycologia 41: 612–618.

Verlaque, M., Latala, A. 1996. Sur une espèce Japonaise de *Chondrus* (Gigartinaceae, Rhodophyta) accidentellement indroite dans l'Étang de de Thau (France, Mediterranée. Cryptogamie, Algol., 17(3): 153–164.

Verlaque, M., Boudouresque, C.-F., Meinesz, A., Gravez, V. 2000. The *Caulerpa racemosa* complex (Caulerpales, Ulvophyceae) in the Mediterranean Sea. Botanica Marina, 43: 49–68.

Verlaque, M., Belsher, T., Deslous-Paoli, J.M. 2002. Morphology and reproduction of Asiatic *Ulva pertusa* (Ulvales, Chlorophyta) in Thau Lagoon (France, Mediterranean Sea). Cryptogamie Algologie, 23: 301–310.

Verlaque, M., Durand, C., Huisman, J.M., Boudouresque, C.F., Le Parco, Y. 2003. On the identity and origin of the Mediterranean invasive *Caulerpla racemosa* (Caulerpales, Chlorophyta). European Journal of Phycology, 38: 325–339.

Viejo, R.M. 1997 The effects of colonization by *Sargassum muticum* on tidepool macroalgal assemblages. J. mar.biol. Ass. U.K., 77: 325–340.

Viejo, R.M., Arrontes, J., Andrew, N.L. 1995. An experimental evaluation of the effect of wave action on the distribution of *Sargassum muticum* in northern Spain. Botanica Marina, 38: 437–441.

Vila, M., Camp, J., Garces, E., Maso, M., Delgado, M. 2001. High resolution spatio-temporal detection of potentially harmful dinoflagellates in confined waters of the NW Mediterranean. Journal of Plankton Research, 23: 497–514.

Villalard-Bohnsack, M., Harlin, M.M. 1997. The appearance of *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) on the northeast coast of North America. Phycologia, 36: 324–328.

Villalard-Bohnsack, M., Harlin, M.M. 2002. *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) in Rhode Island waters (USA): geographical expansion, morphological variations and associated algae. Phycologia, 40: 372–380.

Vogelbein, W.K., Lovko, V.J., Shields, J.D., Reece, K.S., Mason, P.L., Haas, L.W., Walker, C.C. 2002. *Pfiesteria shumwayae* kills fish by micropredation not exotoxin secretion. Nataure, 418 (6901): 967–970.

Voisin, M., Engel, C.R. and Viard, F. 2005. Differential shuffling of native diversity across introduced regions in a brown alga: Aquaculture vs. maritime traffic effects. Proc. National Academy of Sciences, 102 (15): 5432–5437.

Wallentinus, I. 1992. The dispersal of *Sargassum muticum* in the ICES countries. In: Report of the Working Group on Introduction and Transfers of Marine Organisms, Lisbon 14–17 April 1992. ICES C.M. 1992/Poll:3.

Wallentinus, I. 1999a. Introductions and transfers of plants. In: Munro ALS, Utting SD, Wallentinus I (eds) Status of Introductions of Non-indigenous Marine Species to North Atlantic Waters 1981–1991, pp 1–43. ICES Cooperative Research Report, 231, Copenhagen.

Wallentinus, I. 1999b. *Undaria pinnatifida* (Harvey) Suringar, 1872. In: Gollasch S, Minchin D, Rosenthal H, Voigt M (eds) *Exotics Across the Ocean. Case Histories on Introduced Species*, pp 11–19. University of Kiel, Kiel.

Wallentinus, I. 1999c. *Sargassum muticum* (Yendo) Fensholt, 1955. In: Gollasch S, Minchin D, Rosenthal H, Voigt M (eds) *Exotics Across the Ocean. Case Histories on Introduced Species*, pp 21–30. University of Kiel, Kiel.

Wallentinus, I. 2002. Introduced marine algae and vascular plants in European aquatic environments. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 27–54 (+ 1 App. available at http://www.ku.lt/nemo/EuroAquaInvaders.htm).

Wallentinus, I. (submitted) Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp). Submitted to ICES Cooperative Research Report.

Walters, L.J., Brown, K.R., Stam, W.T., Olsen, J.L. 2006. E-commerce and *Caulerpa*: unregulated dispersal of invasive species. Front. Ecol. Environ., 4 (2): 75– .

Watson, K.L., Cheney, D.P., Levine, I. 2000. Biomonitoring of an aquacultured introduced seaweed, *Porphyra yezoensis* (Rhodophyta, Bangiophycidae), in Cobscook BAY, MAINE; USA. *In*: Pederson J. (ed.) Marine Bioinvasions. Proceedings of a Conference, January 24–27, 1999. MIT Sea Grant College Program, MIT, Cambridge, MA, pp 260–264.

Weber, E., D'Antonio, C.M. 1999. Germination and growth responses of hybridizing *Carpobrotus* species (Aizoaceae) from coastal California to soil salinity. American Journal of Botany, 86: 1257–1263.

Wennberg, T. 1992. Colonization and succession of macroalgae on a breakwater in Laholm Bay, a eutrophicated brackish water area (SW Sweden). Acta Phytogeographica Suecia 78: 65–77.

Wernberg, T., Thomsen, M.S., Stæhr, P.A., Pedersen, P.M. 2000. Comparative phenology of *Sargassum muticum* and *Halidrys siliquosa* (Phaeophyceae: Fucales) in Limfjorden, Denmark. Botanica Marina, 43: 31–39.

West, A.L., Mathieson, A.C., Klein, A.S., Neefus, C.D., Bray, T.L. 2005. Molecular ecological studies of New England species of *Porphyra* (Rhodophyta, Bangiales). Nova Hedwigia, 80: 1–24.

Wiedemann, A.M., Pickart, A. 1996. The *Ammophila* problem on the northwest coast of North America. Landscape and Urban Planning, 34: 287–299.

Wikström, S.A., von Wachenfeldt, T., Kautsky, L. 2002. Establishment of the exotic species *Fucus evanescens* C. Ag. (Phaeophyceae) in Öresund, southern Sweden. Botanica Marina, 45: 510–517.

Wikström, S.A., Kautsky, L. 2004. Invasion of a habitat-forming seaweed: effects on associated biota. Biological Invasions, 6: 141–150.

Williams, S.L., Grosholz, E.D. 2002. Preliminary reports from the *Caulerpa taxifolia* invasion in southern California. Marine Ecology Progress Series, 233: 307–310.

Wolf, W.J. 2005. Non-indigenous marine and estuarine species in The Netherlands. Zoologische Mededelningen, 79–1: 1–116.

Wootton, L.S., Halsey, S.D., Bevaart, K., McGough, A., Ondreicka, J., Patel, P. 2005. When invasive species have benefits as well as costs: Managing *Carex kobomugi* (Asiatic sand sedge) in New Jersey's coastal dunes. Biological Invasions, 7 (6): 1017–1027.

Yasumoto, T., Igarashi, T., Furey, A., James, K.J., Koike, K. 2002. Discovery of the origin of azaspiracids. Conf. on Harmful Algae, October 21–25,2002, St. Pete Beach, Florida USA. Book of abstracts p 309.

Zenetos, A., Lantzouni, M., Nicolaido, A. 2002. An account of our knowledge oon fouling and ballast invaders in Greek waters. In*:* ICES/IMO/IOC Report of the Study Group on Ballast and Other Ship Vectors, Gothenborg, Sweden, 18–19 March 2002. ICES CM 2002/ACME:05.

Zuljevic, A., Thibaut, T., Elloukal, H., Meinesz, A. 2001. Sea slug disperses the invasive *Caulerpa taxifolia*. Journal of Marine Biological Association of the United Kingdom, 81: 343–344.

**Table 2.1. Introduced macroalgae ≤ 2002. Areas follow the international codes, except for Ire, which includes both Ireland and Northern Ireland. () = species listed, but not established |Az| = the Azores, |Bal| = the Baleares, |Co| = Corsica , |Sa| = Sardinia, |Si| = Sicily, c = central, n = northern, e = eastern, s = south, w = western, Atl = the Atlantic, Pac = the Pacific, IndO = the Indian Ocean, Carib = the Caribbean, Mediterr = the Mediterranean, Eur = Europe, Afr = Africa, trop = tropical, subtr = subtropical. Vectors: Aqu = aquaria trade, Bal = solid ballast, Cul = cultivated, Exp = experiments, Fi = fishing activities (with baits or nets), Les = Lessepsian immigrant, Mol = mollusc transports, Oy = oyster transports, Pack = packing material around bait or shellfish, Shi = shipping activites (hull fouling or ballast). Species in bold = invasive, <u>bold + underlined</u> = highly invasive.**

| Taxon | Totally new for all areas ≥1991 | New in some areas ≥1991 while earlier in others | Introduced into the following areas < 1991 | Probable origin | Probable vector |
|---|---|---|---|---|---|
| RHODOPHYTA (=Red algae) | | | | | |
| ***Acanthophora nayadiformis*** | | | s&seIT, MT, e&nGR | RedS/IndO | Les |
| *Acrochaetium balticum* | NL | | | Baltic Sea? | Shi? |
| *Acrochaetium* cf. *codicolum* | sFR | | | N.Atl? | Host? |
| *Acrochaetium densum* | | | NL | Pac? | ? |
| <u>***Acrothamnion preissii***</u> | | ES\|Bal\| | sFR, nw&sIT | IndO-Pac | Shi |
| *Agardhiella subulata* | | NL | GB, sFR, sIT | N.Atl?/IndO? | Shi?/Mol? |
| *Aglaothamnion feldmanniae* | | | sFR, nw&neIT | N.Atl | Shi |
| *Aglaothamnion halliae* | | | NO, DE | N Amer? | Shi? |
| *Ahnfeltiopsis flabelliformis* | sFR | | | Japan | Oy |
| *Anotrichium furcellatum* | | | NL, nFR, GB, nES | n Pac?/Mediterr? | Oy? |
| *Antithamnion decipiens* | | | ES\|Bal, Alb\|, FR\|Co\|, w,sw&seIT, nGR | Native? | ? |
| *Antithamnion amphigeneum* | | wIT | seES&\|Bal\| | e AU? | Shi |
| *Antithamnion densum* | | | Ire, nFR, nES&\|CanI\|, | IndO-Pac? | ? |
| *Antithamnion diminuatum* | | | PT\|Az\|, ES\|Can\| | s AU?/S.Atl? | Shi? |
| ***Antithamnion nipponicum*** | | neIT | sFR, PT\|Az\|, US | Japan | Oy |
| *Antithamnionella elegans* | | | wIT | Japan | Shi |
| ***Antithamnionella spirographidis*** | | BE | NL, GB, Ire, nwFR, ?PT\|\|Az\|, n&sES, seIT | n Pac | Shi |
| *Antithamnionella sublittoralis* | | | sIT | wPac | Shi |
| ***Antithamnionella ternifolia*** | | BE | (NL), nFR, GB, Ire, PT, nES | South Hemisph? | Shi |
| *Apoglossum gregarium* | nwIT | | | RedS | |
| <u>***Asparagopsis armata***</u> | | | (NL), GB, Ire, n-sw&sFR, PT, n&sES, IT, MT | AU | Shi |
| " | | | s&nGR, PacUS | | |
| *Asparagopsis taxiformis* | nw-sIT | | | trop & subtr | Les? |
| ***Bonnemaisonia hamifera*** | | | IS, FO, NO, wSE, DK, wDE, (NL), GB, Ire, n-swFR | Japan | Shi |
| " | | | PT\|Az\|), n&sES, IT\|Si\|, AtlCA, AtlUS | | |
| *Botryocladia madagascariensis* | seIT, MT | | | s IndO | ? |
| *Callithamnion byssoides* | | | PacUS | N.Atl.? | Shi? |
| *Caulacanthus ustulatus* | | | nwFR | nw Pac | Oy |
| *Ceramium strobiliforme* | s&eIT | | | Atl | ? |

| Taxon | Totally new for all areas ≥1991 | New in some areas ≥1991 while earlier in others | Introduced into the following areas < 1991 | Probable origin | Probable vector |
|---|---|---|---|---|---|
| *Chondria coerulescens* | sFR | | | Atl?/Mediterr? | Oy |
| *Chondria polyrhiza* | | sIT | neGR | ? | ? |
| *Chondria pygmaea* | AL, IT, MT | | | RedS/IndO | Les |
| *Chondrus giganteus* | sFR | | | Japan? | Oy |
| *Chryptonemia hibernica* | | | (Ire) | Pac? | ? |
| *Chrysymenia wrightii* | | | sFR | nw Pac | Oy |
| *Colaconema dasyae* | | | NL | Mediterr/ne Atl? | Host? |
| *Dasya baillouviana* | | BaltDE | NO, wSE, DK, NL | Mediterr/ne Atl | Shi/Oy? |
| *Dasya sessilis* | | | sFR | nw Pac | Oy |
| *Furcellaria lumbricalis* | | | Atl CA | Europe | Shi |
| *Gelidium vagum* | | | PacCA, PacUS | Japan | Oy |
| *Goniotrichiopsis sublittoralis* | | | nFR, ES\|Bal\| | nw Pac? | ? |
| *Gracilaria multipartita* | | | (Ire) | N.Atl | ? |
| *Gracilaria vermiculophylla* | nFr, NL | | | wPac | Oy?/Shi? |
| *Grallatoria reptans* | | | ES\|Can\| | Carib? | Native? |
| *Grateloupia filicina* var. *luxurians* | | n&sFR | GB, nwES, | AU?/Japan? | Oy |
| *Grateloupia lanceolata* | sFR | | | Japan | Oy |
| *Grateloupia* sp. | | | sFR | nw Pac? | Oy |
| ***Grateloupia turuturu*** | | NL, PT, US | sGB, n&sFR, n&sES, IT | nw Pac | Mol/Shi |
| *Griffithsia corallinoides* | | | sFR, IT | Japan?/Atl? | Oy |
| *Gymnophycus hapsiphorus* | | | ES\|CanI\| | e Austr | Shi |
| *Herposiphonia parca* | sFR | | | Pac/Japan? | Oy |
| ***Heterosiphonia japonica*** | NO, wSE, NL, n&sFR, nES | | | Japan | Oy/Shi |
| *Hypnea cornuta* | sIT | | | RedS/IndO | Les |
| *Hypnea esperi* | | | sGR | RedS/IndO | Les |
| *Hypnea spinella* | | | sIT, neGR | Carib? | Shi? |
| *Hypnea valentiae* | | sFR | sGR | Pac?, RedS | Oy?/Les |
| *Laurencia brogniartii* | | | nFR | Carib?/Japan? | Oy |
| *Laurencia caduciramulosa* | | sFR | sIT | se Asia | Shi? |
| *Laurencia chondroides* | | | sIT | ? | ? |
| *Laurencia majuscula* | | | sIT | ? | ? |
| *Laurencia okamurae* | | | sFR | e Asia | Oy |
| *Lithophyllum yessoense* | sFR | | | Japan? | Oy |
| *Lomentaria clavellosa* | | | AtlUS | Europe? | ? |
| *Lomentaria hakodatensis* | | nES, neIT | s&nFR, PacCA, PacUS | Japan | Oy |
| *Lomentaria orcadensis* | | | (AtlCA) | E Atl? | ? |
| ***<u>Lophocladia lallemandii</u>*** | | | sES, IT, MT, sGR | Pac? | Les? |
| *Mastocarpus stellatus* | | | DK, wDE | N.Atl | Exp/Shi? |
| ***Neosiphonia harveyi*** | | wSE, BE, ES\|CanI\| | NO, DK, wDE, NL, GB, Ire, n&sFR, | n Pac/nwAtl | Shi/Host? |
| " | | | nES, nwIT, AtlCA, AtlUS | | |
| *Pikea californica* | | | GB | California | Shi? |

| **Taxon** | **Totally new for all areas ≥1991** | **New in some areas ≥1991 while earlier in others** | **Introduced into the following areas < 1991** | **Probable origin** | **Probable vector** |
|---|---|---|---|---|---|
| *Platysiphonia caribaea* | | | ES\|CanI\| | S.Atl? | ? |
| ***Pleonosporium caribaeum*** | | | n&sFR, PT, sES&\|CanI\| | Antilles? | Shi |
| *Plocamium secundatum* | | | IT\|Si\| | sub-Antarctic? | ? |
| *Polysiphonia* cf. *breviarticulata* | | | AtlUS | ? | ? |
| ***Polysiphonia denudata*** | | | PacUS | ? | ? |
| ***Polysiphonia fucoides*** | | | sFR, IT, GR? | N.Atl | Fi? |
| *Polysiphonia morrowi* | sFR, neIT | | | nw Pac | Oy |
| *Polysiphonia paniculata* | | | sFR | e Pac | Oy |
| ***Polysiphonia senticulosa*** | NL, BE | | | n Pac | Oy? |
| *Porphyra yezoensis* | | (AtlCA?), AtlUS | sFR, (PacUS?) | Japan | Oy |
| *Predaea huismanii* | | | ES\|CanI\| | AU | Shi |
| *Prionitis patens* | sFR | | | Japan | Oy |
| *Pterosiphonia tanakae* | sFR | | | Japan | Oy |
| *Pterosiphonia pinnulata* | | | sGB | Med?/Jap? | Oy? |
| *Rhodophysema georgii* | | | sFR | N.Atl?/N.Pac? | Oy? |
| *Sarconema filiforme* | | | sFR | IndO | Les |
| *Sarconema scinaiodides* | | | GR | IndO | Les |
| *Solieria chordalis* | | | GB | Atl | ? |
| ***Solieria filiformis*** | | | sIT | trop & subtr Atl? | ? |
| ***Symphyocladia marchantioides*** | | | PT\|Az\|, nwIT | AU? | Shi? |
| <u>***Womersleyella setacea***</u> | | ES\|Bal\|, MT, GR | sFR, nw-sIT | trop | Shi/Fi |
| | | | | | |
| PHAEOPHYCEAE (=Brown algae) | | | | | |
| *Acrothrix gracilis* | sFR | | | Japan | Oy |
| *Ascophyllum nodosum ecad mackayi* | (PacUS) | | | N Atl | Pack |
| *Asperococcus scaber* | NL | | | Adriat | ? |
| *Botryella* sp. | | | NL | ? | ? |
| *Chorda filum* | | | sFR, GR? | N.Atl?/nw Pac? | Oy |
| *Cladosiphon zosterae* | | sFR | sIT | Japan?/Atl? | Oy |
| ***Colpomenia peregrina*** | | | NO, wSE, DK, NL, GB, Ire, n&sFR, | Pac | Oy |
| " | | | PT, n&sES, IT, AtlCA | | |
| *Corynophlaea umbellata* | | | GB | Japan?/Mediterr? | Host? |
| ***Desmarestia viridis*** | | | sFR, sES, neIT, HR | N.At?/nw Pac? | ?/Oy? |
| *Ectocarpus siliculosus var. hiemalis* | neIT | | | Atl? | ? |
| *Elachista* sp. | | | NL | ? | ? |
| *Endarachne binghamiae* | | | PT\|Az\| | ? | ? |
| *Fucus evanescens* | | | sNO, wSE, DK, GB, BaltDE, | n N.Atl | Fi |
| *Fucus serratus* | | | AtlCA | Europe | Shi |
| *Fucus spiralis* | | | (sFR) | N.Atl? | Fi |

| Taxon | Totally new for all areas ≥1991 | New in some areas ≥1991 while earlier in others | Introduced into the following areas < 1991 | Probable origin | Probable vector |
|---|---|---|---|---|---|
| *Halothrix lumbricalis* | | | sFR, sIT | Japan?/N Atl? | Oy |
| *Laminaria japonica* | | | sFR | Japan | Oy |
| *Leathesia difformis* | | neIT | sFR | N.Atl? | Oy |
| *Leathesia verruculiformis* | NL | | | nw Pac | ? |
| *Myriactula* sp. | | | NL | ? | ? |
| *Padina boergesenii* | | | IT | Red S | Les |
| *Pilayella littoralis* | | | sFR | N.Atl?/N.Pac? | Oy |
| *Punctaria tenuissima* | neIT | | | N.Atl? | Oy |
| ***<u>Sargassum muticum</u>*** | | BE, Ire, PT, neIT | NO, wSE, wDE, DK, NL, | n Pac | Oy |
| " | | | s&wGB, n&sFR, nES, PacCA, PacUS | | |
| *Scytosiphon dotyi* | | sFR | GB, neIT | Pac | Oy/Mol |
| *Sorocarpus* sp. | neIT | | | Atl? | ? |
| *Sphaerotrichia divaricata* | | | sFR | Japan | Oy |
| *Stypopodium schimperii* | ES\|CanI\|, sGR | | | Red S | Les |
| ***Undaria pinnatifida*** | | NL, BE, sGB, s&neIT, PacUS | n&sFR, nES | Japan | Oy, Cul,& Shi |
| | | | | | |
| CHLOROPHYTA (=Green algae) | | | | | |
| ***Bryopsis* sp.** | | | PacUS | ? | ? |
| ***Caulerpa brachypus*** | se US | | | IndO/Pac? | Aqu? |
| ***<u>Caulerpa racemosa</u>*** | | sFR, seES, nw-sIT | GR | IndOc? | Les/Aqu? |
| ***Caulerpa scalpelliformis*** | | | IT | IndOc | Les |
| ***<u>Caulerpa taxifolia</u>*** | | ES\|Bal\|, nw-sIT, HR, PacUS | sFR, MO | trop Aquar | Aqu, Shi & Fi |
| *Chara connivens* | | | eSE, EE, LV, wRU, PL, BaltDE | w Eur, n Afr | Bal |
| ***Codium fragile ssp. tomentosoides*** | | BE, AtlCA | IS, NO, wSE, DK, wDE, NL,GB, Ire, n&sFR, | Japan | Shi/Oy |
| " | | | n&sES, PT\|Az\|, s&neIT, GR, Atl&PacUS | | |
| *Codium fragile* ssp. *scandinavicum* | | | NO, wSE, DK | Pac | Shi? |
| *Codium fragile* ssp. *atlanticum* | | | NO, NL, GB, Ire, PT\|Az\| | Pac | Shi? |
| *Derbesia rhizophora* | | | sFR | Japan | Oy |
| *Monostroma obscurum* | | | sFR | Atl?/Pac? | Oy |
| *Ulva pertusa* | | NL | sFR | IndO/Pac? | Oy |

# 3 Invertebrates

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This section is a review of marine invertebrate introductions as provided with WGITMO National Reports submitted in 1992 to 2002. First records of non-indigenous species are provided in Annex 1. WGITMO Reports should be consulted in conjunction with this text. Qualitative data on deliberate introductions and transfers and live imports and transfers of non-native invertebrate species are presented in Annex 1 (excluding species movements within one country and also species introductions for research purposes).

Most deliberate introductions of live invertebrates were for aquaculture, direct human consumption or for recreational purposes such as game fishing. In aquaculture, introductions of molluscs were most common. In a limited number countries crustacean introductions prevail. As report in the previous summary report (1981–1991), of the molluscs the Pacific oyster *Crassostrea gigas* continued to be of prime interest.

Other species of prime concern is the unintentional introduction of the large Asian gastropod mollusc *Rapana venosa* native in the Sea of Japan, Yellow Sea, Bohai Sea, and the East China Sea to Taiwan and the intentional introduction of the Red King Crab, *Paralithodes camtschaticus* native in the north-western Pacific. WGITMO prepared detailed reports on these species which were published as ICES Cooperative Research Reports.

*Rapana venosa* has been introduced to the Black Sea with subsequent range expansion to the Adriatic Sea and Aegean Sea, the Chesapeake Bay on the East Coast of the United States, and the Rio de la Plata between Uruguay and Argentina. Reproductive populations are or appear to be present in all three receptor regions. In addition, there are a limited number of reports of the species from the Brittany coastline of France, Washington State (USA), and two collections from the North Sea and New Zealand. The life history of this species makes it a viable candidate for continuing range expansion and new invasions may have been facilitated by shipping vectors. The ecological impacts of this invader have been severe. The broad dietary preference for bivalve molluscs including the soft-sediment infaunal mollusc species identify *R. venosa* predation as the prime reason for the decline of bivalves in invaded habitats. Their predatory impact becomes especially into focus in areas with aquaculture activities on bivalves.

The Red King Crab *Paralithodes camtschaticus* is native to the Okhotsk and Japan Sea, Bering Sea and Northern Pacific Ocean. On the Asian side of the Pacific, crabs are found from Korea, along the eastern coast of Siberia and the coasts of Kamchatka peninsula. In the Northeast Pacific and Bering Sea the Red King Crabs are distributed throughout the Aleutian Island chain, north to Norton Sound, Alaska, and southeast to Great Bay in Vancouver Island, Canada. Russian scientists intentionally introduced larvae, juveniles and adults of this species from western Kamchatka peninsula to the southern Russian Barents Sea over the period 1961–69. Ten years later, in the late 1970's, a reproductive population of Red King Crabs had become established in the recipient region. The spread from this location may have been due to both natural dispersal of larva by coastal currents and by adult migration. Scallop beds along the Norwegian coast represent a potential food reservoir in spring/summer (May–July) for mature migrating Red King Crabs increasing food ingestion to replace recently expended energy. The impact of the crab was assessed by "before-after" analysis. A predatory impact was clearly shown.

This documentation of species introductions is clearly an understimate as information on certain species are only available without taxonomic identification, e.g. bait worms. Further, not all ICES Member Countries made available National Reports at all WGITMO meetings. For ICES Member States who submitted only a few reports the reporting year was indicated below. The National Reports for Australia (observer status) and Italy (guest status) were also included in this review.

Many of the newly introduced species are attributed to the introduction vector shipping, i.e. ballast water and hull fouling, and those are excluded here. For more detailes the Annexes to this document and reports of ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV) may be consulted.

## 3.1 Belgium

National Reports were received since 2001.

Belgium expressed concerns about the import and export of a wide variety of marine and fresh water species for aquaculture, aquariums, human consumption and research. Much of this transfer appears uncontrolled. Oysters (*Crassostrea gigas*), imported from a number of countries (in 2001 and 2002 mainly from Canada and France), have formed dense populations in several harbours and are present on offshore on buoys. Other imported invertebrates were *Perna* sp., *Cyrtodaria siliqua*, *Mercenaria mercenaria*, *Spisula polynyma* and *Tapes philippinarum*.

As reported by several other European countries, records of the North American lobster (*Homarus americanus* imported from Canada in 2001 and 2002 for direct human consumption) are of concern because of the potential genetic impact on native species.

## 3.2 Canada

During the reporting period, the majority of deliberate species introductions were *Placopecten magellanicus*, *Crassostrea virginica*, *Mercenaria mercenaria*, *Mytilus edulis*.

Extensive research continues on the invasion of the Eurasian zebra mussel *Dreissena polymorpha* in *Canada*. A second species of the invasive zebra mussel *Dreissena* has been identified. This quagga mussel (*D. bugensis*) is common in Lake Erie, Lake Ontario and the St. Lawrence River. Unlike its range expansion into the United States, the zebra mussel has had a limited expansion north from the Great Lakes into adjacent Canadian watersheds. The zebra mussel continued its spread during the entire reporting period.

In 1993, blue mussels (*Mytilus edulis*) were imported from Ireland for processing evaluation on Prince Edward Island. The mussels were held in quarantine until processed. A health check revealed the presence of four parasites previously unrecorded in Canadian mussels (*Mytilicola*-like copepod; *Steinhausia mytilovum*, a microsporidian of mussel ova; *Nematopsis*-like gregarine cysts and a *Proctoeces*-like digenean flatworm). All of the mussels were processed and waste was disposed of according to guidelines set by the Prince Edward Island Introductions and Transfers Committee.

Manila clam (*Tapes philippinarum*) and *Crassostrea gigas* seedstock were imported from the Pacific coast of the USA since 1994 for beach seeding purposes. Japanese scallops (*Placopecten yessoensis*) were imported from Japan in 1994. In the latter case, only the F1 generation will be out-planted into ciastal waters of British Columbia.

An official request from the provincial Department of Fisheries and Aquaculture, New Brunswick to import hard-shell clams (*Mercenaria mercenaria*) from a South Carolina bivalve hatchery was received in 1994. The health of the proposed export stock was examined by a shellfish pathologist on-site, and certified to be free of disease organisms of concern. A permit was issued allowing import into quarantine facilities in New Brunswick in February 1995. The stock spawned in quarantine, and 100% of the original imported organisms were killed and examined before release of the F1 generation was authorized.

Adult sea urchins (*Strongylocentrotus purpuratus, S. droebachiensis* and *Lytechinus pictus*) were imported by the Federal Department of Environment to Nova Scotia from California, USA. The organisms were held in quarantine. The mussel (*Mytilus californianus*) was imported from California, USA.

The use of bay scallops (*Argopecten irradians*) increased in the Maritime Provinces now that a moratorium on their culture in open waters around Prince Edward Island had been lifted. The moratorium was lifted because studies showed that bay scallop parasites are not transmitted to five commercially important native bivalve species. Bay scallops are presently cultured along the Atlantic and Gulf of St. Lawrence coasts of Nova Scotia. In 1993 New Brunswick introduced bay scallops into its Gulf of St. Lawrence waters for aquaculture. Commercial facilities in the Maritimes should satisfy all of the region's requirements for bay scallop spat.

Species imported for direct human consumption included rockfish (unspecified), red abalone (*Haliotis rufescens*), mussels (mostly *Mytilus edulis*), oysters (mostly *Crassostrea gigas*), prawns and shrimps (unspecified), crab (*Scilla serrata* and other unspecified), geoduck (*Panope abrupta*), lobster (including rock and slipper lobster), sea urchins (*Strongylocentrotus* spp.), and whelk (unspecified).

A living specimen of the Chinese mitten crab *Eriocheir sinensis* was collected on the Canadian side of Lake Erie in April 1994. It is not clear whether the crab was introduced by shipping or is an escape from Asian markets after illegal import.

The rusty crayfish (*Orconectes rusticus*) was introduced in central and northwestern Ontario in 1994 and continues to spread. Its spread may be supported by bait-bucket transfers. Bait (unknown species) have also been introduced from the USA.

Four specimens of European flounder (*Platichthys flesus*) were collected in 1994 in Thunder Bay, Ontario, Lake Superior. The introduction vector remains unclear.

In 1999 bar clams (*Spisula solidissima*), ocean quahog (*Polynema mactromeris*) were transferred as seed stock, broodstock or for relay purposes.

Since 1999 a new species being cultured in British Columbia is *Crassostrea sikamea* (Kumamoto oyster). All imports must be from health-certified sites. Especially in the Pacific Region, there was a growing number of freshwater and marine species being imported live for human consumption (e.g. *Channa channa*, *Muranaesox* (*Congresox*) *talabonoides*, *Oreochromis niloticus*) in addition to the traditional species found in the live food market (e.g. *Homarus* sp., *Mytilus edulis*).

Varnish clams (*Nuttalia obscurata*), first recorded from the Gulf of Georgia in the 1990s, were found in Barkley Sound on the west coast of Vancouver Island by 1997 including areas within Pacific Rim National Park. They have now extended their range further north. Because of the density of clams in some areas, a commercial and recreational fishery was considered.

Seafood outlets in the Pacific Region import a large variety of live invertebrates. There are annual reports in the news media of exotic species being found in waters near Vancouver, BC. (e.g. Atlantic lobsters). One of the potential avenues of release of such species is through religious ceremonies for which live seafood is purchased for release. Accidental realeses may also have occurred.

## 3.3 Denmark

The only national Report received was submitted in 1993 not including details of invertebrate importations. According to Swedish National Reports, during 2000 an unknown quantity of *Perna* ap. was imported to Denmark from Sweden.

## 3.4 Finland

Being exposed to brackish and freswater conditions, marine introductions in Finland are rare. However, hobby aquarists and restaurants import live marine invertebrates, including oysters, lobsters and crabs. These imports are permitted without government authorisation as the species will not likely survive when accidentally being released. In contrast authorisation is required for live freshwater species imports when planning to release them in natural waters.

In the early 1990s eggs of the signal crayfish *Pacifastacus leniusculus* were imported from Sweden. Other crayfish are mainly imported from the Soviet Union and USA, and they have to be cooked before sale for consumption (soon after arriving in the country).

Since 1995 *Dreissena polymorpha* has been recorded in the eastern parts of the Gulf of Finland. The abundance of the species seems to be very low.

The mitten crab, *Eriocheir sinensis*, was first reported from the southeastern lake district in 1998.

## 3.5 France

An official request to begin studies on the introduction of the American bay scallop *Argopecten irradians* was submitted to ICES in time for the WGITMO 1993 meeting. The reasoning for the *proposed* introduction is that the native scallop (*Pecten maximus*) fishery is insufficient to support market demand and 40 000 tonnes of scallop meat are imported into France each year. Also, the recently introduced Japanese scallop, *Patinopecten yessoensis*, appears to be unsuitable for commercial culture. To satisfy the demand for scallop meats and to diversify from the monoculture of oysters in France, *Argopecten* will be assessed for its potential for commercial cultivation. Broodstock scallops will be imported from Canada or the USA into quarantine at La Tremblade and seed will be reared at the Argenton hatchery, following the ICES Code of Practice. Once the $F_1$ generation has been diagnosed free of diseases, etc., seed will be planted out at experimental sites. *Argopecten irradians* was imported and held in quarantine. Due to a change in focus of activities this project was not developed further. However, individuals of *Argopecten irradians* are still in use (in containment) for scientific purposes.

France reported in 1994 that, as in previous years, oysters (*Crassostrea gigas*) have been imported for consumption mainly from Ireland, Portugal, the United Kingdom and the Netherlands and imports continued during most of the reporting period. Mussels have also been imported from several European countries (Spain, Netherlands, United Kingdom, Ireland and Denmark). In 1997 flat oysters *O. edulis* were also imported from the former Yugoslavia, Croatia and the Netherlands.

An F2 generation of *Patinopecten yessoensis* has been produced from the F1 resulting from the broodstock introduced into France in 1988. Bad results brought the planned programme to an end but to maintain a strain of *P. yessoensis*, an F2 composed of some thousands of individuals was immersed in bags during the juvenile stages in the estuary of the 'Rade de Brest' (St. Anne). Following this initiative, a new experiment was started in Ile de Houat to test the growth performance using the long-line technique. From November 1993 to November 1994 the average size increased from 50mm to 88mm with a survival rate of 75%.

The Manila Clam*Tapes philippinarum* was introduced for aquaculture purposes during the 1980s. This species has spread naturally to the extent that a public fishery is now operating on a yearly basis. Landings reached 4000 to 5000 metric tons in 1996. A fishery management plan was develped. *T. philippinarum* is now widely distributed. Both the Manila Clam and the native European species *T. decussatus* occur concomitantly on the same beds, with an overlap between the populations. However no hybrids have been yet observed. Juvenile clams of *T. philippinarum* were imported in 1998 for aquaculture purposes from Italy.

In 1998 Juveniles (postlarval stages from hatcheries) of the shrimp *Penaeus japonicus* were imported from Spain for aquaculture purposes in ponds on the Atlantic coastline.

Three living adult gastropods of *Rapana venosa* were collected in a subtidal area of the Bay of Quiberon (Southern Brittany) (biometric characteristics, height 140 and 136 mm; width 101–102mm). Originating from the tropical Indo-Pacific region, this species was introduced into the Black Sea and Marmara Sea during the 1940s and then has spread to Aegean and Adriatic Seas. The first animal was sighted in June 1998. A local enquiry permitted to track and verified another sighting back to summer 1997. In the quarantine station at the research laboratory before destruction, these individuals could efficiently prey on the locally reared oyster *C. gigas*, and therefore pose a potential threat in case of further development. No juvenile has been found and there is yet no evidence that a local population is established. A fourth specimen was caught 21 March 2000. Additional *Rapana* findings were reported and since its first sighting in 1997, a total of 11 *Rapana* individuals have been observed in the same location until 2000. In 2001, two more individuals were captured by fishermen. Although unsuccessful, new trials using nets, and dredge were carried out to eradicate the species. Leaflets and information campaigns to the public and fishermen are currently used to disseminate information and to reward any catch. The introduction of this predatory snail is of great concern (see also relevant ICES Cooperational Research Report). The species may have been introduced with shipping or accidentally with species imports for aquaculture purposes. In 2002 France reported that the (likely) introduction vector for this species is now explained: transfers of *Tapes philippinarum* from the Adriatic Sea (Italy) towards Southern Brittany. *Rapana* individuals were used to ballast clam bags.

A new species of drilling gastropod *Ocinebrellus inornatus* (= *Ocenebra japonica*) has been observed along the French Atlantic coastline, in the Marennes Oleron and Arcachon Bays. The first sighting was observed in April 1997, but seems to be more common since 1998, a year showing a large recruitment of gastropod species. The species spread is likely increased by shellfish trades and may have a negative impact on aquaculture activities. With a native NW Pacific range and distributed in the NE Pacific as well, the introduction vector is unknown and might be related to either ballast waters or shellfish trade.

France reported in 1999 that the slipper limpet *Crepidula fornicata* is well distributed along the French Atlantic coastline and has reached a very high density in specific locations (e.g. 250 000 metric tons in the Bay of St Brieuc) interacting significantly with other species, including commercial species and fisheries (e.g. scallop *Pecten maximus*). A comprehensive research program was carried out by four research institutes and funded by the French Ministry of the Environment. The objectives included to assess 1) interactions between environmental factors and species proliferation, 2) effects on biodiversity, 3) interactions with species of commercial interest, 4) improve knowledge on proliferation mechanisms for this species to develop a spatialised model to simulate population removal, and 5) the efficiency of management practices to limit invasion. Four sites along the Atlantic coastline were in focus of this research programme. The species was suspected to be introduced accidentally by oyster shipments.

In 2000 France reported that the shellfish trade between Ireland, France, and Portugal is including the abalone *Haliotis tuberculata*. Abalone juveniles are provided by an Irish hatchery, then imported to France and Portugal for growing. Moreover, illegal imports of a second abalone species, *Haliotis discus hannai* in culture in Ireland, have been confirmed. Recent mortalities have affected *Haliotis tuberculata* in Brittany resulting from a *Vibrio courtier*, already described in Japan and known for inducing *H. discus hannai* mortality rates. On-going investigations aim to assess if a transfer of *H. discus hannai* could be considered as a healthy carrier for a bacterial transfer, which would then expressed itself in warmer sea waters.

The aquarium trade imported several invertebrate species in 2000, and specifically from Canada the following species: pink anemones (*Anthopleura elegatissima*), giant anemones (*A. xanthogrammica*), white spotted anemones (*Urticina lofotensis*), sunflower stars (*Picnopodia helianthoides*), California cucumber (*Parastichopus californianus*), giant barnacle clusters (*Balanus nobilus*), and the Pacific giant octopus *Octopus dofleini*. No release into the environment is expected due to the aquarium seawater management.

In 2001 an emerging trend concerning the increasing non-commercial fishing activities which are using live baits is reported.

## 3.6 Germany

Since the 1980s an oysterfarm is operated on the Island Sylt in the Waden Sea. In the early years of this aquaculture business several 10 000 juvenile specimens were imported annually from Ireland and the United Kingdom. While the seed oysters usually originate from certified hatcheries, there were several times that it was necessary to postpone direct importation from the hatchery because of long winters and the extreme weather conditions in Germany. Because of the space needed to keep seed oysters longer than anticipated, juvenile oysters had to be 'parked' for a few days or at most for two weeks outside the hatchery in Ireland. This has led to some fouling, and gradually through this (but also through other pathways) non-indigenous species were transmitted. Therefore, through these oyster imports, the culture site served as a gateway for other species into this part of the Wadden Sea. These include the seaweed *Sargassum muticum* and the ascidian *Styela clava*, which originate from the Northwest Pacific and the seaweed *Ascophyllum nodosum* and the ascidian *Aplidium nordmanni* from the north Atlantic. All species have been found previously, but were re-introduced accidentally by activities of this aquaculture farm.

The Pacific oyster culture resulted also in the establishment of *Crassostrea gigas* in the Wadden Sea outside the oyster farm. *C. gigas* has reproduced successfully, and strong spatfalls occurred already in 1991 and 1994 on natural mussel beds. The wild oyster population comprised about one million in number during the summer of 1995. Re-sampling by scientists from the Biologische Anstalt Helgoland in 1996 revealed a survival of 66% in spite of a foregoing severe winter. Oysters growing on mussel beds attained a length of 20 to 50 mm in their first year and 50 to 80 mm in their second year. Some of the oysters were larger and presumably much older, indicating that some specimens had survived since the 1991 reproduction. Abundance was highest (up to 8 oysters per $m^2$) on exposed mussel beds at low tide level. These mussels were not covered by any of the common macroalgae. It is expected that *C. gigas* will become a permanent member of the biotic community in the Wadden Sea. Since the late 1990s the oysters showed good growth and seem to have reached maturity and spawning may have taken place. Field studies document the spread of the Pacific Oyster and it was reported that *C. gigas* was frequently found on blue mussel beds.

On an annual basis Germany reports that live crustaceans (*Nephrops norvegicus*, *Homarus gammarus*, *H. americanus*, *Callinectes sapidus* and *Cancer pagurus*) have been imported for human consumption from various European countries and North America in unknown quantities. It is believed that this practice is ongoing since a long time. Live blue mussels (*Mytilus edulis*) were imported from Denmark for human consumption in an unknown quantity.

Since the beginning of the 1990s, about 60 years after the known extreme mass occurrence in German rivers, the Chinese Mitten Crab was becoming very abundant again. In spring 1998, 850 kg of juvenile crabs were caught by hand in the river Elbe in two hours only. It is supposed that the daily catch could summarise to more than 3000 kg of juvenile crabs. This amount of species is comparable or even higher than the data of the 1930s (in max. 2500 kg of crabs were caught in one day), the peak of the former mass occurrence in German waters. In

1999 the same trend was observed. During mass occurrences of the crab a loss of the harvest of the estuarine and inland fishing industry is known due to its feeding activity on the fish and the fish food. The crabs cause damage to dams, retaining walls and irrigation channels by perforating them with burrows. Openings of the burrows reach 12 cm and a length of 50 cm. During the mid 1930s up to 30 holes per meter square in river banks of the mouth of river Elbe were found. In the end of the 1990s the crab was found in the Kiel fjord. It has not been found in the regions since 1910 and the record might be quoted as an indication of an increasing tendency in the population size.

As in many other countries the zebra mussel *Dreissena polymorpha* is spreading and this seems to take place mainly at the fringes of previous distribution patterns in Europe. One reason for this behaviour may be the improvement in water quality of some German rivers (Elbe and Weser Rivers) in the past few years, through additional urban waste water treatment plants installed in former Eastern Germany. In 1999, the Institute for Marine Research has undertaken a monitoring programme on the settling pattern of zebra mussels in the port of Hamburg which serves several industries. Distribution and growth at various sites including the cooling water systems were investigated over a period of 9 months (March–December 1999). There may also be a re-introduction of zebra mussels to Europe from areas where the mussel was transmitted several decades ago (e.g. Great Lakes and Mississippi River basin) with shipping.

The opening of several oceanaria / public aquaria along German coast has lead to the transfer and introduction of numerous species. Coastal aquarium systems operate with pre-treated water, taken from the Sea. Inland aquaria depend on artificial sea water.

## 3.7 Iceland

No information available.

## 3.8 Ireland

Earlier imported species were continuously cultured in 1992, including *Haliotis discus hannai*, *H. tuberculata* and *Ruditapes semidecussata*. The Manila clam *Ruditapes* semidecussata *( = Tapes philippinarum)* was cultivated on all Irish coasts. Seed was produced in Irish hatcheries and supplemented with importations from Guernsey, United Kingdom and Norway.

During the entire reporting period cultivation of *Crassostrea gigas* took place on all Irish coasts and production exceeded that of the native oyster and oyster imports are recorded on an annual basis from United Kingdom and France. The majority of seed imports are from Guernsey and the United Kingdom. Cultivation takes place on all Irish coasts with the main production from Carlingford Lough (east coast) and Dungarvan Bay (south coast). In 1993 a number of non-native species, including the oyster parasitic copepods *Mytilicola orientalis* and *Myicola orientalis* have been released into Irish waters from France in shipments of half-grown Pacific oysters. Pacific oysters examined in 1999 from Dungarvan Bay had the gut parasite *Mytilicola orientalis* present. The species became establishes following imports of half-grown Pacific oyster in 1993. No samples from this area were examined in 2000, the species may still be present there. The species *Myicola ostraea* was found in Pacific oysters from the same region in 1999. In 2000 large numbers of a gill copepod were found in Pacific oysters in Cork Harbour. In areas with highest copepod frequencies there was an undulating gill condition present. Irish oyster growers continue to be advised against bringing in half-grown oysters because of the high risk of importing unwanted biota and that some samples of imported seed would continue to be examined. Summer mortalities result in some losses in the late summer and were recorded from the Irish south coast in 2001. The gill condition, found in the native oyster (*Ostrea edulis*) in 2001 from Cork Harbour, was noted in Pacific oysters in 2002 in both Cork and Waterford Harbours and may affect growth.

The Japanese scallop *Patinopecten yessoensis* was introduced to Ireland following requests by an Irish fish and shellfish processor to cultivate the species on the south-east coast of Ireland. The earliest discussions took place in late 1988 at which time it was agreed to follow the procedure set forth in the revised ICES Code of Practice of 1988. The use of the Code was rigorously tested and was subsequently modified based on the experience of this introduction. Two WGITMO meetings in 1989 and 1990 were required before the modified project was approved. Progress reports were submitted at following annual meetings of the WGITMO and continued until 1994. Seventy-one specimens of *Patinopecten yessoensis* were imported from Japan. They were held in quarantine and following spawning were destroyed. *Patinopecten yessoensis* were held in lantern nets off the southeast coast of Ireland. In 1994 the project was terminated, the longline holding the F1 broodstock was torn from its moorings in a storm. The longline was recovered but all of the scallops were dead.

In 1994 the slipper limpet *Crepidula fornicata* and the polychaete worm *Terebella lapidaria* have been released into Irish waters with half-grown Pacific oysters from France; in addition an anthozoan and a serpulid polychaete worm which were not known previously in Irish waters were released.

The zebra mussel *Dreissena polymorpha* arrived in Ireland in 1994 or perhaps 1993 and was rapidly spread through the navigable waterways as fouling on the hulls of boats. Annual monitoring surveys of the zebra mussel revealed increases of abundance in the northern lakes of the Shannon navigation. The zebra mussel has expanded its range into northern Lough Erne. It is now present throughout the Shannon and Boyle Rivers where small craft may pass. Small numbers were found in the winter of 1998/99 in the western region of the Grand Canal, which links the Shannon to Dublin. There are indications of increased water clarity in Loughs Derg and Ree and many dead shells of *Anodonta anatina* were found in Lough Derg with >1000 attached zebra mussels, these populations are likely to expire soon. Fouling of power plants and municipal water works was noted during the year. The public awareness campaign on advising anglers on the risks of transporting zebra mussels to lakes by overland transport appear to have been successful. Zebra mussels continued to spread during the entire report period.

An unapproved introduction of American oysters to Ireland from Long Island Sound was intercepted in air freight in 1997. The sample of 10kg contained the commensal pea crab *Pinnotheres ostreum* (5% prevalence), the slipper snails *Crepidula plana* and *Crepidula fornicata* were common (despite oysters being brushed and cleaned) and egg cases of the predatory oyster drill *Urosalpinx cinerea* were found. The intended recipient was anxious to develop a trade in Europe for American oysters. The risk is that American oysters although intended for human consumption would become re-laid somewhere in Europe and act as a vector for these pests and diseases MSX and *Dermoscystidium*.

Also in 1997 a consignment of 11 tonnes of rope-grown market sized mussels from the Venice Lagoon (Chioggio) were transported to Ireland for processing but were refused because these had spawned. The haulier disposed of the mussels on the shore within 0.5 km of an oyster farm. The sample obtained from the shore a week later was made up mainly of dead mussels, some live individuals have been subjected to histology. The shells of these mussels were clean.

A single consignment of 0.25 million scallops *Pecten maximus* were introduced 1997 from the west coast of Scotland.

The Chinese hat limpet *Calyptraea chinensis* which lacks a planktonic stage was probably spread to Ireland in the middle of the last Century with native oyster imports used for restocking Clew and Ballinakill bays (west coast of Ireland). The species has recently appeared in Eastern Galway Bay and was first noted in 1999 probably as a result of oyster movements from the bays where it was formerly established. A separate introduction to Cork

Harbour was noted in 2000 and has probably been established there for at least three years and may have come from Loch Ryan in Scotland.

## 3.9 The Netherlands

On an annual basis, the blue crab (*Callinectes sapidus*) is reported from the ports at Amsterdam, Hoek van Holland and Rotterdam. Four American blue crabs were caught in 1999. One female crab was carrying eggs and, as far as known, this is the second observation of an egg-carrying female in the Netherlands. However, it remains unclear whether or not the species was introduced on purpose or accidentally released from a holding tank. Ballast water realease was also suspected as introduction vector which is especially likely as the crabs were predominantly found in port regions where ballast water discharges frequently occur.

The Pacific oyster, *Crassostrea gigas* is well established and expanded in the Dutch Wadden Sea. *C. gigas* have spawned and successfully recruited for at least since 1996 in the Wadden Sea. Between 1995 and 1999 the *C. gigas* was found in at least 8 localities in the Dutch Wadden Sea. In southwestern Netherlands *C. gigas* was imported by fishermen during the 1960s. Wild grown *C. gigas*, however, became very abundant in Lake Grevelingen, in the Oosterschelde and in the Westerschelde. Recently, fishermen became concerned at the explosive rate of growth. In Lake Grevelingen *C. gigas* may become a competitor for food for the native flat oyster, *Ostrea edulis,* and the blue mussel, *Mytilus edulis*, both commercially cultured in this region. Low spatfalls of the native mussel, *Mytilus edulis*, in recent years are causing concern and may have triggered the success of *C. gigas*.

In 2000 *Perna* sp. was imported from Sweden and in 2002 *Strongylocentratus purpuratus* and *S. franciscanus* from Canada.

Large amounts of living American lobsters *Homarus americanus*, are imported for direct human consumption from the American and Canadian east coast. Similar to other North Sea and Baltic countries, the Netherlands are concerned about the escape and possible interaction of the American lobster, *H. americanus*, with the native lobster, *H. gammarus*.

The trade in marine pet fish and other aquarium species introduces a very large variety of animals from world wide sources. A comprehensive insight is at present lacking. Only Canada reported on a number of marine species exported to the Netherlands and sold alive here. Several live freshwater aquarium species were caught in Dutch inland waters.

## 3.10 Norway

Regulations of marine enhancement and sea ranching have been proposed and were evaluated. The Ministry of Fishery developed a schedule for review in the Parliament. An expert group considered the potential problems associated with the commercial import of ornamental fish and a report, including a number of recommendations, was drafted in September 1997. The report was evaluated by the Norwegian Ministry of Agriculture. From 1 January 1999, Norway is part of the EEA-agreement, and serves as a controlling body for imports from non-EC countries. Regulations of imports and exports have generally been harmonised with the EC-community, with some exceptions. Export/import for aquaculture or sea-ranching for the specified life-stages of the a certain number of species is allowed. In 2001 Norway reported that without permission from the department, nobody is allowed to import viable marine fish, shellfish, etc. for aquaculture or restocking purposes.

The Kamchatka king crab, *Paralithodes camtschatica*, originally introduced into Russian waters to the southern Russian Barents Sea over the period 1961–69 and became established. The subesquent spread resulted in an established population in Norway (see also relevant ICES Cooperative Research Report). In 1992 more than 200 specimens were reported in gillnet catches in the Varangerfjord in Finnmark county. One specimen weighed 5 kg. Some of the specimens were egg-bearing females. The increase in population and distribution is also observed in the long-line and net fisheries where crabs were taken as by-catch. This represents a number of practical problems for the fishermen, and a systematic collection of information from the fishery suggests that a significant fraction of the crab population is taken in this fishery. The investigations on the King crab in 1998 were made within the Varangerfjord and adjacent fjords, thus little reliable information on a westward migration is available. In 2000 the core area was still east of North Cape, but some westward migration has been reported. Also, th eyear 2002 was the first year with a regular commercial catch of the red king crab in Norway. The red King crab will be managed as a resource species rather than a feral species. *Paralithodes camtschatica* continued to spread over the entire report period. No decision has yet been made on how to prevent the species from migrating south and westwards.

*Crassostrea gigas* was introduced from France in 1970 in unknown quantities and is cultivatred since in one locality (western Norway) only. There have been no observations outside the cultivation facility.

Manila clams (*Tapes philippinarum*) were imported for aquaculture in 1986 to two localities. Although the cultivation was terminated, in one location large mature individuals have been found in open waters. The species seems to reproduce in the wild.

The slipper limpet (*Crepidula fornicata*) (unintentionally introduced from North America through oyster imports) was first detected in the wild environment in Denmark and Germany in 1872. The first specimen was found in 1962 in Norwegian waters at the Skagerak coast. Since then, several observations of this species have been reported, mainly in the Skagerak region. In summer, 1996, a new live individual was found at Kvitsoy, in the western part of Norway. This indicates an increase in the distribution area, in a western and northern direction.

The American lobster (*Homarus americanus*) was discovered in 1999 in southern Norway. During 2000 a network of collecting stations were established in southern Norway. Within December, 24 lobsters were collected, and 5 of these were confirmed to be *H. americanus* when studied by genetic tools. In addition to the 5 confirmed *H. americanus*, 3 specimens had morphological features resembling the American Lobster. Another confirmed specimen of the American lobster was found in 2001 in the Oslofjord, bringing the total numbers of confirmed cases up to 11 specimens. The introduction vector remains unclear, but escapes from live storage tanks seem likely. The potential interaction with the native lobster are of concern.

## 3.11 Poland

No data on deliberate or accidental invertebrate introductions are known. However, the Chinese Mitten crab occurs in Polish waters and there seems to be a trend in increasing records since the end of the 1990s.

Imports of crustaceans and other marine organisms for aquaria continued but no detailed data are available at present.

## 3.12 Portugal

The only National Report received was submitted in 1992. The following invertebrate species were deliberately introduced from various sources: *Ruditapes philipinarum*, *Crasosstrea gigas*, Pecten *maximum* and *Ostrea edulis*. For direct human consumption *Cancer pagurus*, *Maja squinado*, *Panullirus guttatus*, *Jasus lalandi*, *Penaeus japonicus* and *Homarus americanus* were imported from France, United Kingdom and the United States. According to the 1995 Irish National Report *Crassostrea gigas* and *Tapes philippinarum* were inported to Portugal from Ireland and in 1998 the Pacific oyster and *Tapes decussatus* were imported from France.

It was also reported that freshwater crayfish were accidentally introduced and may have reached the Guadiana River by secondary spread from Spain.

Portugal reports that the clam Ruditapes *decussatus* and the sea urchin *Paracentrotus lividus* were exported to France in unknown quantities.

## 3.13 Spain

Spain submitted three National Reports (1992, 1993 and 2001). The introduction of macroalgae is of primary concern in Spain (see relevant section in this report).

For aquaculture purposes Crassostrea *gigas* was imported from the United Kingdom in 1992 and 1993, *Penaeus japonicus* in 1998 from France and *Perna* sp. 2000 from Sweden.

## 3.14 Sweden

Since the early 1990s American lobsters were introduced in unknown quantities from USA and Canada. In 2001, a lobster resembling the American lobster was caught.

Oyster imports from France are reported since 1995.

The Chinese mitten crab *Eriocheir sinensis* was reported several times during the summer and early autumn of 1998 from Swedish coastal and inland waters (Kungsbackafjorden, S of Göteborg, in the Hanö Bight in the southern Baltic proper, the island of Lisö in the archipelago south of Stockholm, the northern Baltic proper and in Vänersborg at lake Vänern). On the Swedish coast of the Bothnian Sea it appears very rarely. Lately it seems to be found more frequently across the Gulf of Bothnia, around the Finnish town of Jakobsstad probably due to the increase in the ferry traffic with Bremerhaven, Germany, where there has been one ship arriving each 10 days. The Mitten crab turned up in 1994 and now it has been encountered quite often and kept in aquaria by schools.

## 3.15 United Kingdom

Seed of *Crassostrea gigas* and *Tapes philippinarum ( = Ruditapes semidecussata)* were planted out for commercial cultivation in the early 1990s. Although these species are not released for the purpose of establishing self-sustaining populations, there is evidence that in recent warm summers natural settlement of *C. gigas* has occurred in the River Teign and in the Menai Strait area of North Wales. Numbers of naturally-settled seed are low, but there has been natural recruitment of the Pacific oyster *Crassostrea gigas*.

In 1992 there was an article in the *London Times* newspaper (26/8/92) about giant Japanese whelks (*Rapana venosa*) that were said to have been brought up in a lobster pot from the bed of the North Sea, south of Dogger Bank and about 20 miles out. It was speculated that the whelks could have been carried as eggs from the Black Sea on the hull of a ship. The most recent information is that the find was in fact a hoax. However, living *Rapana* were found later in the region (see the relevant ICES Cooperational Research Report).

As reported 1993, several species are in current commercial practice, including lobsters (*Homarus americanus*) mainly from Canada and the USA; oysters from Ireland, Denmark, France, the Netherlands, Chile, Japan, China and Hong Kong; Scallops (*Pecten*, *Chlamys*, *Placopecten*) from France, China and the USA, and in smaller quantities from the Netherlands, Spain, and Ireland; Mussels (*Mytilus*) from Ireland and the Netherlands. Live American lobsters were imported each year for direct human consumption during the reporting period.

Some *Crassostrea gigas* and *Tapes philippinarum* seed were imported from Guernsey for cultivation, but the industry relied mainly on seed produced in England. The beds of wild Manila clams in Poole Harbour that have become established after the successful recruitment of seed from intentional introductions for aquaculture purposes were fished on a limited commercial basis. Approximately 40 tonnes of clams were fished. As a result of a local management plan, there is some control of this new fishery.

Squid (*Loligo* spp., *Omnastrephes sagittatus*) were imported from France. Other imports included saltwater ornamentals and sea urchins.

*Eriocheir sinensis*, the Chinese mitten crab, has been reported in the River Thames since 1935. Since the 1930s, their numbers in the Thames have increased significantly. From surveys carried out by the Environment Agency since early 1998, it has been shown that burrows are present at every suitable site from Grays in Essex to Richmond half tide weir, which is a distance of 63 km. The crabs dig and use burrows even when there is no tidal cycle and burrows are permanently submerged. Up to 28 burrows per square metre have been found and it was believed that burrows were less than one year old. This is the first evidence of burrowing behaviour from the British Isles. The burrows are reported to have caused considerable damage by weakening the bank structure and causing areas of bank to collapse. Chinese mitten crabs have also been found in other estuaries along the east England coast, from the River Tyne in the north to the River Rother on the southern Kent coast.

During the mid 1990s UK imported 4 tonnes of wild-caught marine ornamentals (equivalent to 350 000 individuals) annually. Trade involves around 1000 species.

## 3.16 United States of America

As noted in the National Reports of the U.S. and Canada over the past several years, the European zebra mussel *Dreissena polymorpha* was discovered by biologists in the Great Lakes, North America, in June 1988 in Lake St. Clair. It is now known that it was earlier observed by a fisherman in December 1987 in Lake Erie. It is believed to have been introduced about 1985–1986. The zebra mussel is now in the major river drainages leading out of the Great Lakes, including the Mississippi, Illinois, Ohio, Tennessee, Arkansas, Hudson, and Susquehanna River systems. In the "first 1000 days" since its escape from the Great Lakes, it has entered 18 U.S. states. In January 1993 it was first detected in eastern Oklahoma. No significant new jumps of the zebra mussel's range have been reported since spring 1994. The zebra mussel, now recognized as consisting of two different species in North America, *Dreissena polymorpha* and *Dreissena bugensis*, continues to fill in many rivers and lakes within its reported range, which now extends into Oklahoma, to the Gulf of Mexico coast in Louisiana, into Lake Champlain on the Vermont/New Hampshire border, and down the Hudson River. The spread of the zebra mussel continued during the entire reporting period.

In 1993 it was reported that the Pacific White Shrimp *Penaeus vannamei* have been taken in high numbers during commercial shrimp hauls off South Carolina. All are believed to result from aquaculture facility escapes, and the establishment of reproducing populations has not yet been demonstrated, although a sexually mature male was collected.

The newest and most startling discovery of an introduced aquatic organism in the U.S. was in November 1994 when specimens (male and ovigerous females) of the Chinese mitten crab *Eriocheir sinensis* were brought to the California Academy of Sciences (San Francisco), having been captured in trawl nets in the southern end of San Francisco Bay. It was later determined that shrimp fishermen had seen the crab as early as 1992. Numerous specimens collected in the fall of 1994 and the winter-spring of 1995 represent at least 2 distinct year classes; ovigerous females are common, and readily produce swimming larvae in laboratory aquaria. Upon this basis, it appears that *Eriocheir* has at long last become established in North America. The Chinese mitten crab has been collected irregularly between the 1970s and the spring of 1994 in the Great Lakes (largely Lake Erie), always as individual, relatively large crabs. All of these are held to be the result of larvae or juvenile crabs having been released in the Lakes some years earlier by ballast water. Being a catadromous species *Eriocheir* cannot establish in the Great Lakes. However, the large stream and river systems of San Francisco Bay provide the habitat necessary for a catadromous life style.

*Eriocheir* is recognized as a burrower in river banks, and thus there is some concern for the 1000 and more kilometers of dikes that pepper the vast agricultural lands of the San Francisco Bay Delta system (the Sacramento and San Joaquin River systems). In addition, *Eriocheir* is the second intermediate host of the Oriental lung fluke; primary hosts, aquatic snails, were already presented in California having been introduced earlier from Asia. *Eriocheir* thus completes the lung fluke's cycle in America. The potential trophic effects of the Chinese mitten crab on the Bay are unknown. The latter question is particularly complex given the wave-upon-wave of invasions that sequentially destabilize and restructure the Bay's food webs, including the preceding invasions of the Chinese clam *Potamocorbula amurensis* (discovered in 1986) and the European shore (green) crab *Carcinus maenas* (discovered in 1990/91).

How *Eriocheir* arrived in the Bay is not clear. The two primary potential mechanisms are (1) ballast water release, and the concomitant release of larvae or juveniles directly from China or Korea and (2) the release of adult crabs from the "live food industry". While the importation of living Chinese mitten crabs is prohibited under both federal U.S. law and under California law, Customs inspectors at large West Coast airports (such as Los Angeles, San Francisco, and Seattle) regularly intercept and impound living crabs that are being brought in either for private consumption or to be sold at Asian markets. The crab is sufficiently popular in Asia as a food item that its release in San Francisco Bay was to be expected. The Chinese mitten crab is now well established and continues to expand its range within San Francisco Bay, California. A single specimen was reported to have been captured in the Columbia River in 1997.

The commercial shellfish industry continues to culture and release of multiple non-native invertebrate species. Along the Pacific coast, these species include the oyster *Crassostrea gigas*, mussel *Mytilus galloprovincialis,* and clam *Venerupis philippinarum*. Non-native species cultured and released along the Atlantic coast include *Ostrea edulis*. Use of these species for fisheries represents an on-going activity.

In 1997 it was reported that *Ostrea edulis* continues to expand range on the American Atlantic coast and continues to spread. Intentional plantings in the 1940s resulted in small permanent populations in the State of Maine. However, since the late 1980s, established populations have been reported in Rhode Island and more extensively along the Maine coast. About 1996, *Ostrea edulis* was reported from the Great Bay Estuary, New Hampshire.

In June 1998 the first specimens of the large, clam-eating Asian whelk *Rapana venosa* were found in lower Chesapeake Bay. This species was earlier introduced to the Black Sea and the Mediterranean Sea, from where it may have arrived to America. *Rapana* is considered to be established in the Chesapeake Bay with a potential to spread further (see relevant ICES Cooperational Research Report).

In 2000, the Virginia Marine Resources Commission was approached with a request from a Virginia oyster industry group to undertake an experimental study with the Japanese oyster *Crassostrea ariakensis.* These will be individually certified triploids from F1 ICES-protocol parents which were quarantined in the Virginia Institute of Marine Sciences hatchery at Gloucester Point, Virginia. A time-limited trial was arranged, with a lengthy list of prerequisites and protocols to be followed. In addition, limited experiments are being conducted to test the performance of the *Crassostrea ariakensis* in Chesapeake Bay waters. The proposed tests will use triploid oysters, and each individual is to be tested for triploidy prior to the tests. Eventually limited field trials were used to test performance of non-native oysters in Chesapeake Bay waters as reported in 2002. Proponents for development of this fishery are expected to submit a multi-year proposal for further evaluation and development of a *C. ariakensis* fishery. In 2002 the proposal was evaluated by an ad-hoc review committee of the EPA Chesapeake Bay Program. The review committee recommendations are advisory in nature, and Virginia will make final decisions on the scope and tempo of this effort. A similar proposal is requested to be submitted simultaneously by the proponents to ICES, serving as the prospectus called for by the ICES Code of Practice.

## 3.17 Australia

Australia has observer status and submitted National Reports in 1998 and 2002. The National Report provided in 1998 deals exclusively with ballast water mediated species introductions. In 2002 Australia reports that mariculture operations continue to result in spawning release of oyster (*Crassostrea gigas*) spat in Tasmania, New South Wales, and South Australia, and blue mussel (*Mytilus galloprovincialis*) spat in Western Australia, South Australia, Victoria, Tasmania, and New South Wales. No new deliberate releases of marine species have been reported in 2001/02. Information on live imports and exports to ICES Member Countries as well as on planned introductions of non-indigenous species were unavailable.

## 3.18 Italy

Italy has guest status and provided detailed National Reports in 1998 and 2000–2002. The main invertebrate species introduced in the open environment for fishery are the bivalves *Crassostrea gigas* and *Tapes philippinarum*. *Crassostrea gigas* was introduced in 1960 in the Northern Adriatic from Atlantic cultures. It is now largely widespread, colonizing all the Northern Adriatic lagoons, having supplanted the native *Ostrea adriatica* (=*edulis* ?) whose populations were already rather scanty.

*Tapes philippinarum* in some cases is cultivated in ponds, without control of possible release to the open environment, but in the majority of cases it has been seeded deliberately in open waters. It was first introduced in 1983 as an experiment in one island outside Venice and was subsequently seeded over large areas of the main Northern Adriatic Lagoons. The catch of the Japanese clams has since then increased, supplanting the catch of the native clams such as *Tapes decussatus* and *Venerupis aurea*, whose populations had been declining already before the introduction. The clam *Tapes philippinarum* (Adams and Reeve) has substituted the indigenous species *Tapes decussatus* (L.) in most areas of the central and northern Adriatic Sea; the same occurred with the oyster *Crassostrea gigas* against *Ostrea edulis* and in some locations the native oyster is now absent.

The whelk, *Rapana venosa* (Mollusca Gastropoda), is known in the Northern Adriatic since 1973. It is widespread along the Northern Adriatic coast (including the lagoon of Venice), both on the Italian side and the Slovenian coast (1997). One specimen has also been found near Elba Island in the Tyrrhenian Sea. The large population in the Northern Adriatic Sea is generally considered to have had no major detrimental effect. The gradual but sustained nature of this range expansion suggests that *Rapana* has yet to exploit all susceptible locations within the Mediterranean. It is believed that *Rapana* was introduced with oyster imports. No damage to the mussel cultures or exploited clam beds has been reported (see also relevant ICES Cooperational Research Report).

The lobster, *Homarus americanus*, is imported live for consumption and held in aquaria until consumption. Requests for using this species for restocking the natural populations of *Palinurus vulgaris* have been repeatedly put forward by fishermen or divers associations.

In 2001 Italy reports that the crayfish *Penaeus japonicus,* as well as *Penaeus monodon* and *Penaeus vannamei,* are reared in ponds using semintensive systems, but only once they have been recorded in an open habitat. A *P. monodon* introduction was planned under controlled and restrictive condition for semi-intensive rearing in pond. The introduction of this species has underlined the risk of introducing pathogen agents such as the *Baculovirus*, a pathogen to be notified to the OIE (Office International Epizooties) when using larvae and postlarvae. Fertilized eggs are preferred for importation to reduce the risk of disease.

In 2002 Italy reports that *Tapes* philippinarum has been released in the brackish coastal Lake Fusaro (near Naples).

**Annex 1. Qualitative data on deliberate introductions and transfers and live imports and transfers of non-native invertebrate species (excluding species movements within one country) extracted from National Reports considered at WGITMO Meetings 1992-2002. ← = imported from (source region indicated when available), WC = west coast, EC = east coast, Be = Belgium, Ca = Canada, De = Denmark, E&W = England & Wales, Fi = Finland, Fr = France, Ge = Germany, Ir = Ireland, It = Italy, Ne = Netherlands, No = Norway, Po = Portugal, Sc = Scotland, Sp = Spain, Sw = Sweden, USA = United States of America. Information gaps refer to unavailable National Reports.**

## Atlantic seaboard of North America

| Recipient country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada | *Limolus polyphemus* ←USA (EC) | *Lytechinus pictus* ←USA (WC)<br><br>*Mytilus edulis* ←Ir<br><br>*Strongylocentrus droebachiensis* ←USA (WC)<br><br>*Strongylocentrus purpuratus* ←USA (WC) | *Placopecten magellanicus* | *Mercenaria mercenaria* ←USA (EC)<br><br>*Mytilus californianus* ←USA (WC)<br><br>*Placopecten magellanicus*<br><br>*Rhepoxynius abronius* ←USA (WC)<br><br>*Strongylocentrus purpuratus* ←USA (WC) | *Crassostrea virginica,*<br><br>*Lytechinus pictus* ←USA (WC)<br><br>*Macoma nasuta* ←USA (WC)<br><br>*Mercenaria mercenaria,*<br><br>*Mytilus edulis,*<br><br>*Placopecten magellanicus,*<br><br>*Rhepoxynius abronius* ←USA (WC)<br><br>*Strongylocentrus purpuratus* ←USA (WC) | *Crassostrea virginica,*<br><br>*Lytechinus pictus* ←USA (WC)<br><br>*Mercenaria mercenaria,*<br><br>*Mytilus edulis,*<br><br>*Ostrea edulis* | *Argopecten irradians* ←USA (WC)<br><br>*Crassostrea virginica,*<br><br>*Mercenaria mercenaria,*<br><br>*Mytilus edulis,*<br><br>*Ostrea edulis,*<br><br>*Placopecten magellanicus* | *Argopecten irradians* ←USA (WC)<br><br>*Crassostrea virginica,*<br><br>*Mercenaria mercenaria,*<br><br>*Ostrea edulis,*<br><br>*Placopecten magellanicus,* | *Argopecten irradians* ←USA (WC)<br><br>*Crassostrea virginica,*<br><br>*Mercenaria mercenaria,*<br><br>*Ostrea edulis,*<br><br>*Placopecten magellanicus* | *Argopecten irradians* ←USA (WC)<br><br>*Crassostrea virginica,*<br><br>*Mercenaria mercenaria,*<br><br>*Ostrea edulis,*<br><br>*Placopecten magellanicus* | *Crassostrea virginica,*<br><br>*Haliotis rufescens* ←Iceland<br><br>*Ostrea edulis* |
| USA | | | *Crassostrea gigas* | | | | | | | *Crassostrea ariakensis,*<br><br>*Ostrea edulis* | *Crassostrea ariakensis,*<br><br>*Ostrea edulis* |

## Atlantic seaboard of south west Europe

| Recipient country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Portugal | *Crassostrea gigas* ←Sp<br>*Homarus americanus* ←UK/Fr<br>*Penaeus japonicus,*<br>*Ruditapes philippinarum* ←Sp | | | *Crassostrea gigas* ←Ir<br>*Tapes philippinarum* ←Ir | | | *Crassostrea gigas* ←Fr<br>*Tapes decussatus* ←Fr | | | | |
| Spain | *Crassostrea gigas* ←E&W | *Crassostrea gigas* ←E&W | | | | | *Penaeus japonicus* ←Fr | | *Perna* sp. ←Sw | | |
| France | *Crassostrea virginica* ←E&W | *Crassostrea gigas* ←Ir<br>*Crassostrea virginica* ←E&W | | *Crassostrea gigas* ←E&W, Ir, Ne<br>*Patinopecten yessoensis* | | *Crassostrea gigas* ←E&W, Ir, Po | *Crassostrea angulata* ←Guyana<br>*Crassostrea gigas* ←E&W, Ir, Ne, Po<br>*Crassostrea rhizophorae* ←Guyana<br>*Penaeus japonicus* ←Sp<br>*Tapes philippinarum* ←It<br>*Tiostrea chilensis* ←Guyana | *Crassostrea gigas* ←E&W,<br>Ir, Ne, Po | *Crassostrea gigas* ←E&W, Ir, Ne, Po<br>*Haliotis discus hannai* ← Ir | *Crassostrea gigas* ←E&W, Ir, Ne, Po | clams ←It, Ne<br>*Crassostrea gigas* ←E&W,<br>Ir, Ne, Po<br>mussels ←Sp |

## North west Europe

| Recipient country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ireland | *Crassostrea gigas* ←E&W, No<br>*Patinopecten yessoensis* ←Japan<br>*Tapes philippinarum* ←E&W | *Crassostrea gigas* ←E&W<br>*Tapes philippinarum* ←E&W, No | *Crassostrea gigas* ←E&W, Fr<br>*Tapes philippinarum* ←E&W | *Crassostrea gigas* ←E&W, Fr<br>*Tapes philippinarum* ←E&W | *Crassostrea gigas* ←E&W, Fr<br>*Tapes philippinarum* ←E&W | *Crassostrea gigas* ←E&W, Fr<br>*Tapes philippinarum* ←E&W | *Crassostrea gigas* ←E&W, Fr<br>*Tapes philippinarum* | *Crassostrea gigas* ←E&W,Fr | *Crassostrea gigas* ←E&W, Fr | *Crassostrea gigas* ←E&W, Fr | *Crassostrea gigas* ←E&W, Fr |
| Scotland | *Crassostrea gigas* ←E&W | *Crassostrea gigas* ←E&W | *Crassostrea gigas* ←E&W<br>lobsters ←Ca | *Crassostrea gigas* ←E&W | | | | | | | |
| England & Wales | *Homarus* sp. ←Ca<br>*Nucella lapillus* ←USA | lobsters ←Ca, USA | lobsters,<br>*Perna* sp. | | *Crassostrea gigas* ←Ir | | | *Homarus americanus* ←Ca | *Homarus americanus* ←Ca | *Haliotis tuberculata* ←Ir<br>*Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←Ir<br>*Haliotis tuberculata* ←Ir<br>*Homarus americanus* ←Ca, USA |
| Belgium | | | | | | | | | *Perna* sp. ←Sw | *Crassostrea gigas* ←Ca, Fr<br>*Cyrtodaria siliqua* ←Ca<br>*Homarus americanus* ←Ca<br>*Mercenaria mercenaria* ←Fr?<br>*Spisula polynyma* ←Ca<br>*Tapes philippinarum* ←Fr? | *Crassostrea gigas* ←Ca, Fr<br>*Homarus americanus* ←<br>*Mercenaria mercenaria* ←<br>*Tapes philippinarum* ← |

| **Recipient country** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Netherlands | | | | | | | | | *Perna* sp. 🡐Sw | *Homarus americanus* 🡐Ca (EC), USA (EC) | *Strongylocentratus purpuratus* 🡐Ca<br>*Strongylocentratus franciscanus* 🡐Ca |
| Germany | | | *Crassostrea gigas* 🡐Ir | | | *Crassostrea gigas* 🡐Ir | *Crassostrea gigas* 🡐Fr, Ir<br>*Homarus americanus* | *Callinectes sapidus* 🡐<br>*Crassostrea gigas* 🡐Ir<br>*Homarus americanus* | *Homarus americanus* 🡐Ca | *Callinectes sapidus* 🡐<br>*Homarus americanus* 🡐Ca | *Callinectes sapidus* 🡐<br>*Crassostrea gigas* 🡐Ir<br>*Homarus americanus* |
| Denmark | | | | | | | | | *Perna* sp. 🡐Sw | | |
| Norway | | *Crassostrea gigas* 🡐Fr | | | | | | | *Perna* sp. 🡐Sw | *Homarus americanus* | |

## Baltic Sea

| Recipient country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Finland | freshwater crayfish ←Russia, USA<br>*Pacifastacus leniusculus* ←Sw | freshwater crayfish ←Russia, USA<br>*Pacifastacus leniusculus* ←Sw | freshwater crayfish ←Russia, USA<br>*Pacifastacus leniusculus* ←Sw | | | | | *Pacifastacus leniusculus* ←Sw | *Perna* sp. ←Sw | | |
| Sweden | *Crassostrea gigas* ←Fr<br>*Homarus americanus* ←Ca, USA | *Homarus americanus* ←Ca, USA | *Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←Fr<br>*Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←Fr<br>*Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←Fr<br>*Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←Fr<br>*Homarus americanus* ←Ca, USA | *Crassostrea gigas* ←De, Fr, Ir, Ne, No<br>*Homarus americanus* ←Ca, USA<br>*Perna* sp. ←De, Ne, No, New Zealand | *Homarus americanus* ←Ca, USA<br>*Perna* sp. ←De, Ne, No | *Homarus americanus* ←Ca, USA | *Homarus americanus* ←Ca, USA |

## Mediterranean Sea

| Recipient country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spain | no data available for the Mediterranean coast | | | | | | | | | | |
| France | no data available for the Mediterranean coast | | | | | | | | | | |
| Italy | | | | | | | | | *Cancer pagurus,*<br>*Glycera dibranchiata,*<br>*Homarus americanus,*<br>*Jasus ialandi,*<br>*Panulirus sp.,*<br>*Perinereis vancaurica* | *Penaeus japonicus,*<br>*Penaeus monodon,*<br>*Penaeus vannamei* | *Tapes philippinarum* |

# 4 FISHES

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## 4.1 Introduction

In this review the reported activities to the Introductions and Transfers of Marine Organisms Working Group are accounted. This has taken place annually over the period of this report, 1991 to 2002. The condensed account is arranged according to geographical area and it should be noted that not all activities have been included on account of the small representation of fish biologists attending each meeting. Records of imports and of movements recorded using a common or local name that could relate to more than one species or inaccurate recording have been deleted to avoid confusion. The majority of fish movements recorded were of salmonids. Egg movements flown out to various world regions were composed mainly of Atlantic salmon and rainbow trout. These movements have enabled aquaculture development in places such as Chile. In Europe recent developments in sturgeon culture have led to records of vagrant specimens over a wide area. For other species and of note are the conditions laid down for the culture of hybrid striped bass in an enclosed system.

Precautionary measures in the management of fish in transit need to be considered as recommended under the recent revision of the ICES Code of Practice 2002. Scientific and common names of fishes used in this account are recorded in Tables at the end of this chapter.

Summary tables for fishes moved for aquaculture and stocking (Table 3.1), for research purposes, including fishes transported alive for human consumption (Table 3.2) and unintentionally and unauthorised releases (Table 3.3) are shown at the end of this chapter.

### 4.1.1 Introduced species in the different regions

#### *4.1.1.1 Salmonid movements*

The principal pathways of transmission take place within either North America or Europe and relate to stocking or aquaculture. Salmon and rainbow trout are moved between all continents except Antarctica (Table 3.4). Movements normally consists of developing eggs transported by plane to hatcheries where they are reared until of sufficient size in supporting either aquaculture and stocking programmes. Eggs come from approved hatcheries, being disinfected prior to departure. Several millions of eggs are moved each year. Local transmissions tend to be of young fish. All transmissions from within North America or Europe require health certification and this greatly reduces the consequences of introducing unwanted diseases. There has been an increased awareness that non-native salmonids are likely to compete with native species and these impacts are of concern. There have been many salmonid releases for the purposes of stocking such as those taking place in the Baltic Sea for salmon, trout and lake whitefish.

**Table 3.4. Movements of salmonids over the period 1991-2002.**

| SPECIES | ORIGIN | DESTINATION |
|---|---|---|
| *Oncorhynchus mykiss* | Canada, Denmark, Isle of man, Northern Ireland, South Africa | USA |
| | Czech Republic, Denmark, The Netherlands, Poland | Germany |
| | Denmark, Isle of Man, Northern Ireland, Isle of Man, South Africa, Tasmania | Ireland, UK |
| | Denmark, I of Man, Northern Ireland, Scotland, South Africa | Ireland |
| | England | Denmark, Isle of Man, Northern Ireland, |

| | | |
|---|---|---|
| | | South Africa, Tasmania |
| | Finland | Chile, Estonia, Portugal, Russia |
| | Germany | Austria |
| | Poland | Russia |
| | Sweden | Austria, Bulgaria, Chile, Croatia, Czech Republic, Estonia, Finland, Greece, Israel, Spain, Norway, Montenegro, Portugal, USA |
| *O. tshawytscha* | Canada | Japan |
| | Sweden | Greece, Norway, Taiwan, Turkey |
| *Salmo salar* | Canada | Chile, USA |
| | Denmark, Iceland, Norway, Sweden, Tasmania, | Ireland |
| | England | Sweden |
| *Rainbows?* | Estonia | Cyprus, Luxemborg, Marshall Islands, St Vincent and the Grenadines |
| | Finland | Norway, Shetlands |
| | Ireland | Belgium, Chile, Denmark, England, France, Germany, Northern Ireland, Scotland, Spain, Wales |
| | Latvia | Poland |
| | The Netherlands | Chile |
| | Norway | Chile, China |
| | Scotland | Ireland, Tasmania |
| | Sweden | Denmark, Germany, Finland, Taiwan |
| | UK | Brazil, Chile, Denmark, Ireland, Morocco, Northern Ireland |
| *Salmo trutta* | Ireland | Luxemborg |
| | UK | Jersey, Turkey, Mexico, South America |
| *Salvelinus alpinus* | Canada | China, France, Germany, Ireland, Scotland, USA |
| | Canada | UK |
| | Iceland, Sweden | Ireland |
| | Ireland | England |
| | Sweden | Canada, Estonia, Finland, Germany |
| *S. alpinus x S. fontinalis* | Canada | Germany, France, USA |
| *Salvalinus fontinalis* | Canada | France, Italy, USA |
| *Salvelinus naymacush* | Canada | USA |

#### *4.1.1.2 Increased interest in sturgeon*

There are several species of sturgeon in culture in areas beyond their native range. These fish generally have long life spans. However, as a result of their late maturation, deterioration of spawning habitats and overfishing their populations have greatly declined. This has resulted in attempts to supplement the lack of natural recruitment through hatchery-produced stocking and this has produced highly variable results. Their use in aquaculture has also developed significantly over the last two decades. Farms have produced sturgeon for food and attempted to produce caviar and ornamental fish for ponds. Some species have been imported as aquarium species to Europe. Escapes from aquaculture pond operations together with deliberate releases from small private ponds, once fish become to large, account for occasional captures from the wild. Experimental studies on hybridisation such as the bester (*Huso huso* x *Acipenser ruthenus*) hybridise easily under culture conditions. Despite different species co-occurring in the wild they do not appear to freely hybridise in the wild. Yet natural hybridization has occurred and the potential for natural cross-breeding exists from releases and may be damaging to those populations whose populations are reduced and endangered.

In December 1999, a storm resulted in the flooding of a sturgeon culture facility on the banks of the Gironde, France, resulting in a loss of over 20% of the stock of *Acipenser baerii* . Local fishermen were employed to recapture escapees on account of concerns in relation to possible habitat competition and interbreeding with the highly endangered native population of *Acipenser sturio*.

In a further case, the appearance at one locality in North America several specimens of the Russian shovelnose sturgeon *Scaphirhynchus platorynchus* were found and removed from the wild because of similar concerns that these could provide competition for native species.

There has been a marked increase in the number of released or escaped specimens reported in German waters over the period 1991 to 2000 (315 fish) compared with 1981–1990 (23 fish), the majority of these captures were in estuarine and coastal waters and large rivers (90%). These are made up of *Acipenser baerii* (44%) and *A. ruthenus* (4%), with the remaining fish not identified to species level.

The restoration of *Acipenser sturio* in Europe is dependant on habitat restoration and requires their survival over several decades in order for the population, based on hatchery releases becoming re-established.

The management, development and restoration of world sturgeon populations are supported by the recently established World Sturgeon Conservation Society (based in Germany: http//:www.wscs.info).

#### *4.1.1.3 Aquarium and pond fishes*

The interest in ornamental fishes for ponds, such as koi carp, has increased in the last decade and many garden centres sell koi and other temperate species directly to the public. This now includes sturgeon.

Aquarium fish imports rely on captures of wild fishes of which ca 1000 species are imported to Europe. These imports are channelled through centres such as one near Heathrow Airport, London, England. This centre also has a breeding programme involving about twelve species that includes the anemone fishes *Amphiprion* spp. In 1992 this involved imports from 23 countries that included: France, The Netherlands, Denmark, USA, Costa Rica, Brazil, Barbados, Egypt, Saudi Arabia, Dubai, Kenya, Australia Singapore, Thailand, The Maldives, Sri-Lanka, The Philippines, Indonesia, Fiji and The Cook Islands. The centre uses water from a borehole and sea-salt preparations. Examples of some of the fish imports appear in Table 3.5.

Similar centres, such as in Germany, import both fresh and saltwater fishes and it is likely that there are millions of fish imported each year principally from South America and south-eastern Asia. In 1980 the estimated biomass of imports was 60mt, whereas in 2000 105mt of freshwater fish and 45 mt of marine fishes were imported.

**Table 3.5. Some of the aquarium and pond cultivated species in transmission. Note there are probably >1000 species in transmission.**

| Species | Common name | Source | Destination | Purpose |
|---|---|---|---|---|
| *Anarhichas ocellatus* | spotted wolffish | Canada | Portugal | marine aquaria |
| *Anarhichas ocellatus* | spotted wolffish | Canada | The Netherlands | |
| *Balantiocheilos melanopterus* | silver 'shark' | Singapore | Ireland | freshwater aquaria |
| *Betta splendens* | Siamese fisghting fish | Singapore | Ireland | freshwater aquaria |
| *Botia morleti* | horae botia | Singapore | Ireland | freshwater aquaria |
| *Brachydanio albolineatus* | pearl danio | Singapore | Ireland | freshwater aquaria |

| SPECIES | COMMON NAME | SOURCE | DESTINATION | PURPOSE |
|---|---|---|---|---|
| *Carassius carassius* | goldfish | Malaysia | Ireland | freshwater aquaria |
| *Cichlasoma everum* | severum cichlid albino | Singapore | Ireland | freshwater aquaria |
| *Colisa lalia* | golden gourami | Malaysia | Ireland | freshwater aquaria |
| *Corydoras aenus* | aenus cory | Malaysia | Ireland | freshwater aquaria |
| *Ctenopharyngodon idella* | grass carp | unknown | Finland | pond |
| *Cyprinus carpio* | koi carp | Malaysia | Ireland | freshwater aquaria |
| *Gymnocorymbus ternetzi* | black tetra | Singapore | Ireland | freshwater aquaria |
| *Haplochromis spp* | cichlids | Singapore | Ireland | freshwater aquaria |
| *Hemigrammus erythrozonus* | glowlight tetra | Malaysia/Singapore | Ireland | freshwater aquaria |
| *Hemigrammus ocellifer* | head and tail light | Singapore | Ireland | freshwater aquaria |
| *Hemilepidotus hemilepidotus* | red Irish lord | Canada | France | marine aquaria |
| *Hexagrammus decagrammus* | kelp greenling | Canada | France | marine aquaria |
| *Hydrolagus colliei* | spotted ratfish | Canada | France | marine aquaria |
| *Hyphessobrycon erythrostigma* | bleeding-heart tetra | Singapore | Ireland | freshwater aquaria |
| *Hyphessobrycon flammeus* | red-tail tetra | Singapore | Ireland | freshwater aquaria |
| *Hyphessobrycon herbertaxelrodi* | black neon-tetra | Singapore | Ireland | freshwater aquaria |
| *Hyphessobrycon herberxa* | black neon-tetra | Malaysia | Ireland | freshwater aquaria |
| *Labeo bicolor* | red-tail black 'shark' | Singapore | Ireland | freshwater aquaria |
| *Lepomis gibbosus* | pumpkinseed | Czech Republic | Ireland | ponds? |
| *Macropodius opercularis* | paradise fish | Singapore | Ireland | freshwater aquaria |
| *Osphronemus goramy* | pearl gourami | Singapore | Ireland | freshwater aquaria |
| *Paracheirodon axelrodi* | cardinal tetra | Malaysia | Ireland | freshwater aquaria |
| *Paracheirodon innesi* | neon tetra | Malaysia/Singapore | Ireland | freshwater aquaria |
| *Poecilia latipinna* | golden molly | Singapore | Ireland | freshwater aquaria |
| *Poecilia reticulata* | fantail guppy | Singapore | Ireland | freshwater aquaria |
| *Poecilia sphenops* | black molly | Singapore | Ireland | freshwater aquaria |
| *Pontius conchonius* | rosy barb | Singapore | Ireland | freshwater aquaria |
| *Pseudotrophaeus sp.* | cichlids | Singapore | Ireland | freshwater aquaria |
| *Pseudotrophaeus zebra* | golden zebra cichlid | Singapore | Ireland | freshwater aquaria |
| *Pterophyllum scalare* | golden angel | Malaysia | Ireland | freshwater aquaria |
| *Pterophyllum scalare scalare* | angel fish | Singapore | Ireland | freshwater aquaria |
| *Puntius sachsi* | neon golden barb | Malaysia/Singapore | Ireland | freshwater aquaria |
| *Rasbora heteromorpha* | harlequin rasbora | Malaysia/Singapore | Ireland | freshwater aquaria |
| *Rhodeus sericeus* | bitterling | Czech Republic | Ireland | freshwater aquaria |
| *Rocca saxatilis* | striped bass | Canada | USA | marine aquaria |
| *Sphaericthys osphromeniodes* | chocolate gourami | Singapore | Ireland | freshwater aquaria |
| *Thayeria boehlkei* | penguin | Singapore | Ireland | freshwater aquaria |
| *Trichogaster tricopterus* | golden gourami | Malaysia | Ireland | freshwater aquaria |
| *Trichogatser leeri* | pearl gourami | Singapore | Ireland | freshwater aquaria |
| *Xiphister mucosus* | monkey-face eel | Canada | Portugal | marine aquaria |
| *Xiphophorus helleri* | red platy | Singapore | Ireland | freshwater aquaria |
| *Xiphophorus maculatus* | red wagtail platy | Malaysia/Singapore | Ireland | freshwater aquaria |

In Germany at warm water discharges some aquaculture is practiced and this includes the production of ornamentals such as koi carp, goldfish and sterlet *Acipenser ruthenus*.

In the expanding trading block of the European Union (EU), the procurement of records is difficult to obtain as imports at one specific entry point within the EU requires documentation. The subsequent trade to other European destinations can not as a result be readily traced. The market in any EU country often includes movements from other European countries.

#### *4.1.1.4 Management of exotic species cultivation in closed re-circulating systems*

It is acknowledged that cultivation of an exotic species can lead to releases to the wild and that these releases may have impacts on native populations. Management of quality fish products in closed re-circulating systems is an industry that can supply a specialist market and is likely to evolve further. In the case of one example, in 1993, the planned introduction of striped bass *Rocca saxatilis* and white bass *Rocca chrysops* and their hybrids to a European culture facility from North America was under consideration by the WGITMO (ICES, 1994). This exercise provided a useful template for the introduction of an exotic fish species to closed re-circulating systems and should be considered together with improved knowledge gained in the meantime gained by WGITMO. In the bass proposal WGITMO did not oppose the introduction subject to the following conditions:

- An assessment will be carried out which addresses the operational and environmental aspects of the disposal of waste products , including dead fish, waste water and liquid manure. (The disposal of these products is to meet with the requirements of the relevant authorities).
- The facility will be constructed so that in the event of complete tank(s) failure all fish and water would be physically contained within the facility.
- A contingency plan will be prepared that addresses any and all identifiable potential accidental events that could lead to fish escape (such as the loss of fingerlings during transfer from the port of entry to the culture facility.
- Breeding stocks will be established within the culture facility as soon as possible by importing surface-disinfected eggs from parents that have been lethally sampled for bacteria, viruses and other potentially vertically transmitted organisms. These breeding stocks should be maintained within the site in isolation from fingerlings in culture.
- No live fish or viable gametes will leave the security of the site.

### 4.2.1 Atlantic seaboard of North America

#### *4.2.1.1 Salmonids*

There are frequent annual movements of eggs, fry and smolts of salmonids in the eastern Provinces of Canada and exports to the United States and elsewhere in the world (Table 3.2.1). These movements are for stock enhancement, aquaculture and research activities. The great majority of movements arise from stock already existing east of the Rocky Mountains. Atlantic salmon and rainbow trout are especially important in aquaculture. Triploid rainbow trout eggs have been moved between eastern Canadian provinces and released into drainages where there may be a risk to local stocks from competition, should they become otherwise established. Other developments will have included the movement of milt of salmon from transgenic fish to New Brunswick from Nova Scotia.

Research into developing faster growing and cold tolerant Atlantic salmon using chinook salmon growth hormone and eel-pout (*Zoarces* sp.) ‘anti-freeze’ promoter took place in Canada in 1996.

#### *4.2.1.2 Attempts to develop a recreation fishery based on Pacific salmon on the Eastern Atlantic seaboard*

Early studies commenced in 1971 (Munro *et al.*, 1999) in New Hampshire and Massachusetts to develop an autumn/winter sport fishery using releases of the Pacific coho salmon *Oncorhynchus kisutch* and in 1985 records of 100 000 pen reared F3 and F4 generation were released in the state of Massachusetts and 118 000 smolts in New Hampshire. In 1986 this ceased but a further programme of smolt releases to the Lamprey River was embarked upon over a five year period from 1989 to 1993 with annual releases of 400 000 to 550 000 smolts in September/October. The fish were supplied by a hatchery in New York State. A study had indicated that there was unlikely to be any significant environmental impact from this project. However, as the returns were very poor the project was discontinued. In the earlier studies small numbers of Chinook salmon *Oncorhynchus tshawytscha* were also released. To 1994 only four returns were recorded from the Lamprey River. The state of New Jersey considered releases of chinook salmon to support a sport fishery but the results from the coho study and the lack of returns from the earlier investigations led to a decision not to make these releases.

#### *4.2.1.3 Development of species for aquaculture*

Several marine species are under consideration for aquaculture. Already some experimental cultivation of Atlantic halibut in Canada has taken place with imports of young specimens from Iceland. Research into the development of several other species are outlined in Table 3.2.

#### *4.2.1.4 Other species*

Live fish for human consumption are exported to Canada in relatively small quantities and include carp, brown bullhead, pacu, tambaqui and tilapia and some of these were imported for research purpose to Nova Scotia. For most of these species the true volumes imported remain unknown but also included smaller numbers of black bullhead, lake trout, yellow perch, lake sturgeon. Some species were either imported alive for the table or for research purposes, these included: the Arroyo chub *Gila orcotti*, inconnu *Stenodus leucichthys* and shovelnose sturgeon *Scaphirhynchus platorhynchus*. In 1996 muskellunge were imported to Manatoba from Minnesota with the aim of attempting to develop a self-sustaining population, where previously these attempts had failed.

The northern pike *Esox lucius* and the pikeperch/ walleye *Stizostedion vitreum* have been used to stock lakes in Manitoba to create self-sustaining populations or to replaced populations that has expired from cold winters. *Micropterus dolomieui* and *Ictalurus nebulosus* were imported into Canadian waters supporting aquaculture projects.

#### *4.2.1.5 Species unintentionally introduced to the Atlantic region of North America*

*Esox masquinongy* – the muskellunge (Esocidae)

This North American fish was north of its range in the St John River in Quebec in 2001, it is thought it may have been introduced there in 2000.

*Esox niger* – the pickerel (Esocidae)

This predatory fish was found in a lake on the Miramichie River basin. The lake was treated with rotenone to eliminate the species on account of its threat to wild fish in the system.

*Oreochromis niloctica* – Nile tilapia (Cichlidae)

This euryhaline species was found in the Estuary of the Pascagoula River in the Mississippi Basin. It is probably an escape from an aquaculture facility. As it had survived two winters at the time of the report the species is most probably established.

*Pterois volitans* – lionfish (Scorpaenidae)

This Indo-Pacific species was first recorded in Biscayne Bay in 1992 and since then it has been seen at wreck sites by divers as far north as Long Island. As juveniles have been found off the North Carolina coast, indicating successful recruitment, the species may be established. It may have been an aquarium or ballast water release.

## 4.2.2 American Great Lakes region.

### *4.2.2.1 Species unintentionally introduced to the Great Lakes region of North America*

Over the last two decades there has been a noticeable increase in the number of exotic species becoming established within the Great Lakes region including fishes. Some of these are aggressive competitors with consequences for some native populations. It should be noted that there have been noticeable changes to the environment following the invasion by the zebra mussel in the mid-1980’s. These are efficient filter feeders and they have removed much of the particulate matter from the water column to provide an energy rich benthic environment. The reduced plankton biomass has almost certainly had effects for the recruitment of some fish species.

*Neogobius melanostomus* – round goby (Gobiidae)

This Pontocaspian species, often attaining 15cm in length, was first noticed in a small river between Lakes Huron and Erie in 1990. It is thought it may have been introduced with ships ballast water. By 1994 the species became common in the southern part of Lake Erie and specimens were found in the Welland Canal in 1996.

*Proterorhinus marmoratus* – tube-nosed goby (Gobiidae)

Found on the United States side of the St Clair River in 1990 this Pontocaspian species became common on the south side of Lake St Clair in 1994 and spread to the Lower Detroit River in 1995. This species has become rare by 1996 possibly as a result of competition from the round goby.

*Scardinius erythropthalmus* – rudd (Cyprinidae)

This European fish was found in the St Laurence River and is thought to have been introduced as a result of releases of baitfish by anglers and by 1996 the rudd was found in western Lake Ontario and eastern Lake Erie.

*Platichthys flesus* – European flounder (Pleuronectidae)

This estuarine species is known to ascend rivers in Europe and is tolerant of freshwater. It occurrence is thought to have been as a result of ballast water discharges with records from Thunder Bay. Occasional records of this species were recorded previously.

*Noturus insignis* – madtom (Ictaluridae)

This fish was established by 1994 in Lake Muskoka and Lake Rousseau Ontario and may have arrived as a result of bait bucket releases.

*Gymnocephalus cernuus* – Ruffe (Percidae)

This European fish was first noted in Duluth Harbour in 1986. By 1993 it was found 156 miles away with an average expansion of 29m per year. Spreading its range along the south coast of Lake Superior. By 1995 the species had spread to rivers in Wisconsin and Michigan and in western Superior in Thunder Bay and were found for the first time in Canadian waters in 1994 in the Kaministiquia River. A Ruffe control program was set up to manage the expansion of this invasive fish in 1994 by using chemical piscicides, population investigations, biogeographical recording and biological interaction assessments and a public information campaign. Despite this the species continued to spread being found for the first time in Lake Huron in 1995.

*Apeltes quadracus* – four-spined stickleback (Gasterosteridae )

This species has a natural range in Atlantic North America and was found in Thunder Bay, Lake Superior.

*Ctenophyrangodon idella* – grass carp (Cyprinidae)

Were introduced to Alberta to examine their potential for controlling aquatic vegetation in irrigation canals and farm dugout ponds. The stock was imported from the United States.

### 4.2.3 North western Europe

#### *4.2.3.1 Salmonids*

Salmonids almost certainly make up the greatest number of fish in transit. These are principally rainbow trout and salmon. Some of the movements are clearly experimental whereas the bulk of consignments are part of an established trade. Large volumes of surface-disinfected eggs continue to be exchanged within Europe as well as exports to Chile, to support aquaculture ventures. Some of these movements are extensive, for example, imports of one million salmon eggs to England and Wales were planned based on broodstock grown in New South Wales, Australia previously introduced from British Columbia. Rainbow trout eggs are imported for culture, these come from Tasmania and South Africa so that a more continuous production is possible. Eggs from South Africa arrive in July-August. Imports to England and Wales ranged from 20 to 60 million eggs each year. Such movements appear to be consistent annually and are part of an established trading practice.

In a conservation plan to re-establish the Atlantic salmon in the Meuse River in Northern Europe salmon have been imported from Ireland for stocking.

There has been recent interest in the use of Arctic Char for cultivation in Europe with a flow of >100 000 eggs from Sweden to Ireland in 1992. Imports in 1994 included eggs from Canada and Iceland, by 1998 there were imports of 1.2 million eggs.

#### *4.2.3.2 Other species*

The great bulk of specific species movements are follow developed practices in aquaculture. Until 1996 turbot cultivation in Galicia, Spain was in-part supported with annual exports of 250 000 to 500 000 fry from the Isle of Man when local hatchery production in Spain became sufficient. Research into turbot in Ireland has also resulted in imports from the same source. Cultured turbot are marketed within Europe. Imports of turbot to Ireland from the Isle of Man were 8000 and had increase to 45 000 by 1994.

Striped bass cultivation in England involves the importation of 250 000 fry annually. These are cultivated at one site in water heated from thermal discharges from a power plant.

Eels, *Anguilla anguilla* are moved within Europe for human consumption and has involved imports of eels *Anguilla* sp. From Canada, USA and New Zealand.

Live elvers of *Anguilla anguilla* have been collected for re-distribution in Europe either for human consumption, for culture activities or restocking. In Ireland these are captured in the estuaries and brought inland for restocking a practice that promotes their survival, similar programmes occur with elver imports to the Baltic region and Germany. Elvers have also been exported from Europe to Asia for culture. Some

Atlantic halibut cultivation research programme involved the movement of juveniles from The Orkneys and from the Isle of Man to Ireland and from Iceland to Canada.

#### *4.2.3.3 Species unintentionally introduced to north western Europe*

*Acipenser baerii* – Siberian sturgeon (Acipenseridae)

The Siberian sturgeon was recorded in Germany and may have followed releases from private aquaria or escaped from aquaculture ponds. There are apparently further accounts recalled by German fishermen that have not been verified.

*Tetraodon fluvialtilis* – green puffer (Tetraodontidae)

A single record of this Asian fish was captured off the coast of Belgium and may have originally been in an aquarium and subsequently released.

*Micropogonias undulatus* – Atlantic croaker (Sciaenidae)

This species is native to the east coast of North America and the Gulf of Mexico and a single specimen was found in the Scheldt Estuary in 2001. It may have been a ballast water release.

*Vimba vimba* – Baltic vimba (Cyprinidae)

Two juveniles were found in the Scheldt Estuary. The species is native to the rivers draining into the Baltic Sea. It is not known how they arrived.

### 4.24 Baltic Sea

#### *4.2.4.1 Whitefish re-introduction to the Baltic Sea*

The whitefish *Coregonus lavaretus* programme to re-introduce this species was undertaken by Sweden, Finland, Estonia and Poland. This commenced in 1991 with juvenile releases into Puck Bay, and the Szczecin Lagoon, Poland. Fish reared in Finland were exported to Sweden. In Finland in 1999 28 million newly hatched and 10 million juveniles were released to the Baltic Sea, Estonia released 117 000 in 2000.

#### *4.2.4.2 Restocking of the northern pike*

Pike *Esox lucius* juveniles have been released into two coastal lagoons on the Polish coast Szczecin and Vistula lagoons with releases of 381 000 and 436 000 fish respectively.

#### *4.2.4.3 Species unintentionally introduced to the Baltic Sea*

*Neogobius melanostomus* – round goby (Gobiidae)

May have been introduced to the Gulf of Gdansk before 1987 and by 1990 the species was found from Gdansk westwards to all of the shallows of Puck Bay. The species may have arrived with ballast water with ships coming from the Caspian and Black seas region. A further possible means of arrival is *via* the canal and river system entering the Gulf of Finland. Some specimens were found on the rivers along this route. However, if this is the case it is difficult to explain why the species has not been observed in the Gulf of Finland or coastal bays and lagoons north of the Gulf of Gdansk. By 1999 the species had reached the eastern border of Germany and appeared for the first time in the Vistula Lagoon, Poland. The species was found at one isolated location, Rügen Island, on the Baltic Sea coast of Germany. This fish is avidly eaten by cod and cormorants.

*Polyodon spathula* – Mississipi paddlefish (Polyodontidae)

A single *Polyodon spathula* was found in 1999 in the southern part of the Szczecin Lagoon, Poland.

*Acipenser güldenstädti* – Russian sturgeon (Acipenseridae)

Two Russian sturgeon were captured on the southwestern coast of Finland and in the eastern Gulf during 2000.

*Acipenser stellatus* – starry sturgeon (Acipenseridae)

A single specimen was captured in 1999 and three further specimens were captured in 2000, all in Finish waters. A single specimen was captured in Swedish waters in 2000.

### 4.2.5 Atlantic seaboard of south western Europe

#### *4.2.5.1 Species unintentionally introduced to the Atlantic Iberian region*

*Fundulus heteroclinus* – mummichog (Fundulidae)

The mummichog from the North American Atlantic coast was introduced to Spain over the period 1973–1976 from eastern Canada and has now expanded its range towards Portugal.

### 4.2.6 The Mediterranean Sea

#### *4.2.6.1 Species in cultivation*

The fishes used in culture in Italy include the bastard flounder *Paralicthys olivaceus* the drum *Sciaenops ocellatus* and the sparid *Pagrus major. P. major* is reared in commercial hatcheries which include land-based culture facilities. Broodstock of *P. olivaceus* and *S. ocellatus* were introduced in 1994 and their subsequent generations have been cultured under semi-intensive and intensive conditions. By 2000 these species produced 100 tonnes.

#### *4.2.6.2 Species unintentionally introduced to the Mediterranean Sea*

*Stephanolepis diaspros* – filefish (Monocanthidae)

This small monocanthid, a filefish, is a Lessepsian migrant first known from the Mediterranean in 1927 and well established in the eastern Mediterranean has expanded its range to Italian waters by 2000.

*Abudefduf vaigiensis* – damselfish (Pomacentridae)

This is a Lessepsian species, with a first record in Italy before 1959. Very few records of this species exist (Vacchi and Chiantore, 2000) and its appearance as a natural range expansion from the Suez region is difficult to explain unless the species was introduced by some other means.

*Epinephalus coioides* – spotted grouper (Serranidae)

This is a Lessepsian migrant that can be confused for *E. malabaricus* which also emerged in the Mediterranean from the Red Sea. A single juvenile was found in the Gulf of Trieste, Italy.

## 4.3 Summary

There is an apparent increase in the number of fishes being tried as ‘new’ aquaculture species and much interest for various reasons in research on non-native species. Some of the non-native species recoveries from the wild most probably relate to releases or escapes from research establishments and the pet trade. With competition for space in sheltered inlets and the expense of using offshore facilities it is likely that more land-based intensive culture operations will take place. Should the security of these operations be effective escapes from such operations are not expected. What is of concern is the large number of reports of established non-native fishes whose occurrence has been presumed to be as a result of ballast water releases by shipping or bait releases by fishermen. In the case of the expanding

European Union, and reduced controls on trade, further Pontocaspian species and exotic species, already established in regions of the European Union, may be expected to spread to central and western Europe. The gradual impacts of a changing climate may result in some severe meteorological events such as the flooding of the Rhine, Danube and Gironde rivers are likely to result in further purges from ponds. Escapes from storm-damaged cage culture units of non-native fishes in the sea, such as rainbow trout, will allow further access to the wild. It is likely that there will be major advances in the culture and management of fishes over the following decade.

## 4.4 References


Baltz, D.M., 1991. Introduced fish in marine systems and inland seas. Biological Conservation 56: 151-177.

Boero, F. and Carli, C., 1977. Prima segnalazione mediterranea di *Sphyna mokarran* (Rüppel, 1837) (Selachii, Sphyrnidae). Boll. Mus. 1st Biol. Univ. Genova, 45: 91–93.

Bower, S.M., S.E. McGladdery. 2001. Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish: Table of Contents. URL: http://www-sci.pac.dfo-mpo.gc.ca/shelldis/toc_e.htm.

Bronzi, P., Rosenthal, H., Arlati, G. and Williot, P. 1999. A brief overview on the status and prospects of sturgeon farming in Western and Central Europe. Journal of Applied Ichthyology, 15: 224–227.

Cigarría, J. and R. Elston. 1997. Independent introduction of *Bonamia ostreae*, a parasite of *Ostrea edulis* to Spain. Diseases of Aquatic Organisms, 29: 157–158.

Cross, T.F., and Galwvin, P.T., 1997. The nature and current status of transgenic Atlantic salmon. Marine Resources Series (No 1) Marine Institute, Ireland.

Crossman, E.J., Holm, E., Cholmondeley, R.,, Turinga, K.. 1992. First record for Canada of the rudd *Scardinus erythrophthalmus*, and notes on the introduced round goby, *Neogobius melanostomus*. Canadian Field Naturalist, 106(2): 206–209.

DeCharleroy, D.L., L. Grisez, K. Thomas, C. Belpaire, F. Ollevier. 1990. The life cycle of Anguillicola crassus. Diseases of Aquatic Organisms 8, 77-84.

DeGroot, S.J. and Nijssen, H.. 1997. The North Sea houting, *Coregonus oxyrhynchus*, back in The Netherlands (Pices, Salmoniformes, Salmonidae) Bulletin Zoologisch Museum, 16(4): 21–24.

Elston, R.A., Farley, C.A. and Kent, M.L. 1986. Occurrence and significance of bonamiasis in European flat oysters *Ostrea edulis* in North America. Diseases of Aquatic Organisms, 2: 49–54.

Friedman, C.S. and Perkins, F.O. 1994. Range extension of Bonamia ostreae to Maine, U.S.A. Journal of Invertebrate Pathology, 64: 179–181

Gessner, J., Debus, L., Filipiak, J., Spratte, S., Skora, K.E. and Arndt, G.-M. 1999. Development of sturgeon catches in German and adjacent waters since 1980. Journal of Applied Ichthyology, 15: 136–141.

Gulf States Marine Site: Material on *Anguillicola crassus*: http://nis.gsmfc.org/nis_factsheet.php?toc_id=9

Johnsen, B.O. and Jensen, A.J. 1991. The Gyrodactylus story in Norway. Aquaculture, 98 (3,4): 289–302.

Johnsen, B.O. and Jensen, A.J. 1994. The spread of furunculosis in Norwegian Rivers. J. Fish Biology, 45 (1): 47–55.

Lightner, D.V., Bell, T.A., Redman, R.M., Mohney, L.L., Natividad, J.M., Rukyani, A., and Poernomo, A. 1992. A review of some major diseases of economic significance in penaid prawns/shrimp of the Americas and Indopacific. In: Diseases in Asian aquaculture I. M. Shariff, R.P. Subsinghe and J.R. Arthur (eds), pp57-80. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Jude, D.J., Reider, R.H., Smith, G.R. 1992. Establishment of the gobiidae in the Great Lakes Basin. Canadian Journal of Fisheries and Aquatic Sciences, 49(2): 416–421.

Landis, N. 2001. Exotic fish species turns up a long way from home. http://www.fayettevilleobserver.com

Munro, A.L.S., Utting, S.D. and Wallentinus, I., 1999. Status of introductions of non-indigenous marine species to North Atlantic waters 1981–1991. ICES Cooperative Research Report No 231, ICES Copenhagen, 91pp.

Office International des Epizooties. 2002. International Aquatic Animal Health Code 2002, Paris, France, 157 p.

Pratt, D.M., Blust, W.H. and Selgeby, J.H. 1992. Ruffe, *Gymnocephalus cernuus*: newly introduced in North America. Canadian Journal of Fisheries and Aquatic Sciences, 49: 1616–1618.

Skora, K., Olenin, S. and Gollasch, S. *Neogobius melanostomus* (Pallas, 1811). In*:* Exotics across the ocean: case histories on introduced species: their general biology, distribution, range, expansion and impact. (eds) S. Gollasch, D. Minchin, H. Rosenthal & M. Voight. Logos Verlag, Berlin 78pp.

Soto, D., Jara, F. and Moreno, C. 2001. Escaped salmon in the inner seas, southern Chile: facing ecological and social conflicts. Ecological Applications, 11(6): 1750–1762.

Steffens, W., Jähnichen, H and Fredrich, F. 1983. Successful propagation of the hybrid beluga and sterlet (*Huso huso x Acipenser ruthenus*)(Pices, Acipensseridae) Zool. Anz., 211:55–64.

Vacchi, M. and Chiantore, M.C., 2000. *Abudefduf* vaigiensis (Quoy and Gaimard, 1825): a tropical damselfish in the Mediterranean Sea. Biol. Mar. Medit., **7**(1): 841–843.

**Table 3.1. List of fishes transferred for aquaculture and stocking purposes 1991-2002. Fish stages E = eggs, F = fry, Y = juveniles, A = adults. Countries in bold have significant transfers within them.**

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *A. ruthenus x A baeri* | sturgeon hybrid | 91 | | | Russia | Portugal | aquaculture |
| *Acipenser baerii* | Siberian sturgeon | 97, 98, 99, 00, 01 | | Y, E | Russia | Germany, Poland | aquaculture |
| *Acipenser ruthenus* | sterlet | 00 | | | | Germany | aquaculture |
| *Acipenser sturio* | sturgeon | 97 | | Y | Russia | Germany | stocking |
| *Amphiprion sp.* | clownfish | 96 | | | | Britain | aquaculture/aquaria |
| *Anguilla anguilla* | freshwater eel | 92 | | Y | France, UK, | Denmark | aquaculture |
| *Anguilla anguilla* | freshwater eel | 96 | | Y | France | Japan, South Korea, China | aquaculture |
| *Anguilla anguilla* | freshwater eel | 94, 01 | | Y | Sweden | Finland | stocking |
| *Anguilla anguilla* | freshwater eel | 91, 95, 96, 00, 01 | 5mt | Y | England | Sweden | stocking |
| *Anguilla anguilla* | freshwater eel | 98 | | | Britain | Estonia | stocking |
| *Coregonus artedii* | cisco | 96 | | E | Canada | China | aquaculture |
| *Coregonus lavaretus* | whitefish | 91-01 | 200.000 | Y | Poland, Finland | Poland, Finland | stocking |
| *Coregonus lavaretus* | whitefish | 95,97,98,99 | ca 30,000+ | Y | | Estonia, Poland | stocking |
| *Ctenopharyngdon idella* | grass carp | 95 | | | USA | Canada | weed control |
| *Cyprinus carpio* | common carp | 01, | ~5,000mt | | Poland, Hungary, Czech Rep. | Germany | aquaculture |
| *Cyprinus carpio* | common carp | 96, 97, 98, 99 | | Y | | Estonia | stocking |
| *Dicentrarchus labrax* | bass | 99, 00 | 120.000 | Y | France, Malta | Norway | aquaculture |
| *Dicentrarchus labrax* | bass | 92/ 96, 97 | | E | France | Denmark / Greece, Italy | aquaculture |
| *Dicentrarchus labrax* | bass | 97 | | Y | France | Malta,Turkey, Tunisia, Spain | aquaculture |
| *Esox lucius* | northern pike | 95.96 | | | USA | Canada | stocking |
| *Esox lucius* | northern pike | 95, 96, 98.99, 01 | | Y | | Estonia | stocking |
| *Esox masquinongy* | muskellunge | 97 | 250.000 | | Canada | USA | stocking |
| *Gadus morhua* | cod | 01 | | | | Canada | aquaculture |
| *Hippoglossus hippoglossus* | Atlantic halibut | 98 | >50,000 | Y | Iceland | USA | aquaculture |
| *Hippoglossus* | Atlantic | 99, 00, 01 | >100,000 | F (E) | Iceland | Norway | aquaculture |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *hippoglossus* | halibut | | (2,000,000) | | | | |
| *Ictalurus nebulosus* | brown bullhead | 95 | | | | Canada | aquaculture/stocking |
| *Micropterus dolomieui* | smallmouth bass | 96 | 25.000 | | USA | Canada | stock |
| *Morone chrysops* | wild white bass | 95 | <500 | | Canada | USA | research |
| *Onchorhnchus tshawytscha* | chinook | 92 | 500.000 | Y | | **USA** | stocking |
| *Oncorhynchus kisutch* | coho salmon | 96 | | | W. Canada | Canada | Research |
| *Oncorhynchus mykiss* | Rainbow trout | 91-02 | >1,000,000 | E, F | **Canada** | various | aquaculture/stocking |
| *Oncorhynchus mykiss* triploids | Rainbow trout | 92, 95 | >100,000 | E | **Canada** | | aquaculture/stocking |
| *Oreochromis nilocticus* | nile tilapia | 01 | | | USA | Canada | aquaculture |
| *Perca flavescens* | yellow perch | 96 | | | | Canada | stocking/aquaculture |
| *Pleuronectes platessa* | plaice | 92 | | Y | **Denmark** | | stocking |
| *Psetta maxima* | turbot | 01 | 100.000 | | Ireland | China | aquaculture |
| *Psetta maxima* | turbot | 00 | 5.000.000 | L | Norway | Spain | aquaculture |
| *Psetta maxima* | turbot | 01 | | | France, Spain, Denmark | Norway | aquaculture |
| *Psetta maxima* | turbot | 92, 01 | 3.000.000 | L | Norway | Denmark | aquaculture |
| *Psetta maxima* | turbot | 92-01 | <25,000 | Y | Isle of Man | Ireland | aquaculture |
| *Psetta maxima* | turbot | 97 | | Y | France | Malta, Turkey, Tunisia, Spain | aquaculture |
| *Psetta maxima* | turbot | 96 | | Y | **France** | Spain, Italy | aquaculture |
| *Psetta maxima* | turbot | 00, 01 | 2.000 | Y | France | Belgium | stocking |
| *Psetta maxima* | turbot | 92 | | Y | **Denmark** | | stocking |
| *Psetta maxima* | turbot | 92 | | E | France | Denmark | stocking |
| *Rocca saxatilus* | striped bass | 91-02 | 250.000 | F @ 1g | USA | UK | aquaculture |
| *Rocca saxatilus* | striped bass | 96 | /1500 | | **Canada** | USA | aquaculture/stocking |
| *S. alpinus x S. fontinalis* | hybrid trout | 96 | | | | Canada | stocking |
| *S. fontinalis x S, namaycush* | splake | 95, 96 | | | | Canada | stocking |
| *Salmo clarkii* | cutthroat trout | 97 | | | | Canada | unclear |
| *Salmo salar* | Atlantic salmon | 9302 | >1,000,000 | E, F | see Table 3.2 | various | aquaculture &stocking |
| *Salmo trutta* | brown trout | 96 | | | see Table 3.2 | various | stocking |
| *Salvelinus alpinus* | Arctic charr | 93 | | E | see Table 3.2 | various | stocking |
| *Salvelinus* | brook trout | 91-02 | >1,000,000 | E, F | see | various | stocking |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *fontinalis* | | | | | Table 3.2 | | |
| *Salvelinus namaycush* | lake trout | 92, 94 | >10,000 | E, F | see Table 3.2 | various | stocking |
| *Solea solea* | sole | 00 | | E | USA | Spain | aquaculture |
| *Sparus aurata* | gilthead bream | 94 | | y | Greece | Germany | research |
| *Stizostedion lucioperca* | pikeperch | 95,96,97,98,99,01 | 40,000+ | y | | Estonia | stocking |
| *Stizostedion vitreum* | zander, walleye | 95 | 4.000.000 | E | **Canada** | China | stocking |
| *Thymallus thymallus* | grayling | 92, 96 | | E | Sweden | Germany, France | stocking? |
| *Thymallus thymallus* | grayling | 91, 92,/01 | | E | Finland | France/Austria | stocking? |
| *Zander lucioperca* | pikeperch | | | Y | Sweden | Sweden | stocking |

**Table 3.2. List of fishes transferred for research purposes or transported alive for human consumption. Countries in bold have significant transfers within them. See Table 3.1 for abbreviations used.**

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *A. baeri x A. medirostis* | sturgeon hybrid | 01 | | | | Poland | research |
| *Acipencer brevirostrum* | shortnose sturgeon | 97 | | | | Canada | Research |
| *Acipenser baeri* | Siberian sturgeon | 99 | | | | Poland | research |
| *Acipenser baeri x A. ruthenus* | hybrid sturgeon | 91 | triploids | | Russia | Portugal | research? |
| *Acipenser fulvescens* | lake sturgeon | 93 | | | | Canada | food |
| *Acipenser medirostris* | green sturgeon | 99 | | | | Poland | research |
| *Acipenser sturio* | European sturgeon | 97, 99 | | | | Germany, Poland | conservation |
| *Acipenser transmontanus* | white sturgeon | 01 | | | USA | Canada | research |
| *Acipenser transmontanus* | white sturgeon | 93, 94 | several | | USA, Italy | Germany | research |
| *Aciperser baeri x A. medirostris* | hybrid sturgeon | 99 | | | Russia | Poland | Research |
| *Ameiurus nebulosus* | brown bullhead | 97 | | | | Canada | unclear |
| *Anarhichas lupus* | wolffish | 97 | | A | | Canada | research |
| *Anguilla anguilla* | feshwater eel | 00 | | A | Sweden | Germany Denmark, Belgium | food |
| *Anguilla anguilla* | feshwater eel | 94, 95 | | A | Sweden | Poland, Hong Kong, Japan | food |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *Anguilla anguilla* | feshwater eel | 99 | | A | Lithuania, Norway | Sweden | food |
| *Anguilla anguilla* | feshwater eel | 97 | | A | Sweden | Israel, Italy, Spain, Poland | food |
| *Anguilla anguilla* | feshwater eel | 91 | | A | England | Europe, Israel, Hong Kong | food |
| *Anguilla anguilla* | feshwater eel | | | A | Ireland | UK | food |
| *Anguilla rostrata* | freshwater eel | 00 | | A | Canada | Netherlands | food |
| *Anguilla rostrata* | freshwater eel | | | A | Canada, USA | UK | food |
| *Anguilla sp.* | freshwater eel | 91, 92 | | A | New Zealand | UK | food |
| *Centrarchus macrochirus* | bluegill sunfish | 92 | 2000 | | USA | Scotland | research |
| *Channa sp.* | snakehead | 99 | | | Pacific | Canada | food |
| *Colossoma macropomum* | tambaqui | 96 | | | Brazil | Canada | food |
| *Ctenopharyngdon idella* | grass carp (triploids) | 95 | | A | USA | Canada | plant control research |
| *Cyclopterus lumpus* | lumpfish | 97 | | | | Canada | research |
| *Cyprinus carpio* | common carp | 00 | 3,000mt | A | Denmark, Poland | Germany | food |
| *Cyprinus carpio* | common carp | 00 | | A | Poland, The Netherlands | Sweden | food |
| *Cyprinus carpio* | common carp | 91, 93, 95, 99 | | | W-USA, USA | Canada | research |
| *Cyprinus carpio* | common carp | 95 | | | Canada | USA | research |
| *Dicentrarchus labrax* | bass | 99 | | Y | Malta, France | The Netherlands | research |
| *Fundulus sp.* | killifish | 91 | | Y | Canada | Norway | research |
| *Gadus morhua* | cod | 97, 99, 01 | | E | | Canada | research |
| *Gadus ogac* | Greenland cod | 97 | | | | Canada | research |
| *Gila orcotti* | arroyo chub | 94 | | | USA | Canada | food/research |
| *Glyptocephalus glyptocephalus* | witch flounder | 00 | | | | Canada | research |
| *Hippoglossoides platessoides* | American plaice | 97 | | | | Canada | research |
| *Hippoglossus hippoglossus* | Atlantic halibut | 97, 98, 99, 00, 01 | | E | | Canada | Research |
| *Hippoglossus hippoglossus* | Atlantic halibut | 01 | >1,000 | Y | Isle of Man | Ireland | research |
| *Hippoglossus hippoglossus* | Atlantic halibut | 94 | | | Norway | Ireland | research |
| *Hippoglossus* | Atlantic | 95 | 5.000 | A | Orkneys | Ireland | research |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *hippoglossus* | halibut | | | | | | |
| *Hippoglossus hippoglossus* | Atlantic halibut | 01 | 1.000 | F | Norway | Britain | research |
| *Hypophthalmichthys nobilis* | bighead carp | 91 | | | USA | Canada | unclear |
| *Ictalurus nebulosus* | brown bullhead | 92 | 3mt | | USA | Canada | food |
| *Ictalurus punctatus* | channel catfish | 91 | | | USA | Canada | unclear |
| *Ictiobus sp.* | buffalo fish | 91 | | | USA | Canada | unclear |
| *Limanda ferruginea* | yellowtail flounder | 97, 98, 99, 00 | | | | Canada | research |
| *Melanogrammus aeglefinus* | haddock | 99, 00, 01 | | | | Canada | research |
| *Microgadus tomcod* | tomcod | 96 | gametes | | USA | Canada | research |
| *Morone chrysops* | white bass | 96 | | | Canada | USA | food |
| *Morone saxatilus* | striped bass | 96, 99, 00 | | | USA | Canada | research |
| *Muranaesox talabonoides* | Indian pike conger | 99 | | | Pacific | Canada | food |
| *Noturius insignis* | mad tom | 96 | | E, milt | USA | Canada | research |
| *Oncorhynchus apache* | apache trout | 01 | | | Finland, Denmark | Estonia | research |
| *Oncorhynchus chrysogaster* | Mexican golden trout | 01 | | | Finland, Denmark | Estonia | research |
| *Oncorhynchus gilae* | gila trout | 99 | | | Finland, Russia | Estonia | food? |
| *Oncorhynchus kisutch* | coho salmon | 95 | | | W-Canada | Canada | research |
| *Oncorhynchus mykiss* | rainbow trout | 92 | >10,000 | | **Canada** | | food |
| *Oncorhynchus tshawytscha* | chinook salmon | 89-93 | >100,000 | Y | **USA** | | research/stocking |
| *Oreochromis nilocticus* | Nile tilapia | 99 | | | Pacific | Canada | food |
| *Paralichthys dentatus* | summer flounder | 99, 00 | | | | Canada | research |
| *Phoxinus sp* | dace | 96 | 50 gallons | A | Canada | USA | baitfish |
| *Paralichthys dentataus* | summer flounder | 93 | | | | Canada | food |
| *Piaractus brachypomus* | characin | 96 | | | Brazil | Canada | research |
| *Pinguipes brasilianus* | sandperch | 97 | | | | Italy | ballast water? |
| *Psetta maxima* | turbot | 99 | | | Iceland, France | The Netherlands | research |
| *Psetta maxima* | turbot | 01 | ~1000 | F | Norway | UK | research |
| *Pseudopleuronectes americanus* | winter flounder | 97, 98, 99, 00 | | | | Canada | research |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *Rutilus rutilus* | roach | 00 | 15kg | A | Ireland | England | research |
| *Salmo salar* | Atlantic salmon | 96 | | | W-Canada | Canada | research |
| *Salmo salar transgenics* | Atlantic salmon | 96 | 8 vials | milt | **Canada** | | research |
| *Salvelinus alpinus* | char | 92-02 | >100 | | **Canada** | | food |
| *Salvelinus namaycush* | lake whitefish | 92 | | | | Canada | food |
| *Scaphirhynchus platorynchus* | shovelnose sturgeon | 95 | | | | Canada | research |
| *Sparus aurata* | gilthead bream | 94 | 250 @1-2g | F | Greece | Germany, UK | research |
| *Sparus aurata* | gilthead bream | 94 | | Y | France | Germany, UK | research |
| *Stenodus leucicthys* | inconnu | 95 | | | | Canada | research |
| *Thymallus thymallus* | grayling | 96 | | E | Sweden | France | research |
| *Tilapia sp* | tilapia | 92 | | | USA | Canada | food |
| *Tilapia sp.* | tilapia | 96 | <1mt | | | Canada | food |
| *Tilapia sp.* | tilapia | 92 | 1.000 | | Scotland | Norway | research |
| *Tilapia sp.* | tilapia | 99 | >1000 | | Thialand | Canada | research |
| *Tliapia aura* | gold tilapia | 94 | | | Mexico | Canada | research/ food |
| *Torpedo marmorata* | marbled electric ray | 97 | 9 | | France | England | research |

**Table 3.3. Fishes unintentionally released, including unauthorised releases, to the wild. See Table 3.1 for abbreviations used.**

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *Abudefduf vaigiensis* | damselfish | j | record | | | Italy | unknown |
| *Acipenser baerii* | Siberian sturgeon | j | records | A | | Germany | escapes |
| *Acipenser gueldenstaedti* | Russian sturgeon | j | records | A | | Germany | escapes |
| *Acipenser gueldenstaedti* | Russian sturgeon | j | record | A | | Sweden, The Netherlands | escape |
| *Acipenser gueldenstaedti* | Russian sturgeon | j | records | A | | Italy | escape? |
| *Acipenser transmontanus* | white sturgeon | j | records | A | | Germany | escapes |
| *Adudefduf vaigiensis* | damselfish | g | | adult | Red Sea | Italy | lessipian immigrant |
| *Apeltes quadracus* | four-spine stickleback | g | record | | | Canada | unknown |
| *Aspius aspius* | asp | g | record | | | Canada | range expansion? |
| *Coregonus oxyrhinchus* | houting | g,l | records | A | | The Netherlands | re-establishment? |
| *Epinephalus coioides* | grouper | k | record | | | Italy | lessipian migrant |
| *Esox masquinongy* | muskellunge | k | records | A | | Canada | from stocking? |

| Species | Common name | Years | Relative volume | Stage | Source | Destination | Purpose |
|---|---|---|---|---|---|---|---|
| *Esox niger* | pickerel | k | eradicated? | A | | Canada | unknown |
| *Fundulus heteroclitus* | mummichog | j | established | | Canada | Spain | unknown |
| *Gymnocephalus cernuus* | ruffe | b | established | | | Canada | ballast water? |
| *Hypophthalmichthys molitrix* | silver carp | g | record | | | Canada, USA | unknown |
| *Hypophthalmichthys nobilis* | bighead carp | g | record | | | Canada | unknown |
| *Hypostomus plecostomus* | sucker-mouth catfish | a | record | | USA? | Spain | aquarium release? |
| *Hypostomus plecostomus* | sucker-mouth catfish | a | record | A | USA | | Aquarium release? |
| *Lepomis gibbosus* | pumpkinseed | h | record | | | Poland | aquarium release? |
| *Micropogonias undulatus* | Atlantic croaker | k | records | Y | | The Netherlands | ballast water? |
| *Mugil labrosus* | grey mullet | h | record | A | | Poland | unknown |
| *Neogobius melanostomus* | round goby | b | established | | | Canada, USA | ballast water? |
| *Neogobius melanostomus* | round goby | b | established | | | Poland | range expansion? |
| *Noturis insignis* | mad tom | c | established | | USA | Canada | baitfish release? |
| *Oreochromis nilocticus* | nile tilapia | j | established | | | USA | aquaculture escape? |
| *Platichthys flesus* | European flounder | d,g | records | | | Canada, USA | ballast water? |
| *Polyodon spathula* | Mississipi paddlefish | l | record | | | Poland | unknown |
| *Pomadasys stridens* | grunt | l | record | adult | Red Sea | Italy | Lessipian migrant |
| *Pseudorasbora parva* | stone moroka | g | record | | | The Netherlands | range extension? |
| *Pterois volitans* | lionfish | j | established | Y, A | | USA | aquarium release? |
| *Rocca saxatilus* | striped bass | l | records | | | Netherlands | unknown |
| *Scaphirhynchus platorynchus* | shovelnosed sturgeon | e,f | <10 | | | Canada | research escape |
| *Scardinius erythrophthalmus* | rudd | j | established? | | | Canada | baitfish release? |
| *Serrasalmas nattereri* | red-bellied piranha | a | record | | | Canada | aquarium release? |
| *Stephanolepis dispros* | filefish | j | record | | | Italy | lessipian species |
| *Synagrops japonicus* | Japanese splitfin | j | record | | | Italy | lessipian immigrant? |
| *Tetraodon fluviatilis* | green puffer | k | record | | | Belgium | aquarium release? |
| *Tinca tinca* | tench | i | records | | | Canada | escapes from pond? |
| *Trinectes maculatus* | hogchoker | g | record | A | | The Netherlands | unknown |
| *Vimba vimba* | Baltic vimba | k | records | | | Belgium | expansion? Bait? |

# Annex 1. First records of non-indigenous species (all taxa) 1992–2002 world-wide including uncertain introductions, excluding species in containment. Entries are sorted by name of taxa (after National Reports and Abstracts in recent ICES WGITMO and ICES/IOC/IMO WGBOSV Meeting Reports). N = North, E = East, S = South and W = West. Additional data from http://www.ciesm.org/atlas/.

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Abudefduf vaigiensis<br>Fish | 1998s? (since 1959 in Italy) | Israel | rare | unknown | Suez Canal, range expansion | Indo-Pacific, Red Sea, S Africa to Oceania |
| Acanthaster planci<br>Echinodermata | 2000 | France, Port of Cros, Mediterranean Sea | unknown | unknown | unknown | |
| Acanthomysis aspersa<br>Mysid | 1992 | USA, San Francisco Bay | unknown | unknown | ballast water | Japan |
| Acanthomysis sp.<br>Mysid | 1992 | USA, San Francisco Bay | unknown | unknown | ballast water | Pacific? |
| Acanthurus monroviae<br>Fish | 1990s? (since 1987 in S. Spain) | Israel | single specimens | unknown | range expansion (via Gibraltar) | tropical W Africa from Morocco to Angola |
| Acartia grani<br>Copepoda | 1997 | Italy, Ligurian Sea | unknown | unknown | ballast water, range expansion | NW Europe |
| Acartiella sinensis<br>Copepoda | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water | China |
| Acentrogobius (cf) pflaumi<br>Fish | 2002 | New Zealand | unknown | unknown | unknown | Japan & Korea |
| Achirus fasciatus<br>Fish | 1998 | Netherlands, off shore | single specimen | unknown | unknown | America |
| Acipenser baeri<br>Fish, Siberian sturgeon | 1998 | Germany | occasional records | unknown | stocking | NE Asia, Siberia |
| Acipenser baeri<br>Fish, Siberian sturgeon | 1999 | France, Port of Cros | single specimen | unknown | escaped from farm | NE Asia, Siberia |
| Acipenser cf. gueldenstaedti<br>Fish | 2000 | Sweden, near Kalmar | unknown | unknown | stocking | Ponto-Caspian |
| Acipenser gueldenstaedti<br>Fish | 2000 & 2001 | Finland, south-western coast | single specimen | unknown | stocking | Ponto-Caspian |
| Acipenser spp.<br>Fish | 1998 | Netherlands | unknown | unknown | aquarium release | cannot be determined on genus level |
| Acipenser stellatus<br>Fish | 1999 | Finland, coastal water | unknown | unknown | stocking | Ponto-Caspian |
| Acipenser stellatus<br>Fish | 1999 | USA, Great Lakes | unknown | unknown | stocking | Ponto-Caspian |
| Acrochaetium balticum<br>Red alga | 1990s | Norway, W coast | unknown specimens | unknown | unknown | Baltic |
| Acrochaetium balticum<br>Red alga | 1998 | Netherlands, Lake Veere | occasional records | minimal | unknown | Baltic |
| Acrothamnion preissii<br>Alga | 1994 | Spain, Balearic Islands, Mallorca, Menorca | unknown | fouling, competition | unknown | |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Acteocina mucronata<br>Gastropoda | 1990s? (since 1986 in Israel) | Greece, Naxos Island | unknown | unknown | Suez Canal, range expansion | Red Sea |
| Adelactaeon amoenus<br>Gastropoda | 1990s? (Since 1978 in Israel) | Cyprus | unknown | unknown | Suez Canal, range expansion | Indo-Pacific |
| Agardhiella subulata<br>Red alga | 1998 | Netherlands, Oosterschelde | occasional records | unknown | unknown | N America |
| Alcyonidium sp.<br>Tentaculata | 2002 | USA | unknown | fouling? | unknown | Europe? |
| Alexandrium angustitabulatum<br>Phytoplankton, Dinoflagellate | 1997 | Sweden, Skagerrak | unknown | potentially toxic | ballast water? | New Zealand? |
| Alexandrium angustitabulatum<br>Phytoplankton, Dinoflagellate | 1997 | Sweden, west coast | established | unknown | ballast water? | New Zealand |
| Alexandrium catenella<br>Phytoplankton, Dinoflagellate | 1998 | Spain, Catalonia | established | potentially causing harmful algal blooms | ballast water | |
| Alexandrium leeii<br>Phytoplankon, Dinoflagellate | 1995 | North Sea | localized | unknown | unknown | N Pacific |
| Alexandrium minutum<br>Phytoplankton | 1996 | Sweden, eastern Skagerrak | unknown | PST production | ballast water, range expansion? | |
| Alexandrium ostenfeldi<br>Phytoplankon, Dinoflagellate | 1997 | Baltic proper, near Oeland Island | unknown | potentially causing algal blooms | ballast water? | |
| Alexandrium taylori<br>Phytoplankon, Dinoflagellate | 1994 | France, Atlantic coast near Arcachon | unknown | unknown | unknown | |
| Alexandrium taylori<br>Phytoplankon, Dinoflagellate | 1995 | Italy, near Sicily | unknown | unknown | unknown | |
| Alexandrium taylori<br>Phytoplankon, Dinoflagellate | 1998 | Spain, Catalanian coast | unknown | unknown | unknown | |
| Alpheus audouini<br>Prawn | 2002 (earlier record 1924 in Egypt) | Turkey, Fethiye | occasional records | unknown | Suez Canal, range expansion | Indo-W Pacific, Red Sea to New Zealand & Hawaii |
| Alpheus migrans<br>Prawn | 1994 (earlier record 1978 Egypt) | Turkey, S coast | occasional records | unknown | Suez Canal, range expansion | Red Sea |
| Ampharetidae<br>Polychaete | 2001 | Italy, Gulf of Noto, Sicily | unknown | unknown | Suez Canals or transferred via ballast water | Indian Ocean |
| Anachis savignyi<br>Gastropoda | 1990s? (since 1954 in Israel) | Turkey | established | unknown | Suez Canal | Red Sea |
| Anachis selasphora<br>Gastropoda | 1990s? (since 1980 in Israel) | Turkey | established | unknown | Suez Canal | Indian Ocean & Red Sea |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Anadara demiri Bivalve | 1990s (since 1972 in Turkey) | Greece, N Aegean | unknown | unknown | hull fouling? range expansion | Indian Ocean |
| Anadara demiri Bivalve | 2000 (since 1972 in Turkey) | Italy, Central Adriatic & Venice Lagoon | unknown | unknown | hull fouling?, range expansion | Indian Ocean |
| Anguillicola crassus Nematode | 1997 | Ireland, Shannon River | spreading, common locally | eel parasite | living imports, | Japan. NW Pacific |
| Anguillicola crassus Nematode | 2002 | Finland | rare | eel parasite | living imports, secondary introduction | Japan. NW Pacific |
| Antigona lamellaris Bivalve | 1992 | Turkey, Iskenderum | single specimen (one valves found) | unknown | Suez Canal questionable as not known from Israel. Shipping? | Indo-Pacific, Red Sea |
| Antithamnion amphigeneum Alga | 1992 | Spain, Balearic Islands, Mallorca | established?, Catalonian coast in 1997, Valencio in 1999 | unknown | unknown | |
| Antithamnionella spirographidis Red Alga | 1992 | Belgium, Oostende | Established in Zeebrugge before 1983. | unknown | | |
| Apeltes quadracus Fish | 1996 | Canada, Lake Superior | occasional records | unknown | shipping?, range expansion | W Atlantic, Gulf of St. Lawrence North Carolina |
| Aplidium nordmanni Ascidian | 1998 | Germany, near Sylt Island, North Sea | spreading | unknown | escapes from oyster farm | SW England, Brittany to Mediterranean |
| Aplysia dactylomela Gastropod | 2002 | Italy, near Sicily | unknown | unknown | unknown | circum-tropical |
| Asperococcus scaber Brown alga | 1998 | Netherlands, Lake Grevelingen | occasional records | minimal | unknown | Mediterranean |
| Aspius aspius Fish | 1998 | Netherlands | unknown | unknown | range expansion? | Europe |
| Atyaephyra desmaresti Crustacea | 2000 | Poland, Odra River | unknown | unknown | unknown | Mediterranean |
| Aulacomya ater Bivalve | 1994 & 1997 | United Kingdom, Moray Firth | occasional records | unknown | ballast water, hull fouling? | S America |
| Aurelia aurita Jelly fish | 1998 | Caspian Sea | unknown | zooplankton predator | ballast water? | cosmopolitan |
| Balanus perforatus Barnacle | 1996 (earlier records known) | Belgium (on buoys). Recorded from Dutch buoys in 1978. | occasional records | fouling | hull fouling, range expansion from Iberian peninsula? | E Atlantic, warm-water species |
| Balanus reticulatus Barnacle | 1997 | Belgium (on buoys) | occasional records | fouling | hull fouling | circum-tropical |
| Balanus trigonus Barnacle | 1997 | Belgium (on buoys) | one empty shell settled on a buoy | fouling | hull fouling, range expansion from Iberian peninsula? | tropical & warm-temperate seas |
| Balanus variegatus Barnacle | 1997 | Belgium (on buoys) | occasional records | fouling | hull fouling | Indo-Pacific |
| Batophora sp. Green alga | 2002 | Italy, Ionian Sea | unknown | unknown | unknown | cannot be determined on genus level |
| Beroe cucumis | 1998 | Black Sea | common | zooplankton | ballast water | N Atlantic |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Ctenophore | | | | predator | | |
| Beroe ovata Ctenophore | 1999 | Black Sea | unknown | zooplankton predator | ballast water | USA, Atlantic coast |
| Beroe ovata Ctenophore | 2001 | Caspian Sea | unknown | zooplankton predator | ballast water | USA, Atlantic coast |
| Beryx splendens Fish | 1995 | Italy, Ligurian Sea | single specimen | unknown | range expansion via Gibraltar | Atlantic, Indian Ocean, Pacific (Australia, Japan, Hawaii & New Zealand) |
| Bonamia ostreae Haplosporida | 1994 | Spain, Catalan coast | unknown | disease agent of mussels | mussel movements? | ? |
| Botryllus schlosseri Tunicate | 2002 | Canada, E coast, Prince Edward Island | unknown | fouling? | shipping? | Asia |
| Botryllus violaceus Tunicate | 2000 | USA, Alaska at Sitka and Tatilek | unknown | fouling? | shipping? | |
| Bractechlamys vexillum Bivalve | 2000 | France, Port of Cros, Mediterranean Sea | unknown | unknown | unknown | N Australia |
| Bugula neritina Bryozoan | 1999 | Belgium, Oostende | occasional records | fouling | hull fouling | |
| Bugula simplex Bryozoan | 2000 | Belgium, Oostende | established? range extension | fouling | hull fouling | |
| Bulla ampulla Gastropoda | 1990s? (since 1978 in Israel) | Greece, Saronikos | established, but rare | unknown | Suez Canal, range expansion | tropical Indo-Pacific |
| Bythotrephes cederstroemi Amphipoda | 1995 (earlier records known) | Canada, Great Lakes region | continues spreading during entire period of this report | unknown | unknown | |
| Cabomba caroliana Alga | 2000 | Canada, Lake Kasshabog, Ontario | extremely dense, established? | driving native species to extinction | aquarium release | |
| Calappa pelii Decapod | 1996 (earlier record off Marocco in 1991 | Italy, Gulf of Taranto | occasional records | unknown | Suez Canal, range expansion | E Atlantic |
| Callinectes bocourti Decapod | 1990 (first record in 1971) | USA, Alabama, Mississippi, Gulf of Mexico. | occasional records in 1997, 1998, 1 juvenile in 2001 in Alabama | unknown | ballast water, range expansion | Caribbean to S Florida, West Indies, Colombia-Brazil |
| Callinectes sapidus Decapod | 1995 - 2002 | France, Atlantic coast | occasional records | predation | shipping | NW Atlantic, Nova Scotia to Uruguay |
| Callinectes sapidus Decapod | 1995 – 2002 (earlier records in Europe since 1900) | Belgium | occasional records | predation | shipping | NW Atlantic, Nova Scotia to Uruguay |
| Callinectes sapidus Decapod | 1999 | Netherlands, Ports of Amsterdam & Rotterdam | occasional records also in 2000 from | predation | shipping | NW Atlantic, Nova Scotia to Uruguay |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | Westerschelde, including egg carrying females. | | | |
| Callionymus filamentosus<br>Fish | 1994 (since 1953 in Israel) | Turkey | common | unknown | Suez Canal, range expansion | Indo-Pacific, Red Sea, E Africa, Madagascar & Mauritius to New Guinea & China |
| Calyptraea chinensis<br>Gastropod | 1999 (first record in 1950s) | Ireland, E Galway Bay, Cork Harbour in 2000 | established | unknown | mussel movements | China |
| Caprella mutica<br>Amphipod | 1998 | Belgium, buoys of Zeebrugge harbour | established | unknown, clogging of gear? | ballast water, hull fouling? | E Asia & Siberia |
| Caprella mutica<br>Amphipod | 1998 | Netherlands | unknown | unknown, clogging of gear? | ballast water, hull fouling? | E Asia & Siberia |
| Caprella mutica<br>Amphipod | 2000 | Norway, near Stavanger | unknown | unknown, clogging of gear? | ballast water, hull fouling? | E Asia & Siberia |
| Caprella mutica<br>Amphipod | 2000 | USA, Massachusetts & Rhode Island | rapid range expansion | unknown, clogging of gear? | ballast water, hull fouling? | E Asia & Siberia |
| Carcharhinus altimus<br>Shark | 1996 (since 1983 in Algeria) | Israel, Levatine Basin | single specimen | unknown | range expansion via Gibraltar | temperate & tropical waters of Atlantic, Pacific & W Indian Oceans |
| Carcinus maenas<br>Decapod | 1993 (first record 1990/91) | USA, San Francisco Bay | established, spreads northwards during entire period of this report. Hundreds of crabs been found in Washington. | predator | ballast water | Atlantic Europe |
| Carcinus maenas<br>Decapod | 1998 (first record 1950s) | Canada, Prince Edward Island, S Gulf of St. Lawrence & Cape Breton in 1999 | established, further spread in 2000 | ecosystem engineer, predation, eel fishing and oyster production threatened. | secondary introduction from Fundy Bay or range expansion | Atlantic Europe |
| Carcinus maenas<br>Decapod | 1999 | Canada, W coast, Barkley Sound, Vancouver Island | rare specimens, additional findings in northern British Columbia over the entire duration of this report | ecosystem engineer, predation | secondary introduction from US Pacific Coast or range expansion | Atlantic Europe |
| Carupa tenuipes<br>Decapoda | 1996 | SW Turkey | occasional records | unknown | Suez Canal | Indo-Pacific, Red Sea to Japan, Australia, Polynesia & Hawaii |
| Carupa tenuipes<br>Decapoda | 2002 | Israel, Tel Aviv | several specimens | unknown | Suez Canal, range expansion | Indo-Pacific, Red Sea to |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | | | | Japan, Australia, Polynesia & Hawaii |
| Caulerpa racemosa Green alga | 1993 | Italy, Lampedusa Island | spreading | unknown | Suez Canal | |
| Caulerpa racemosa Green alga | 1998 | France, Marseille | unknown | unknown | Suez Canal | |
| Caulerpa racemosa Green alga | 1998 | Spain, Balearen Islands, Mallorca, Ibiza | spreading | unknown | Suez Canal | |
| Caulerpa taxifolia Green alga | 1992 (first record 1980s) | France | spreading during the entire period of this report | competition, habitat modification | likely an accidental aquarium release | aquarium strain from Germany |
| Caulerpa taxifolia Green alga | 1992 | Italy, Ligurian Sea, Messina Strait in 1999 | established, spreading during entire period of this report | competition, habitat modification | range expansion | aquarium strain from Germany |
| Caulerpa taxifolia Green alga | 1993 | Spain, Balearean Islands | not spreading | competition, habitat modification | range expansion | aquarium strain from Germany |
| Caulerpa taxifolia Green alga | 1998 | Croatia | established, spreading during entire period of this report | competition, habitat modification | range expansion | aquarium strain from Germany |
| Caulerpa taxifolia Green alga | 1998 | Tunisia | established, spreading during entire period of this report | competition, habitat modification | range expansion | aquarium strain from Germany |
| Caulerpa taxifolia Green alga | 2000 | Australia, near Sidney | unknown | competition, habitat modification | range expansion | native strain |
| Caulerpa taxifolia Green alga | 2000 | USA, San Diego, Aqua Hedionda Lagoon, Carlsbad, California, & Huntington Harbour, California | eradication effort carried out / underway | competition, habitat modification | aquarium trade? | Mediterranean Sea strain |
| Cellana rota Gastropoda | 1990s? (since 1961 in Israel) | Greece, Saronikos Gulf | unknown | range expansion | Suez Canal, range expansion | Red Sea & Indian Ocean |
| Ceramium bisporum Red alga | 2002 | Italy, Tuscany | unknown | minimal | unknown | |
| Cercopagis pengoi Cladoceran | 1992 | Estonia, Gulf of Riga (first record in Baltic) | established, spreading over the entire period of this report. | competition, predation on zooplankton, clogging of fishing gear | ballast water | Ponto-Caspian |
| Cercopagis pengoi Cladoceran | 1995 | Finland | established, spreading. | competition, predation on zooplankton, clogging of fishing gear | range expansion from earlier introduction in 1992 | Ponto-Caspian |
| Cercopagis pengoi Cladoceran | 1995 | Sweden and central & southern parts of Baltic | established, spreading. Mass development in 2001. | competition, predation on zooplankton, clogging of fishing gear | range expansion from earlier introduction in 1992 | Ponto-Caspian |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Cercopagis pengoi Cladoceran | 1998 | Canada, Great Lakes | established, spreading | competition, predation on zooplankton, clogging of fishing gear | ballast water | Ponto-Caspian |
| Cercopagis pengoi Cladoceran | 1998 | USA, Great Lakes | established, spreading | competition, predation on zooplankton, clogging of fishing gear | ballast water | Ponto-Caspian |
| Cercopagis pengoi Cladoceran | 1999 | Poland, Vistula Lagoon | established, spreading, mass development | competition, predation on zooplankton, clogging of fishing gear | range expansion | Ponto-Caspian |
| Cerithium nesioticum Gastropoda | 1990s? (since 1970 in Israel) | Cyprus | unknown | unknown | Suez Canal, range expansion | Red Sea, Indian Ocean, tropical W Pacific |
| Cerithium scabridum Gastropoda | 1990s? | Cyprus | unknown | unknown | Suez Canal, range expansion | Red Sea, Persian Gulf, W & S India |
| Cerithium scabridum Gastropoda | 1990s? | Turkey, S coast | unknown | unknown | Suez Canal, range expansion | Red Sea, Persian Gulf, W & S India |
| Charibdys helleri Decapod | 1990s (first records in Med 1924in Israel) | Syria | occasional records | unknown | ballast water, hull fouling, range expansion | Indo-W Pacific, Red Sea to New Caledonia |
| Charibdys helleri Decapod | 1999 (first records in Med 1924in Israel) | Cyprus | occasional records | unknown | ballast water, hull fouling, range expansion | Indo-W Pacific, Red Sea to New Caledonia |
| Charibdys helleri Decapod | 2000 | USA, Florida to North Carolina | spreading | unknown | unknown | Indo-W Pacific, Red Sea to New Caledonia |
| Charybdis japonica Decapod | 2000 | Australia, near Adelaide | single specimen | nuisance to fishers, gets into nets, very aggressive to remove | unknown | Japan, Korea, Malaysia |
| Charybdis japonica Decapod | 2000 | New Zealand, Auckland region | established | nuisance to fishers, gets into nets, very aggressive to remove | unknown | Japan, Korea, Malaysia |
| Charybdis longicollis Decapoda | 2002? (first record in Med 1959 in Turkey) | Greece, Rhodes Island | established | unknown | Suez Canal | Red Sea, East Africa, Persian Gulf |
| Chattonella cf. verruculosa Phytoplankton, Rhaphidophycean | 1998 | Denmark, North Kattegat, Skagerrak | established, blooming | causing harmful algal blooms | ballast water? | Japan |
| Chattonella cf. verruculosa Phytoplankton, Rhaphidophycean | 1998 | Norway | established, blooming | causing harmful algal blooms, severe fish | ballast water? | Japan |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | | kill in 2001 | | |
| Chattonella cf. verruculosa<br>Phytoplankton, Rhaphidophycean | 1998 (earlier records in 1990s) | Sweden, North Kattegat, Skagerrak | established, blooming | causing harmful algal blooms | ballast water? | Japan |
| Chaunax suttkusi<br>Fish | 1997 | Italy, Sicily Strait | rare | unknown | range expansion via Gibraltar | WE Atlantic |
| Chaunax suttkusi<br>Fish | 2000 | Italy | unknown | unknown | unknown | E Atlantic, Azores to Angola. W Atlantic South Carolina to Rio Grande |
| Chilomycterus spilostylus<br>Fish | 1993 | Israel | single specimen | unknown | Suez Canal | Indo-Pacific |
| Chionoecetes opilio<br>Decapod | 1996 | Barents Sea, SE part | occasional records, no findings in 2001 | unknown | ballast water? | NW Atlantic |
| Chrisallida fisheri<br>Gastropod | 2002 | Italy, Adriatic Sea | unknown | unknown | range expansion? | Red Sea, E Mediterranean |
| Chrysallida maiae<br>Gastropoda | 1990s? (since 1935 in Israel) | Caprus | occasional records | unknown | Suez Canal, range expansion | Red Sea |
| Chrysallida maiae<br>Gastropoda | 1990s? (since 1935 in Israel) | Turkey, near Tasuçu | occasional records | unknown | Suez Canal, range expansion | Red Sea |
| Ciona savignyi<br>Tunicata | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water, hull fouling | Japan? |
| Cipangopaludina chinensis malleata<br>Gastropod | 1996 | Canada, Ontario´s inland lakes | established, first record in Great lakes in 1930s | unknown | unknown | Asia |
| Clathrofenella ferruginea<br>Gastropoda | 1990s? (since 1970 in Israel) | SE coast of Turkey, Mersina to Tasuçu | established | unknown | Suez Canal, range expansion | Indo-Pacific, Red Sea & Persian Gulf, E Japan |
| Cochlodinium polykrikoides<br>Phytoplankton, Dinoflagellate | 1998 | Canada, W coast | increasing | fish kills (salmon farming) | ballast water? | Korea? |
| Codium fragile ssp. tomentosoides<br>Green alga | 1992 | Canada, Nova Scotia | established, spreading during the entire period of this report, eradication trial underway. | algal mats cover oysters making harvests difficult | boat traffic from USA or tidal flow | |
| Codium fragile ssp. tomentosoides<br>Green alga | 1998 | Belgium, Oostende | secondary introduction, not persisting. No records since 2001. | habitat modification, fouling on shellfish and gear | oyster imports?, range expansion | Japan |
| Coenobita rugosus<br>Fish | 2000 | France | unknown | unknown | release with bait | Asia? |
| Convoluta convoluta<br>Flatworm | 1995 | Canada, Nova Scotia | spreading | unknown | ballast water | Europe |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Convoluta convoluta Flatworm | 1999 | USA, from Canada to Massachusetts | spreading | unknown | ballast water | Europe |
| Corbula gibba Bivalve | 1995 | Netherlands | spreading | E Atlantic | ballast water, hull fouling? | |
| Corbula gibba Bivalve | 1996 | France, Dunkerque | unknown | unknown | ballast water, hull fouling? | |
| Corbula gibba Bivalve | 1998 | Belgium | unknown | unknown | ballast water, hull fouling? | |
| Coregonus lavaretus Fish | 1999 | Netherlands, large rivers | unknown | unknown | restocking, range expansion | Europe |
| Coregonus oxyrhynchus Fish | 1996 | Netherlands, Yssel Lake | unknown | unknown | restocking (fish was extinct) | Europe |
| Corella eumyota Sea squirt | 2002 | France, Brittany | unknown | unknown | unknown | southern hemisphere |
| Corophium curvispinum Bivalve | 1995 | Netherlands | spreading | unknown | ballast water, hull fouling? | |
| Corophium sextonae Amphipoda | 1997 | North Sea, S & E coasts | established | unknown | ballast water, hull fouling | S Pacific |
| Crangonyx pseudogracilis Crustacea | 1992 | Germany | rare | unknown | release | N America |
| Crassostrea gigas Bivalve | 1994 | Germany, North Sea | occasional records. Since end of 1990s established, spreading | unknown | accidental release, recruitment outside farm | Japan |
| Crassostrea gigas Bivalve | 1995 (imported in 1960s) | Belgium, Netherlands | established, very common, spreading | unknown | accidental release, recruitment outside farm | Japan |
| Crassostrea gigas Bivalve | 1995 | United Kingdom, Conwy Estuary, N Wales | small population of patchy distribution | unknown | accidental release, recruitment outside farm | Japan |
| Crassostrea gigas Bivalve | 1999 | United Kingdom, Carrew River, SW Wales | small population | unknown | accidental release, recruitment outside farm | Japan |
| Crepidula fornicata Gastropod | 1996 (first record in 1962) | Norway, Kvitsoy, near Stavanger. | spreading until 2000. Not reported in 2000. | competition | oyster imports, range expansion? | East coast of N America |
| Crepidula fornicata Gastropod | 1996 | Spain, Galicia | unknown | unknown | oyster imports from France & Ireland | East coast of N America |
| Crepidula fornicata Gastropod | 1999 (first record in 1957) | France, Atlantic coast | established, mass development | competition | oyster imports, range expansion? | E coast of N America, from Canada to Florida & Texas |
| Crepidula fornicata Gastropod | 2000 (first record in 1940s) | Belgium | established, mass development | competition | oyster imports, range expansion? | East coast of N America |
| Cyclope neritea Gastropoda | 1992 | Spain, Galicia | unknown | unknown | range expansion | Mediterranean |
| Cylichna girardi Gastropoda | 1990s? (since 1976 in Egypt) | Cyprus | unknown | unknown | Suez Canal, range expansion | Indo-Pacific |
| Cylichna girardi Gastropoda | 1990s? (since | Greece, Crete | unknown | unknown | Suez Canal, range expansion | Indo-Pacific |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | 1976 in Egypt) | | | | | |
| Daphnia lumholtzi Cladoceran | 1999 | USA, Great Lakes | established | unknown | ballast water | Africa, India, Australia |
| Dasya baillouviana Red alga | 1999 (first record in 1950s) | Sweden, near Ringhals E Kattegat being southernmost record in Sweden | unknown | unknown | secondary spread, range expansion | S Europe (incl. Mediterranean Sea) & W Atlantic |
| Dasya baillouviana Red alga | 2002 | Germany | unknown | unknown | secondary spread, range expansion | S Europe (incl. Mediterranean Sea) & W Atlantic |
| Dasysiphonia sp. Red alga | 1994 | Netherlands | localized | unknown | ballast water, hull fouling | N Pacific |
| Dasysiphonia sp. Red alga | 1996 | Norway, near Bergen, reached Sognefjord in 2001 | established, spreading rapidly north- & southwards | overgrows other algae | ballast water, hull fouling | N Pacific |
| Dendrocoelum romanodanubiale Tricladida | 1992 | Germany, inland waters | rare | unknown | ballast water? | Ponto-Caspian |
| Desmarestia viridis Brown alga | 1998 | Italy | unknown | overgrows other algae | introduction with oysters? | Asia |
| Didemnum sp. Ascidian | 2000 | USA, Cape Cod, Massachusetts & Rhode Island | unknown | fouling | unknown | New Zealand? |
| Dinophysis acuata Phytoplankton, Dinoflagellate | 1992 | Norway | first observation, bloom | unknown | ballast water | United Kingdom |
| Diodora ruppellii Gastropoda | 1990s? (since 1940s in Israel) | Turkey | unknown | unknown | range expansion from Israel | Indo-Pacific, Red Sea, Aden, Persian Gulf, Somalia, Madagascar, Natal, Seychelles, Mauritius & Hawaii. |
| Discroerisma psilonereiella Phytoplankton, Phytoplankton | 1997 | Sweden, Skagerrak | unknown | unknown | ballast water? | Kamchatka, Canada (British Columbia) |
| Discroerisma psilonereiella Dinoflagellate, Phytoplankton | 1997 | Sweden, W coast | unknown | unknown | ballast water | Kamchatka, Canada |
| Dispio uncinata Polychaete | 2001 | Italy, Gulf of Noto, Sicily | unknown | unknown | unknown | Atlantic, Pacific & Red Sea |
| Dreissena bugensis Bivalve | 1993 | Canada, Great Lakes | unknown | unknown | unknown | Ukraine |
| Dreissena bugensis Bivalve | 1993 | USA, Great Lakes | unknown | unknown | unknown | Ukraine |
| Dreissena polymorpha Bivalve | 1992 (first record 1986) | Canada, Great Lakes region | continues spreading during entire period of this report | severe fouling | ballast water (or hull fouling) | Ponto-Caspian |
| Dreissena polymorpha Bivalve | 1992 (first record 1986) | USA, Great Lakes region, reached Mississippi River | continues spreading during entire period of this report | severe fouling | ballast water (or hull fouling) | Ponto-Caspian |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Dreissena polymorpha<br>Bivalve | 1994 | Ireland, Shannon River | established, spreading during the entire period of this report | severe fouling, drives native mussels to extinction | hull fouling, ballast water? | Ponto-Caspian |
| Dreissena polymorpha<br>Bivalve | 1995 | Finland, E Gulf of Finland | spreading | severe fouling | ballast water or hull fouling | Ponto-Caspian |
| Dreissena polymorpha<br>Bivalve | 1996 | Germany, S inland lakes | spreading | severe fouling | ballast water or hull fouling | Ponto-Caspian |
| Dreissena polymorpha<br>Bivalve | 2000 | Canada, W coast | not found in the environment, but on boat hull trailered from Michigan | severe fouling | hull fouling | Ponto-Caspian |
| Dreissena polymorpha<br>Bivalve | 2000 | Estonia | spreading | severe fouling, phytoplankton biomass decline? | hull fouling, ballast water? | Ponto-Caspian |
| Dreissena polymorpha<br>Bivalve | 2001 | Spain, Ebro River | unknown | severe fouling | hull fouling, ballast water? | Ponto-Caspian |
| Drymonema dalmatinum<br>Cnidaria | 2000 | USA, Florida to Mississippi, Gulf of Mexico | unknown | unknoww | range expansion, ballast water, hull fouling | |
| Dyspanopeus sayi<br>Decapod | 1992 | Italy, Venice Lagoon | spreading | unknown | ballast water, hull fouling, mussel movements? | NW Atlantic |
| Dyspanopeus sayi<br>Decapod | 1999 | Italy, Romagna coast | spreading | unknown | ballast water, hull fouling, mussel movements? | NW Atlantic |
| Echinogammarus ischnus<br>Amphipod | 1996 | Canada, Great Lakes region | established, continues spreading during the entire period of this report | unknown | ballast water | Ponto-Caspian |
| Echinogammarus ischnus<br>Amphipod | 1998 | USA, Great Lakes | established, continues spreading during the entire period of this report | unknown | ballast water | Ponto-Caspian |
| Echinogammarus trichiatus<br>Amphipoda | 1996 | Germany | rare | unknown | ballast water? | Ponto-Caspian |
| Ectocarpus siliculosus<br>Brown alga | 1998 | Italy, Venice | unknown | competition | fishing | |
| Ensis directus<br>Bivalve | 1990s | United Kingdom, SE coast | established, spreading | unknown | ballast water, range expansion | N America |
| Ensis directus<br>Bivalve | 1992 | France, Channel coast | established, spreading | unknown | ballast water, range expansion | N America |
| Epinebalia sp.<br>Crustacea | 1992 | USA, San Francisco Bay | unknown | unknown | ballast water | cannot be determined on genus level |
| Epinephelus coiodes<br>Fish | 1998 (since 1969 in Israel) | Italy | occasional records | unknown | Suez Canal, ballast water | Red Sea |
| Ergalatax obscura<br>Gastropoda | 1990s? | Turkey, Mersina to Tasuçu, S coast | unknown | unknown | Lessepsian migrant | Red Sea & Gulf of Aden |
| Eriocheir sinensis<br>Decapod | 1990s (first | United Kingdom, Thames River. | established, spreading | predation, clogging of | ballast water | China |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | record 1935) | River Tyne in 2000. | along north eastern coast. | water intakes, increase of erosion | | |
| Eriocheir sinensis Decapod | 1992 | USA, San Francisco Bay, Columbia River in 1997 | established, spreading in California during the entire period of this report | unknown | ballast water, release | China or Europe |
| Eriocheir sinensis Decapod | 1994 | Canada, Lake Erie | single specimen | unknown | ballast water | China or Europe |
| Eriocheir sinensis Decapod | 1996 – 2000 (first record 1912) | Germany, Elbe River | established, mass development, further spread | predation, pond fisheries, clogging of water intakes and fishing nets, increase of erosion | ballast water | China |
| Eriocheir sinensis Decapod | 1998 | Finland | occasional records | predation, competition, habitat modification | ballast water, hull fouling, migration from Germany | China |
| Eriocheir sinensis Decapod | 1998 | Sweden | occasional records | predation, competition, habitat modification | ballast water, hull fouling, migration from Germany | China |
| Eriocheir sinensis Decapod | 1998 | Ukraine, Black Sea | occasional records | predation, competition, habitat modification | ballast water, hull fouling | China |
| Eriocheir sinensis Decapod | 2001 | Spain, Guadalquivir Estuary | established | predation, competition, habitat modification | ballast water, hull fouling | China |
| Erugosquilla massavensis Shrimp | 1994 (first record in Med 1933 in Egypt) | Greece, Crete | established | unknown | Suez Canal | Red Sea, Persian Gulf |
| Erugosquilla massavensis Shrimp | 2002 (first record in Med 1933 in Egypt) | Greece, Rhodes Island | established | unknown | Suez Canal | Red Sea, Persian Gulf |
| Esox masquinongy Fish | 2000 | Canada, St. John River System | unknown | unknown | import from Quebec | N America, St. Lawrence River - Great Lakes, Hudson Bay, Mississippi |
| Esox niger Fish | 2000 | Canada, lake in the Miramichie drainage | Eradication effort underway. | unknown | unknown | Africa |
| Etrumeus teres Fish | 2000 (since 1963 in Israel | Cyprus | common | unknown | Suez Canal, range expansion | Red Sea, E Africa, Japan, S Australia, E Pacific & W Atlantic |
| Etrumeus teres Fish | 1997 (since 1963 in Israel | Turkey | unknown | unknown | Suez Canal, range expansion | Red Sea, E Africa, Japan, S Australia, E Pacific & W Atlantic |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Eucrate crenata<br>Decapoda | 1997 (first record in Med in 1924) | Israel | locally common | unknown | Lesspsian migrant | Indo-Pacific, Red Sea to Hawaii |
| Eunapius carteri<br>Porifera | 1993 | Germany, inland waters | rare | unknown | release | Africa, Asia |
| European Sheatfish Virus (ESV)<br>Disease agent | 2002 | Finland | unknown | fish disease | unknown | Europe |
| Favonogobius exquisites<br>Fish | 2001 | New Zealand | unknown | unknown | unknown | Australia |
| Ficopomatus enigmaticus<br>Polychaete | 1997 (first record 1921) | France, Normandy, Mediterranean lagoons in 1999 | established, mass development in 1997 | fouling impact | hull fouling, ballast water | Indo-Pacific |
| Ficopomatus enigmaticus<br>Polychaete | 1998 (first record 1972) | Ireland, Shannon Estuary | established | small fouling impact | hull fouling, ballast water | Indo-Pacific |
| Ficopomatus enigmaticus<br>Polychaete | 2000 | USA, Chesapeake Bay | established | fouling | hull fouling, ballast water | Indo-Pacific |
| Fistularia commersonii<br>Fish | 2000 | Israel | common | species is of commercial importance | Suez Canal | Indian Ocean, Pacific Ocean, Central & S America. |
| Fistularia petimba<br>Fish | 1997 | Spain, Alboran Sea | single specimen | unknown | range expansion via Gibraltar | E Atlantic, Angola to Senegal & Cape Verde Islands, Indo-west Pacific to Hawaii |
| Fundulus heteroclitus<br>Fish | 1996 (first record 1973) | Spain | spreading westwards | unknown | unknown | Atlantic coast of N America |
| Galeocerdo cuvier<br>Shark | 1990s? (since 1987 Spain, Malaga) | Italy, Messina | unknown | unknown | range expansion via Gibraltar | circum-global, tropical & temperate waters |
| Gammarus tigrinus<br>Amphipod | 1995 (first record 1988) | Poland, Szczecin Lagoon, Vistula Lagoon in 1999 | established, spreading eastwards | unknown | range expansion | |
| Gibbula adansoni | 1992 | Spain, Galicia | unknown | unknown | range expansion | Mediterranean |
| Grateloupia doryphora<br>Red alga | 1993 | North Sea | established | unknown | shipping? | Pacific |
| Grateloupia doryphora<br>Red alga | 1996 | USA, Rhode Island, S of Cape Cod in 1998 | established, spreading | unknown | shipping? | Pacific |
| Gymnocephalus cernuus<br>Fish | 1992 (first record in 1986) | Canada, Great Lakes, first record outside Lake Superior in Lake Huron. | continues spreading during the entire period of this report | unknown | unknown | Europe |
| Gymnocephalus cernuus<br>Fish | 1995 (first record in 1986) | USA, Great Lakes, first records outside Lake Superior in Lake Huron. | continues spreading | unknown | unknown | Europe |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Gymnodinium catenatum Phytoplankton, Dinoflagellate | 2000 | Black Sea | unknown | harmful algal bloom, PSP | ballast water | |
| Gymnodinium catenatum Phytoplankton, Dinoflagellate | 2000 | New Zealand | recorded during bloom | harmful algal bloom, PSP | ballast water? | |
| Gyrodactylus salaries | 1992 | Norway, 35 Salmon rivers | unknown | unknown | unknown | |
| Gyrodinium corallinum Phytoplankton, Dinoflagellate | 1997 | Sweden, W coast | unknown | unknown | ballast water | USA, California |
| Gyrodinium corallium Phytoplankton, Dinoflagellate | 1997 | Sweden, Skagerrak | unknown | unknown | ballast water? | USA, California? |
| Halimede tyche Decapod | 1998 | Israel | single specimen | unknown | Lesspsian migrant | Indo-W Pacific, Persian Gulf to Australia |
| Haliplanella lineata Anthozoan | 1998 | Belgium | established, range extension | fouling? | oyster imports? | Pacific |
| Haminoea callidegenita Gastropoda | 1992 | Italy, Venice Lagoon | established | unknown | mussel movements | USA, Washington State, NE Pacific & E Atlantic in Arosa & Eo estuaries, NW Spain |
| Haminoea cyanomarginata Gastropod | 2001 | Mediterranean | unknown | unknown | shipping, Suez Canal? | Red Sea |
| Haplosporidium costale Disease agent causing SSO disease | 2002 | Canada, Nova Scotia, Prince Edward Island, New Brunswick | First observation | Disease of oysters | unknown | Atlantic coast of USA |
| Haplosporidium nelsoni Disease agent causing MSX disease | 2002 | Canada, Nova Scotia | First observation | Disease of oysters | shipping? | Pacific? |
| Hemigrapsus penicillatus Decapod | 1994 | France, near La Rochelle | spreading north- and southwards, Le Havre, English Channel in 1998 | competition | hull fouling, ballast water? | NW Pacific |
| Hemigrapsus penicillatus Decapod | 1997 | Spain, Laredo | spreading | competition | hull fouling, ballast water? | NW Pacific |
| Hemigrapsus penicillatus Decapod | 2000 | Netherlands, Oosterschelde | at one location, females carrying eggs about to hatch | competition | hull fouling, ballast water? | NW Pacific |
| Hemigrapsus sanguineus Decapod | 1993 (first record in New Jersey 1988) | USA, Cape Cod, occurs from Massachusetts to North Carolina in 1997, reached Maine in 2000. | continues spreading northwards & southwards during entire period of this report | unknown | unknown | Japan |
| Hemigrapsus sanguineus Decapod | 1999 | Netherlands, Oosterschelde | occasional finding, | competition | hull fouling, ballast water? | W Pacific |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | not observed in 2000 | | | |
| Hemigrapsus sanguineus Decapod | 2001 | Croatia, western Istra, northern Adriatic | single specimen | competition | hull fouling, ballast water? | W Pacific |
| Hemimysis anomala Mysid | 1992 | Finland | range extension, spreading | unknown | ballast water | Ponto-Caspian |
| Hemimysis anomala Mysid | 1995 | Sweden, near Stockholm | range extension, spreading | unknown | ballast water | Ponto-Caspian |
| Hemimysis anomala Mysid | 1999 | Belgium | established? range extension | unknown | unknown | Ponto-Caspian |
| Herbstia nitida Decapoda | 2002 | Italy, Otranto Channel | few specimens | unknown | ballast water, hull fouling? | E Atlantic, Gulf of Guinea |
| Himantura uarnak Ray | 1998 (since 1955 in Israel) | Turkey | established | unknown | range expansion | Indo-Pacific from Red Sea, E Africa to N Australia & the Philippines |
| Himantura uarnak Ray | 1994 (since 1955 in Israel) | Egypt | established | unknown | range expansion | Indo-Pacific from Red Sea, E Africa to N Australia & the Philippines |
| Hippolyte longirostres Crustacea | 1999 (earlier records known) | United Kingdom, Cornwall | few specimens | unknown | unknown | |
| Homarus americanus Decapod | 1999 | Norway, Oslofjord | occasional findings annually | hybridisation, disease transfer | accidental release? | N America, Atlantic |
| Homarus americanus Decapod | 2002 | Canada, British Columbia, Vancouver harbour | unknown | hybridisation, disease transfer | accidental release? | N America, Atlantic |
| Homarus americanus Decapod | 2002 | France | unknown | hybridisation, disease transfer | accidental release? | N America, Atlantic |
| Homarus cf. americanus Decapod | 2000 & 2001 | Sweden | single specimen annually | hybridisation, disease transfer | accidental release? | N America, Atlantic |
| Hydrocharis morsus-ranae Plant | 1996 | Canada, Ontario´s inland lakes | established, first record in 1932, spreading | unknown | unknown | Asia |
| Hydroides sanctaecrucis Polychaete | 2001 | Australia, Cairns | not spreading | unknown | hull fouling | |
| Hypnea cornuta Red alga | 2002 | Italy, Ionian Sea | unknown | unknown | unknown | |
| Hypophthalmichthys molitrix Fish | 1998 | Netherlands | unknown | unknown | secondary spread | Asia, China & E Siberia |
| Hypophthalmichthys nobilis Fish | 1998 | Netherlands | unknown | unknown | secondary spread | China |
| Hypophthalmichthys nobilis Fish | 2002 | Estonia, Gulf of Riga | unknown | unknown | secondary spread | China |
| Hypostomus plecostomus Fish | 1992 | Canada, Lake Erie | occasional records | unknown | accidental aquarium release | S USA |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Ianiropsis sp. Isopoda | 2000 | USA, Massachusetts & Rhode Island | unknown | unknown | unknown | cannot be determined on genus level |
| Illex illecebrosus Squid | 1998 | USA, washed ashore Lake Huron | few specimens. Will not survive freshwater conditions | no impact in Great Lakes | taken onboard during ballast water exchange | N Atlantic |
| Infectious Salmon Anemia (ISA) Disease agent | 1999 | Scotland | unknown | impact on farmed Salmon | fish movements or imports | ? |
| Infectious Salmon Anemia (ISA) Disease agent | 2001 | USA, Maine | unknown, Eradication effort and control plan | impact on farmed Salmon | fish movements or imports | |
| Iolaea neofelixoides Gastropoda | 1994 | Turkey, Yumurtalik Harbour | unknown | unknown | | Japan |
| Isolda pulcella Polychaete | 2001 | Italy, Gulf of Noto, Sicily | unknown | unknown | unknown | Atlantic & Indian Ocean |
| Ixa monody Decapod | 2002 (earlier record in Turkey in 1955) | Greece, Rhodes Island | occasional records | unknown | Suez Canal, range expansion | Red Sea? |
| Leathesia verruculiformis Phaeophyta | 1994 | Netherlands, Lake Grevelingen & Oosterschelde | unknown, annual findings | unknown | unknown | NW Pacific |
| Lepomis gibbosus Fish | 1999 | Poland, Odra River, Szczecin Lagoon | rare | unknown | unknown | N America, New Brunswick South Carolina |
| Libinia dubia Decapoda | 1996 | Tunisia, S coast | common | unknown | ballast water, hull fouling? | W Atlantic, from Massachusetts to Cuba |
| Limnoithona tetraspina Copepoda | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water | China |
| Limnomysis benedeni Mysid | 1994 | Germany | rare | unknown | ballast water? | Ponto-Caspian |
| Littorina saxatilis Gastropod | 1993 | USA, San Francisco Bay | unknown | unknown | seaweed packing from New England | N Atlantic |
| Lomentaria hakodatensis Seaweed | 1992 | Spain | unknown | unknown | Oyster culture | Japan, Korea |
| Lomentaria hakodatensis Seaweed | 1993 | Spain, Galicia | spreading | unknown | Oyster culture | Japan, Korea |
| Lophocladia lallemandii Alga | 1999 (first records on mainland in 1988) | Spain, Balearic Island, Ibiza | established, locally very abundant | outcompetes natives species | unknown | |
| Macrophthalmus graeffei Decapoda | 1994 | S Turkey | unknown | unknown | Suez Canal | Indo-W Pacific |
| Macrophthalmus graeffei Decapoda | 2003 | Israel, Haifa Bay | rare | unknown | Suez Canal | Indo-W Pacific |
| Maeotias inexpectata Cnidaria | 1992 | USA, San Francisco Bay | unknown | unknown | ballast water, hull fouling | Black |
| Maeotias inexpectata Cnidaria | 1999 | Estonia | occasional records | possibly predation on | ballast water | Ponto-Caspian |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | | zooplankton | | |
| Marenzelleria cf. wireni Polychaete | 1995 (first record in 1989) | Netherlands, W Scheldt, Rotterdam in 1997 | spreading | unknown | ballast water? | N America, Atlantic |
| Marenzelleria viridis Polychaete | 1990s | Poland, Szczecin Lagoon | established, spreading | unknown | range expansion | N America, Atlantic |
| Marenzelleria viridis Polychaete | 1991 | Estonia | established, spreading over the entire period of this report. | unknown | range expansion | N America, Atlantic |
| Marenzelleria viridis Polychaete | 1992 (first record in 1990) | Sweden, E coast, reached Bothnian Bay in 2001 | spreading during entire period of this report | unknown | ballast water | N America, Atlantic |
| Marenzelleria viridis Polychaete | 1993 | Finland | established, spreading | unknown | range expansion | N America, Atlantic |
| Marsupenaeus japonicus Prawn | 1996 | Greece. First record in Mediterranean in 1927 | established | unknown | Suez Canal, aquaculture release | Indo-Pacific |
| Marsupenaeus japonicus Prawn | 2001 | Turkey, Marmara Sea. First record in Mediterranean in 1927 | occasional records | unknown | Suez Canal, aquaculture release | Indo-Pacific |
| Mediomastus capensis Polychaete | 1990 | Italy, in 2001 in Salerno | spreading | unknown | Suez Canal | |
| Megabalanus coccopoma Barnacle | 1998 | Belgium (on buoys) | occasional records | fouling | hull fouling | E Pacific |
| Megabalanus sp. Barnacle | 2000 | France, Port of Cros, Mediterranean | unknown | unknown | unknown | W Pacific |
| Megabalanus tintinnabulum Barnacle | 1998 (earlier records known) | Belgium (on buoys) | occasional records annually until 2002 | fouling | hull fouling, range expansion | cosmopolitan |
| Melicertus hathor Prawn | 1997 | Israel, Haifa Bay, Ashdod & Palmahim | locally common | unknown | Suez Canal | Indian Ocean, Red Sea |
| Melicertus hathor Prawn | 2002 | Turkey, SE coast, Yumurtalik bight | occasional records | unknown | Suez Canal | Indian Ocean, Red Sea |
| Melita sp. Isopod | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water, hull fouling | cannot be determined on genus level |
| Merceneria merceneria Bivalve | 1995 (imported < 1900) | Netherlands | unknown | unknown | remains of imported and released populations | |
| Metapenaeopsis aegyptia Prawn | 1998 (first records in Med. in 1987 in Israel) | Greece, Rhodes Island | occasional records | unknown | Suez Canal, range expansion | |
| Metapenaeopsis mogiensis consobrina Prawn | 1996 | Israel | common | unknown | Suez Canal? | Indo-W Pacific, Red Sea to Indonesia |
| Metapenaeopsis mogiensis consobrina Prawn | 1998 | Greece, Rhodes Island | occasional records | unknown | Suez Canal? | Indo-W Pacific, Red Sea to Indonesia |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Metaxia bacillum Gastropoda | 1990s? (since 1978 in Israel) | Southern Turkey, from Gulf of Iskenderun to Tasuçu | established | unknown | Suez Canal, range expansion | Red Sea, Indo-Pacific |
| Micippa thalia Decapoda | 1994 | Turkey | rare | unknown | Suez Canal | Indo-W Pacific |
| Micippa thalia Decapoda | 1999 | Lebanon | unknown | unknown | Suez Canal | Indo-W Pacific |
| Micropogonias undulatus Fish | 1998 | Belgium | unknown | competition | unknown | NW Atlantic, USA - Mexico |
| Mnemiopsis leidyi Comb jelly | 2001 | Caspian Sea | established? | predation | ballast water? | W Atlantic |
| Morone saxatilis Fish | 1998 | Netherlands, Yssel Lake | single specimen | unknown | unknown | N America |
| Mugil labrosus Fish | 1998 | Poland, Puck Bay | single specimen | unknown | release? | E Atlantic, Scandinavia, Iceland S to Senegal & Cape Verde. Mediterranean, SW Black Sea |
| Mugil soiuy Fish | 1998 | Greece, N -east Thracian Sea & N Aegean Sea | single specimen | unknown | Introduced by humans for aquaculture in the Sea of Azov, Black Sea before entering to the Mediterranean (the northern Aegean Sea) via the Sea of Marmara. | Far-Eastern Asia, from Russia to China |
| Mugiligobius sp. Fish | 1993 | USA, Hawaii | unknown | unknown | ballast water | Philippines |
| Murchisonella columna Gastropoda | 1990s? | Turkey, near Tasuçu | occasional records | unknown | Suez Canal? No record from in Israel, i.e. ballast water introduction? | Indo-Pacific |
| Musculista senhousia Bivalve | 1997 | Canada, British Columbia, Barkley Sound, Vancouver Island | Uncommon scattered. Spreading. Species occurred in Pudget Sound USA since 1940s, but not in BC. | unknown | unknown | |
| Myicola ostraea Parasitic copepod | 1993 | Ireland | unknown | undulating oyster gill condition | live oyster imports from France | |
| Mytilicola orientalis Parasitic copepod | 1992 | North Sea | few localities | unknown | live oyster imports | N Pacific |
| Mytilicola orientalis Parasitic copepod | 1993 | Ireland | established | unknown | live oyster imports from France | |
| Mytilicola ostreae Parasitic copepod | 1992 | North Sea | few localities | unknown | live oyster imports | N Pacific |
| Mytilopsis leucophaeta Bivalve | 1994 | Belgium, Antwerp | established | fouling problems, clogging of water intakes | hull fouling, ballast water | America |
| Mytilopsis leucophaeta Bivalve | 1996 | United Kingdom, Cardiff docks | established | fouling problems | hull fouling, ballast water | America |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Mytilopsis sallei<br>Bivalve | 1998 | Australia, Darwin | established population was eradicated by chemical treatment | fouling problems | hull fouling, pleasure boats | |
| Nemopsis bachei<br>Cnidaria | 1994 | Netherlands | unknown | fouling? | oyster imports? | Pacific |
| Nemopsis bachei<br>Cnidaria | 1996 | Belgium, Zeebrugge | established, range extension | fouling? | oyster imports? | Pacific |
| Neogobius melanostomus<br>Fish | 1992 (first record in 1990) | Canada, Great Lakes, outside St. Claire river | spreading during the entire period of this report | competition | range expansion | Ponto-Caspian |
| Neogobius melanostomus<br>Fish | 1992 (first record in 1990) | USA, Great lakes, outside St. Claire river in Michigan & Erie Lakes until 1993, Lake Superior in 1995. | spreading during the entire period of this report | competition | range expansion | Ponto-Caspian |
| Neogobius melanostomus<br>Fish | 1999 | Germany, Ruegen Island, Baltic | occasional records | competition | secondary introduction? | Ponto-Caspian |
| Neogobius melanostomus<br>Fish | 1999 (first record in 1985) | Poland, Vistula Lagoon | established | competition | secondary introduction? | Ponto-Caspian |
| Neogobius melanostomus<br>Fish | 2002 (first record in 1990) | Gulf of Riga | unknown | competition | secondary introduction? | Ponto-Caspian |
| Neogobius melanostomus<br>Fish | 2002 (first record in 1990) | Lithuania, Curonian Lagoon | unknown | competition | secondary introduction? | Ponto-Caspian |
| Nuttalia obsurata<br>Bivalve | 1997 | Canada, British Columbia, Barkley Sound, Vancouver Island | established, spreading northwards | fishing on species considered | unknown | |
| Nuttalia obsurata<br>Bivalve | 2000 | USA, Washington, Oregon until Coos Bay | established | fishing on species considered | unknown | |
| Obesogammarus obesus<br>Amphipoda | 1995 | Germany | rare | unknown | ballast water? | Ponto-Caspian |
| Ocinobrellus inornatus<br>Gastropod | 1997 | France, Atlantic coast | established, spreading | oyster drill | shellfish trade or ballast water | NW Pacific |
| Olisthodiscus luteus<br>Phytoplankton, Rhaphidophycean alga | 1999 | Norway | unknown | harmful to fish? | unknown | |
| Oncorhynchus mykiss<br>Fish | 2001 | Finland | unknown | unknown | escapes from farm | E Pacific: Kamchatka |
| Ophryotrocha japonica<br>Polychaete | 1999 | Italy, Ravenna harbour | established, spreading | unknown | unknown | |
| Orchestia cavimana<br>Amphipod | 1999 | Estonia | established | unknown | secondary introduction | N Africa |
| Orconectes rusticus<br>Decapoda | 1995 (earlier records known) | Canada, Great Lakes | continues spreading | unknown | unknown | |
| Oreochromis niloticus<br>Fish | 2000 | USA, Mississippi region | unknown | unknown | Aquaculture escape | Africa |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Ostrea edulis<br>Bivalvia | 1992 | USA, Rhode Island, in 1996 in New Hampshire | established, continues spreading | unknown | range expansion, accidental release of larvae, ballast water | Europe |
| Oxyurichthys petersi<br>Fish | 1992 (since 1983 in Israel) | Turkey | common | unknown | Suez Canal, range expansion | Red Sea |
| Oxyurichthys petersi<br>Fish | 1995 (since 1983 in Israel) | Syria | common | unknown | Suez Canal, range expansion | Red Sea |
| Palaemonella rotumana<br>Prawn | 1999 (first record in Med 1948 in Israel | Turkey, Fethiye | occasional records | unknown | Suez Canal, range expansion | Indo-W Pacific, Red Sea to Hawaii |
| Palmadusta lentiginosa lentigginosa<br>Gastropoda | 1990 | Israel, Tel Aviv, Habonim & Palmahim | occassional records | unknown | Suez Canal? | Indian Ocean & Persian Gulf |
| Paracorophium brisbanensis<br>Amphipod | 2002 | New Zealand, Tauranga Harbour | unknown | unknown | shipping? | Australia |
| Paradexamine sp.<br>Isopod | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water, hull fouling | W Pacific? |
| Paralithoides camtschaticus<br>King crab, Decapoda | 1993 | N Norway | established, continues spreading during the entire period of this report | predator, fishing of species initiated with regular commercial catch in 2002 | range expansion from Russia. Deliberate release in Russia | Kamtschatka |
| Paranthura sp.<br>Isopod | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water, hull fouling | W Pacific? |
| Pecotus glehni<br>taxon? | 1999 | Poland, Vistula Lagoon & River | unknown | unknown | shipping | Ponto-Caspian |
| Penaeus vannamei<br>Shrimp | 1993 | USA, South Carolina | unknown | unknown | accidental release | Pacific |
| Percnon gibbesi<br>Decapod | 1999 | Italy, Sicily | established, locally common, spreading. In 2002 S coast of Sardinia, in 2003 Ionian coast of Calabria | competition | fishing, shipping | California to Chile, Florida to Brazil |
| Percnon gibbesi<br>Decapod | 1999 | Spain, Balearic Islands | established | competition | fishing, shipping | California to Chile, Florida to Brazil |
| Percnon gibbesi<br>Decapod | 2002 | Malta | established | competition | fishing, shipping | California to Chile, Florida to Brazil |
| Perkinsus atlanticus<br>Haplosporida | 1993 | Spain, mar Menor (first record in Mediteranean) | unknown | disease agent of oysters | mussel movements? | |
| Perna perna (viridis)<br>Bivalve | 1993 | USA, Texas reached Tampa Bay in 1999 | spreads eastwards | fouling | ballast water, hull fouling | Venezuela |
| Perna perna (viridis)<br>Bivalve | 1998 | Australia | eradication successful in 1998. New finding in | fouling | hull fouling | Venezuela |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | 2000 near Cairns | | | |
| Perophora japonica<br>Ascidian | 2000 | United Kingdom, Plymouth | established, spreading | fouling? | unknown | Japan |
| Petromyzon marinus<br>Cyclostomata | 2002 | Poland, Puck Bay | single specimen | unknown | range expansion | NE Atlantic, Mediterranean, Baltic & North Sea |
| Petroscirtes ancylodon<br>Fish | 2000 (since 1989 in Israel) | Turkey, Iskenderan Bay | single specimen | unknown | Suez Canal, range expansion | Red Sea to Arabian Gulf |
| Pfiesteria piscicida<br>Phytoplankton, Dinoflagellate | 2000 | New Zealand | unknown | potential for fish kill | unknown | possibly native |
| Pfiesteria piscicida<br>Phytoplankton, Dinoflagellate | 2002 | Norway, Oslo fjord | unknown | potential for fish kill | unknown | possibly native |
| Pfiesteria shumwayae<br>Phytoplankton, Dinoflagellate | 2002 | Norway, Oslo fjord | unknown | potential for fish kill | unknown | possibly native |
| Philine auriformis<br>Gastropod | 1992 | USA, San Francisco Bay | unknown | unknown | ballast water | New Zealand |
| Photobacterium damsela<br>Microbe | 1992 | Italy, N Adriatic Sea | spreading | causing Pasteurellosis & Nodavirus of fish. | imported with fish fry for aquaculture. | |
| Phyllorhiza punctata<br>Cnidarian | 2000 | USA, Gulf of Mexico, Atlantic coast of Florida. Indian River Lagoon (Cape Canaveral, Florida) in 2001 | established. Rare & sporadic in 2001-2002 | unknown | ballast water, hull fouling | tropical Pacific |
| Pinguipes brasilianus<br>Fish | 1990 | Itaky, Loano, Ligurian Sea, Messina | occasional records | unknown | unknown | Argentina, Uruguay, Brazil |
| Pisodonophis semicinctus<br>Eel | 1990s? (since 1958 in Algeria) | Italy, Strait of Sicily & Tyrrhenian Sea | unknown | unknown | range expansion | E Atlantic, Gibraltar to Angola |
| Pisodonophis semicinctus<br>Eel | 1990s? (since 1958 in Algeria) | Malta | unknown | unknown | range expansion | E Atlantic, Gibraltar to Angola |
| Pisodonophis semicinctus<br>Fish | 1999 | Italy | unknown | unknown | unknown | Atlantic |
| Planaxis savignyi<br>Gastropoda | 1990s? (<1905 in Egypt, Med.) | Israel, Haifa | established | unknown | Suez Canal, range expansion | Red Sea |
| Platichthys flesus<br>Fish, European Flounder | 1994 (earlier records known) | Canada, Ontario | occasional records | unknown | ballast water? | Europe |
| Pleurosira laevis f. polyphorma<br>Diatom, Phytoplankton | 1995 | Sweden in cooling water of power plants | unknown | unknown | eel stocking? | subtropical regions |
| Polycerella emertoni<br>Gastropod | 2000 | Greece | unknown | unknown | shipping | Atlantic |
| Polydora redeki<br>Polychaete | 1998 | Sweden, Oesthammer | unknown | unknown | range expansion (known from | |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | | | Finland since 1950s), shipping | |
| Polyodon spathula<br>Fish | 1999 | Poland, Szczecin Lagoon | single specimen | unknown | unknown | N America: Mississippi River system |
| Polysiphonia harveyi<br>Red alga | 1997 | USA, Massachusetts, Rhode Island | unknown | unknown | unknown | |
| Polysiphonia morrowii<br>Red alga | 1999 | Italy | spreading | unknown | unknown | Japan, China & Korea |
| Polysiphonia senticulosa<br>Red alga | 1993 | Netherlands, Oosterschelde | spreading | unknown | aquaculture | NE Pacific |
| Polysiphonia senticulosa<br>Red alga | 2001 | Belgium, Oostende | spreading | unknown | aquaculture | NE Pacific |
| Pontogammarus robustoides<br>Amphipod | 1994 | Germany | rare | unknown | ballast water? | Ponto-Caspian |
| Pontogammarus robustoides<br>Amphipod | 1998 (first record in 1988) | Poland, Szczecin Lagoon, Vistula River in 1999 | spreading eastwards | unknown | ballast water, canal migrant? | Ponto-Caspian |
| Porphyra yezoensis<br>Alga | 1996 - 1998 | USA, Maine | rare | unknown | imported for aquaculture, now outside culture facility. No indication to affect native *Porphyra*. | Japan |
| Portumnus latipes<br>Decapod | 2001 | Germany | occasional records | competition | range expansion | S North Sea to N Africa, Black Sea & Mediterranean |
| Portunus hastatus<br>Decapod | 1998 | France, Port Cros, Mediterranean | single specimen | predation | range expansion? | E Mediterranean |
| Potamopyrgus antipodarum<br>Gastropod | 1993 | Canada, Great Lakes | established | unknown | ballast water | New Zealand |
| Procambrus clarckii<br>Decapoda | 1992 | Portugal | wide-spread | unknown | range expansion | N America |
| Proterorhinus marmoratus<br>Fish | 1992 (first record 1990) | Canada, Great Lakes | spreading during the entire period of this report | unknown | shipping? | E Europe, Black Sea, Sea of Azov & Caspian Sea |
| Proterorhinus marmoratus<br>Fish | 2002 | Netherlands, Waal River | unknown | unknown | unknown | Ponto-Caspian |
| Protodorvillea egena<br>Polychaete | 2001 | Italy, Gulf of Noto, Sicily | unknown | unknown | unknown | S Africa |
| Psammotreta praerupta<br>Bivalve | 1992 | Turkey, off Adana | single specimen (four valves found) | unknown | Suez Canal questionable as not known from Israel. Shipping? | Indo-Pacific including Red Sea |
| Psenes pellucidus<br>Fish | 1990s? (since 1995 in Algeria) | France, Gulf of Lions & Provence | rare | unknown | range expansion from Spain | temperate & warm water of Atlantic, Indian & W Pacific Oceans |
| Psenes pellucidus<br>Fish | 1995 (since 1995 in Algeria) | Spain, BalearicBalearic Islands | rare | unknown | range expansion via Gibraltar | temperate & warm water of Atlantic, Indian & W Pacific oceans |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Pseudobacciger harengulae<br>Digene parasite | 1994 | Sweden, W coast | unknown, in ca. 20% of Herring catch | parasite | ballast water or with introduction of intermediate host (*Ensis directus*) | tropical to warm-temperate waters of Atlantic, Indic, Pacific & Black Sea |
| Pseudodactylogyrus anguillae<br>Trematoda | 1992 | Canada, Gulf of Maine, Nova Scotia | unknown | unknown | import of live eel | Asia, NW Pacific |
| Pseudodactylogyrus anguillae<br>Trematoda | 1995 | USA, Chesapeake Bay, Maryland, Cooper & Edisto Rivers, South Carolina | unknown | unknown | import of live eel, ballast water | Asia, NW Pacific |
| Pseudodactylogyrus bini<br>Trematoda | 1999 | USA, Cooper & Edisto Rivers, South Carolina | unknown | unknown | import of live eel, ballast water | Asia, NW Pacific |
| Pseudodiaptomus inopinus<br>Copepod | 1992 | USA, Oregon, Washington | abundant | unknown | ballast water | Asia |
| Pseudofabriciola filamentosa<br>Polychaete | 1986 | Italy, Porto Cesareo Lagoon, Ionian Sea, in 2001 in Salerno | spreading | unknown | Suez Canal | |
| Pseudominolia nedyma<br>Gastropoda | 1990s? (since 1966 in Israel) | Turkey, from Mersina to Tasuçu | established | unknown | Suez Canal, range expansion | Red Sea, Persian Gulf, Ceylon |
| Pseudonitzschia sp.<br>Phytoplankton, Diatom<br>causing Amnesic Shellfish Poisoning (ASP) | 1999 | Ireland, W coast | unknown | affecting *Pecten maximus* | live mussel trade? | cannot be determined on genus level |
| Pseudorambara parva<br>Fish | 1998 | Netherlands | unknown | unknown | release of aquarium spp. and canal migrant from Romania | Asia? |
| Pteragogus pelycus<br>Fish | 1999 | Greece, Rhodes Island | established | unknown | Suez Canal, range expansion | Red Sea to E Africa, Madagascar & Mauritius |
| Pteragogus pelycus<br>Fish | 2000 | Cyprus, N coast | unknown | unknown | Suez Canal, range expansion | Red Sea to E Africa, Madagascar & Mauritius |
| Pteragogus pelycus<br>Fish | 1992 | Israel, Haifa Bay | rare | unknown | Suez Canal | Red Sea to E Africa, Madagascar & Mauritius |
| Pterois miles<br>Fish | 1992 | Israel | single specimen | unknown | Suez Canal, aquarium release | Red Sea & E Indian Ocean |
| Pterois volitans<br>Fish | 1992 | USA, Biscayne Bay, Florida | occasional records since 1992. In 2001 juveniles collected from Long Island, persistent population off North Carolina | unknown | aquarium release, ballast water | Indo-Pacific |
| Punctaria tenuissima<br>Brown Alga | 1998 | Italy, Venice | established | competition | fishing | Atlantic |
| Pyrunculus fourierii | 1990s? (<1987 in | Cyprus | unknown | unknown | Suez Canal, range expansion | Indo-W Pacific, Red |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Gastropoda | Lebanon) | | | | | Sea |
| Questa caudicirra Polychaete | 1993 | Italy, Ponza Island, Tyrrhenian Sea, in 2001 in Gulf of Noto, Sicily | spreading | unknown | range expansion, ballast water? | Atlantic & Pacific coasts of America |
| Rapana venosa Gastropod | 1992 | North Sea, near Dogger Bank | single specimen | predation, mussel culture at risk | disposal from ship´s galley? | SE Asia |
| Rapana venosa Gastropod | 1997 (first records in 1973) | Adriatic Sea, N coast | spreading | predation, mussel culture at risk | hull fouling, ballast water, live oyster imports? Range expansion from Black Sea (first records 1947)? | SE Asia |
| Rapana venosa Gastropod | 1997 | France, Atlantic coast | occasional records during entire period of this report, eradication trial in 2000. New findings in 2001, including egg cases | predation, mussel culture at risk | hull fouling, ballast water, live oyster imports? Range expansion from Adriatic Sea (first records 1973)? Rapana was used to ballast culture bags of *Tapes philippinarum* transferred from Adriac. | SE Asia |
| Rapana venosa Gastropod | 1998 | USA, Chesapeake Bay | spreading during entire period of this report within the bay. Single specimens from Washington State in 1950s. | predation, mussel culture at risk | hull fouling, ballast water, live oyster imports? | SE Asia |
| Rapana venosa Gastropod | 1999 | Argentina, Rio de la Plata | not established | predation, mussel culture at risk | hull fouling, ballast water, live oyster imports? | SE Asia |
| Rapana venosa Gastropod | 1999 | Uruguay, Rio de la Plata | established | predation, mussel culture at risk | hull fouling, ballast water, live oyster imports? | SE Asia |
| Rhabdosargus haffara Fish | 1992 | Israel | rare | unknown | Suez Canal | Red Sea & Arabian Gulf |
| Rhinoclavis kochi Gastropoda | 1990s? (since 1963 in Israel) | Turkey, from Gulf of Iskenderun to Alanya | unknown | unknown | Suez Canal, range expansion | Red Sea, Indian Ocean Natal to NW Australia, W Pacific N Australia & New Caledonia |
| Rhithropanopeus harrisii Decapod | 1994 | Italy, Po River Delta, Adriatic | established, spreading. Reached in 2000 Italy, Emilia Romagna coast | unknown | ballast water, hull fouling | NW Atlantic |
| Rhithropanopeus harrisii Decapod | 1996 | United Kingdom, Cardiff | unknown | unknown | ballast water, hull fouling | NW Atlantic |
| Rhithropanopeus harrisii Decapod | 1999 | France, near Marseille | established, spreading | unknown | ballast water, hull fouling | NW Atlantic |
| Rhynchoconger | 1993 | Israel | occasional | unknown | Suez Canal | Red Sea |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| trewavasae Eel | | | records | | | |
| Rissoina bertholleti Gastropoda | 1990s? (since 1965 in Israel) | Southeast coast of Turkey, from Gulf of Iskenderun to Tasuçu | established | unknown | Suez Canal, range expansion | Red Sea & Indian Ocean |
| Rissoina spirata Gastropoda | 1990s? | Israel, Haifa | unknown | unknown | Suez Canal | Indo-Pacific |
| Sabia conica Gastropoda | 1990s (single shell in Israel 1980) | Italy, Sicily | single specimen | unknown | Suez Canal, range expansion | Red Sea, Indian Ocean, tropical Pacific |
| Sagartia elegans ssp. roseacae Anthozoan | 2000 | USA, Massachusetts | not spreading | unknown | hull fouling | Europe |
| Salmo salar Atlantic salmon | 1996 | Canada, British Columbia, Vancouver Island | occasional records until 2001. | hybridization | aquaculture escapes? | Atlantic |
| Sargassum muticum Brown alga | 1991 | Portugal, near Oporto | spreading, southwards | fouling | unknown | Asia |
| Sargassum muticum Brown alga | 1991 | United Kingdom, Cornwall, south-W coast of Wales in 1995 | established, spreading during the entire period of this report | unknown | oyster imports | |
| Sargassum muticum Brown alga | 1992 | Italy, Adriatic Sea near Venice | spreading | fouling | oyster imports, range expansion | Asia |
| Sargassum muticum Brown alga | 1992 | Norway, Skagerrak coast | spreading northwards, reached Bergen in 1993, Rogaland in 1997, Sognefjord 1998. Since 1998 no record of further spread. | fouling | range expansion? | Asia |
| Sargassum muticum Brown alga | 1992 drifting, 1995 attached | Sweden, W coast, southernmost record of attached plants in middle part of the Halland province | spreading until 1999. Since 1999 no major changes. | fouling | unknown | Asia |
| Sargassum muticum Brown alga | 1993 | Denmark, Kattegat | spreading | fouling | range expansion? | Asia |
| Sargassum muticum Brown alga | 1995 | United Kingdom, Northern Ireland | eradication trial since 1996 failed. spreading | fouling | oyster imports | |
| Sargassum muticum Brown alga | 1998 | Germany, near Sylt Island, North Sea | spreading | unknown | escapes from oyster farm | |
| Sargassum muticum Brown alga | 1999 | Belgium, Zeebrugge, Oostende | first record of attached specimens. Floating algae recorded since 1977. Not persisting. No records after 1999. | competition, habitat modification | oyster imports, secondary introduction | Japan |
| Sargassum muticum | 2001 | Ireland, SE coast, | spreading | fouling | oyster imports, | Asia |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Brown alga | | SW coast & W coast | | | range expansion | |
| Scardinius erythrophthalmus Fish | 1992 (first records 1990) | Canada, Great Lakes | occasional records | unknown | shipping? | Europe, Asia, North, Baltic Black, Caspian & Aral Seas |
| Seriola carpenteri Fish | 1990s | Italy | established | unknown | unknown | E Atlantic, Angola to Bay of Biscay |
| Seriola fasciata Fish | 1990s | Italy, southern Tyrrhenian Sea, off Sicily & Lampedusa in the Sicilian channel | rare | unknown | range expansion | Madeira & Canary Islands, Gulf of Mexico, Cuba, Puerto Rico & Bermuda |
| Seriola fasciata Fish | | Spain, Balearic Islands | unknown | unknown | range expansion via Gibraltar | Madeira & Canary Islands, Gulf of Mexico, Cuba, Puerto Rico & Bermuda |
| Seriola rivoliana Fish | 2002 | Italy | unknown | unknown | unknown | Atlantic |
| Serrasalmas nattereri Fish (Piranha) | 1992 | Canada, Lake Ontario | single specimen | unknown | accidental aquarium release | tropical S America |
| Serrasalmas nattereri Fish (Piranha) | 1993 | Germany, Elbe River | single specimen | unknown | accidental aquarium release | tropical S America |
| Silhouetta aegyptia Fish | 1999 (since 1970s in Med, Egypt) | Israel, Mediterranean, Ashdod | common | unknown | Suez Canal, range expansion | N Red Sea |
| Sillago sihama Fish | 1994 (since 1977 in Lebanon) | Turkey | Very common in the Eastern Levant | unknown | Suez Canal | Indo-Pacific, Red Sea E Africa to Korea, N Australia, to Solomon Islands |
| Sillago sihama Fish | 1994 (since 1977 in Lebanon) | Egypt | Very common in the Eastern Levant | unknown | Suez Canal | Indo-Pacific, Red Sea E Africa to Korea, N Australia, to Solomon Islands |
| Smaragdia souverbiana Gastropoda | 1990s? | SE Turkey | established | unknown | Suez Canal | Indo-Pacific, Japan, to Fiji, Tonga & Samoa in W Pacific, Indian Ocean, Red Sea |
| Solanema corona Cnidaria | 1997 | Shetland Islands | unknown | unknown | unknown | |
| Sphoeroides pachygaster Fish | 1992 (since 1981 in Spain, Mallorca) | Greece | common | unknown | range expansion via Gibraltar or Suez Canal | Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean |
| Sphoeroides pachygaster Fish | 1996 (since | Israel, Ashdod, Mediterranean | common | unknown | range expansion via Gibraltar or | Atlantic, Irish waters to S |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | 1981 in Spain, Mallorca) | coast | | | Suez Canal | Africa & New Jersey to Argentina. Indian Ocean |
| Sphoeroides pachygaster Fish | 1990 (since 1981 in Spain, Mallorca) | Italy, S Adriatic, Ionian Sea | common | unknown | range expansion via Gibraltar or Suez Canal | Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean |
| Sphoeroides pachygaster Fish | 1993 (since 1981 in Spain, Mallorca) | Tunesia | common | unknown | range expansion via Gibraltar or Suez Canal | Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean |
| Sphyraena chrysotaenia Fish | 1990s? (since 1931 in Israel) | Malta | established | unknown | Suez Canal | Indo-Pacific, Red Sea, E Africa, Madagascar & Seychelles to China & N Australia |
| Sphyraena flavicauda Fish | 1992 | Israel | occasional records | unknown | Suez Canal | Indo-Pacific, Red Sea, eastern Africa to Durban |
| Spondylus groschi Bivalve | 1990s? | Israel | established? | unknown | Suez Canal | E Africa, Red Sea & Persian Gulf |
| Spondylus spinosus Bivalve | 1990s? (since 1988 in Israel) | Turkey: Iskenderum | established | unknown | Suez Canal, range expansion | Indo-Pacific, Red Sea |
| Spring Viraemia of Carp Virus | 2002 | United Kingdom | unknown | fish disease | movement of live fish? | ? |
| Stephanolepis cf. dispros Fish | 1999 | Italy | unknown | unknown | Suez Canal? | Red Sea, Indo-W-Pacific |
| Stephanolepis diaspros Fish | 1993 (since 1927 in Israel) | Italy, Gulf of Palermo, Sicily | spreading | unknown | Suez Canal, range expansion | Red Sea to Arabian Gulf |
| Sticteulima cf. lentigginosa Gastropoda | 1990s? | Turkey, Aydincik & Tasuçu | occassional records | unknown | Suez Canal? | Indo-Pacific |
| Styela clava Ascidiacea | 1997 | Germany, Sylt island, North Sea | spreading | fouling | escaped from oyster farm | N Pacific |
| Styela clava Tunicate | 1998 | Canada, Prince Edward Island | established, mass development in 1999 + 2000 | fouling, competition with mussels for food | mussel or boat movements | Asia |
| Styloptygma beatrix Gastropoda | 1990s? (since 1988 in Turkey) | Israel | established, but rare | unknown | ballast water? | Persian Gulf |
| Syrnola cinctella Gastropoda | 1994 | Turkey, Yumurtalik Harbour | single specimen (two empty shells) | unknown | unknown | Indo-Pacific, Korea & Japan to the Persian Gulf & Red Sea |
| Syrnola fasciata Gastropoda | 1990s? (since 1958 in Israel) | Cyprus | established | unknown | Suez Canal, range expansion from population in Turkey or Israel | Indo-Pacific |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| Teredo navalis<br>Bivalve | 1994 | Germany, Baltic | first record of free living larvae | unknown | unknown | tropical coasts of Asia? |
| Tetraodon fluviatilis<br>Fish | 2001 | Belgium, off shore | unknown | unknown | aquarium release | Asia |
| Thais lacerus<br>Gastropoda | 1990s?<br>(since <1939 in Egypt) | | unknown | unknown | Suez Canal questionable as no occurrence in Red Sea. Ballast water? | Indian Ocean & Persian Gulf |
| Thalamita poissonii<br>Decapoda | 1994<br>(first record in Med in Israel 1952) | Greece, Crete | locally common | unknown | Suez Canal, range expansion | Indo-W Pacific, Red Sea to Taiwan |
| Tinca tinca<br>Fish | 2000 | Canada, near St. Lawrence River | few specimens | unknown | escaped from aquaculture pond | Europe, Arctic Ocean drainage, Lake Baikal |
| Tortanus sp.<br>Copepoda | 1993 | USA, San Francisco Bay | unknown | unknown | ballast water | cannot be determined on genus level |
| Trachysalambria palaestinensis<br>Prawn | 1998<br>(earlier records 1924 Israel, 1960s Turkey, 1970s Egypt, 1990s Tunesia | Greece, Rhodes Island | established | species is of commercial interest, compedes with other Red sea prawns | Suez Canal, range expansion | Red Sea |
| Trachyscorpia cristulata chinata<br>Fish | 1990s?<br>(since 1962 in Marocco) | Spain, Balearic Islands | rare | unknown | range expansion via Gibraltar | E Atlantic, Ireland to Angola & Namibia |
| Tricellaria inopinata<br>Bryozoan | 1998 | Southern England | established, abundant | fouling, competition | hull fouling | Indo-Pacific |
| Tricellaria inopinata<br>Bryozoan | 2000 | Belgium<br>(various ports) | occasional records, range extension | fouling, competition | fouling on pleasure crafts, range expansion | Indo-Pacific |
| Tricellaria inopinata<br>Bryozoan | 2000 | France, the Netherlands | established | fouling, competition | hull fouling, range expansion | Indo-Pacific |
| Trochus erythreus<br>Gastropoda | 1990s?<br>(since 1968 in Israel) | Greece, Crete | established, spreading | unknown | Suez Canal, range expansion | Red Sea, Gulf of Aden & Persian Gulf |
| Trochus erythreus<br>Gastropoda | 1990s?<br>(since 1968 in Israel) | Turkey Gulf of Iskenderun | established, spreading | unknown | Suez Canal, range expansion | Red Sea, Gulf of Aden & Persian Gulf. |
| Turbonilla edgarii<br>Gastropoda | 1990s?<br>(since 1980 in Israel) | Cyprus | established | unknown | Suez Canal, range expansion from population in Turkey or Israel | Indo-Pacific |
| Undaria pinnatifida<br>Brown alga | 1992 | Italy, Adriatic Sea, near Venice, records near Bari in 1999 | established, spreading | competition with other algae, problems with harvesting/ dredging of oysters, | mussel movements, hull fouling? | Japan |

| Species (including higher taxon) | Year of first record | Region of first record | Population status | Impact or potential impact | Likely introducing vector | Native range |
|---|---|---|---|---|---|---|
| | | | | habitat modification | | |
| Undaria pinnatifida<br>Brown alga | 1992 (first record in 1981) | Spain, Ria de Arosa | established | unknown | range expansion | Japan |
| Undaria pinnatifida<br>Brown alga | 1994 | United Kingdom, Hamble estuary, Isle of Wight by 1997 | established, continued spreading during the entire period of this report | unknown | oyster movements, range expansion? | Japan |
| Undaria pinnatifida<br>Brown alga | 1996 | Australia, near Melbourne (former in Tasmania in 1988) | unknown | unknown | hull fouling. Unlikely introduced from Tasmania, but from New Zealand or Asia | Japan |
| Undaria pinnatifida<br>Brown alga | 1998 | Belgium, Zeebrugge | occasional records, not spreading | unknown | fouling on pleasure crafts, range expansion | Japan |
| Undaria pinnatifida<br>Brown alga | 1999 | Netherlands, Oosterschelde | spreading fast since 2000 | unknown | unknown | Japan |
| Undaria pinnatifida<br>Brown alga | 1999 | USA, Santa Barbara Harbor; Cabrillo Beach (San Pedro); Channel Islands Harbor (Oxnard), southern California | established | unknown | ballast water, hull fouling | Japan |
| Veneruperis philippinarum<br>Bivalve | 1994 | United Kingdom, south coast | established | unknown | range expansion from aquaculture areas | Philippines |
| Veneruperis philippinarum<br>Bivalve | 1998 | Norway | occasional records | unknown | records at aquaculture site, operation terminated in 1991 | Philippines |
| Vibrio heamolyticus<br>Disease agent | 1994 | Netherlands, near Amsterdam | unknown | disease agent affecting humans | life eel imports | ? |
| Vimba vimba<br>Fish | 2001 | Belgium | occasional records | competition | bait imports, range expansion | Black, Caspian & Azov Seas |
| Viral Haemorrhagic Septicaemia(VHS)<br>Disease agent | 2000 | Finland & Baltic | first observation | disease of rainbow trout in fish farms | unknown. Herring stocks suspected | ? |
| Viral Hemorrhagic Septicaemia (VHS)<br>Disease agent | 1995 | Scotland | disease of turbot (*Scophthalmus maximus*) | unknown | unknown | ? |
| Womersleyella setacea<br>Alga | 1993 | Spain, Balearic coasts of Cabrera Island | spreading, Alboran Island in 1995, Menorca in 1997 | competition and fisheries | unknown | |
| Xenostrobus secures<br>Bivalve | 1992 | Italy, Ravenna Lagoon, Venice Lagoon | established | unknown | shipping | Australia, New Zealand |

# Annex 2 Participants of WGITMO Meetings 1992-2002 per country.

| Country | Name | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | Colgan | | | | | | | | X | | | |
| | Goggin | | | | | | X | | | | | |
| | Hewitt | | | | | | | X | | | | |
| | Lockwood | | | | | | | X | | | | |
| | Oemcke | | | | | | | X | | | | |
| | Rigby | | | | | | | X | | | | |
| | Thresher | | | | | | X | | | | | |
| Belgium | Kerckhof | | | | | | | | | | X | X |
| Bermuda | Knap | | | | | | | X | | | | |
| Canada | Arthur | | | | | X | | | | | | |
| | Campbell | | X | X | | X | X | X | X | | | |
| | Carey | X | X | X | | | | | | | | |
| | Cook | | | X | | | | | | | | |
| | Dermott | X | | | | | | | | | | |
| | Gilbert | | | | | | X | X | X | | X | |
| | Kieser | | | X | X | X | | X | X | X | X | X |
| | Randall | | X | | | | X | | | | | |
| Estonia | Eero | | | | | | | | | X | | |
| | Ojaveer | | | | | X | | | X | X | X | |
| | Pollumäe | | | | | | | | | X | | |
| Finland | Leppäkoski | | | | | X | | | | X | | |
| | Rahkonen | X | | X | | | | | | | | |
| | Tuunainen | | | | | | | | X | | | |
| | Urho | | | | | | | | | | X | |
| France | Goulletquer | | | | | | X | X | | X | | |
| | Grizel | X | X | | X | | X | | | | X | |
| | Heral | | | | | | X | | | | | |
| | Masson | | | | | | | | X | | | |
| | Meinesz | | | | | | X | | | | | |
| | Noel | | | | | | X | | | | | |
| | Thibaut | | | | | | X | | | | | |
| Georgia | Gogothishvili | | | | | | | | X | | | |
| | Shotadze | | | | | | | X | X | | X | |
| | Tengiz | | | | | | | | | | X | |
| Germany | Dammer | | X | | X | | | | | | | |
| | Gollasch | | X | X | X | X | X | X | X | X | X | X |
| | Huelsmann | | | | X | | X | X | X | | | |
| | Rosenthal | | | | X | | | | | | | X |
| | Schulz | | | | | X | | | | | | |
| Ireland | Clarke | | | | | | | | | X | | |
| | Minchin | X | X | X | X | X | X | X | X | X | X | X |
| Israel | Abelson | | | | | | | X | X | | | |
| | Galil | | | | | | | X | | | | |
| Italy | Occhipinti | | | | | | | | X | X | X | X |
| | Relini | | | | | | | X | | | | |
| Lithuania | Olenin | | | | X | X | | X | | | | |

| Country | Name | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Netherlands | de Groot | | | | | | | X | X | | | |
| | Weststeyn | | | | | | | | | X | X | |
| New Zealand | Hall | | | | | | | X | | | | |
| | Hay | | | | | | | X | | | | |
| Norway | Botnen | | | | | | | X | | | | |
| | Jelmert | | | | | | X | X | X | X | X | |
| | Jörgensen | | | | | | | | | | | X |
| | Jorstad | | | | | X | X | X | | | | |
| | Loennechen | | | | | | | | X | | | |
| | Tilseth | | X | X | | | | | | | | |
| Poland | Gruszka | | | | | X | | | | | | |
| | Janta | | | | | X | | | | | | |
| | Pelczarski | | | | | X | | | | X | | |
| | Sapota | | | | | X | | | | | | |
| | Skora | | | | | X | | | | | | |
| | Sobol | | | | | X | | | | | | |
| | Wolowicz | | | | | X | | | | | | |
| Portugal | Brogueira | X | | | | | | | | | | |
| | Cabecadat | X | | | | | | | | | | |
| | Figueiredo | X | | | | | | | | | | |
| | Ruano | X | | | | | | | | | | |
| Russia | Karasiova | | | | | X | | | | | | |
| Spain | Pages | | | | | | | | | | X | |
| | Ribera | | | | | | X | | | | X | |
| Sweden | Carlberg | | | | | | | | | | | X |
| | Dybern | X | X | | X | X | | | | | | |
| | Holmberg | X | X | | | X | X | | | | | |
| | Jansson | | | | X | X | X | X | | | | |
| | Nordwall | | | | | | | | | | | X |
| | Sparrevik | | | | | | | | | X | X | |
| | v. Wachenfeld | | | | | X | | | | | | |
| | Wallentinus | X | X | X | X | X | X | X | X | X | X | X |
| United Kingdom | Dyrynda | | | | | | | | X | X | | |
| | Eno | | | | X | X | X | X | X | | | |
| | Frazer | | X | | | | | | | | | |
| | Hamer | | | | | | X | | | | | |
| | Hayes | | | X | X | | | | | | | |
| | Laing | | | | | | | | X | | | |
| | Lucas | | | | | | | X | X | | | |
| | Macdonald | | | | | | | X | | | | |
| | McCollin | | | | | | X | X | X | | | |
| | McGillivary | | X | | | | | | | | | |
| | McVicar | | X | | | | | | | | | |
| | Mueller | | | | X | | | | | | | |
| | Munro | X | X | | | | | | | | | |
| | Side | | X | | | | | | | | | |
| | Utting | X | X | X | X | | X | X | X | X | | |
| USA | Allen | | | X | | | | | | | | |
| | Cangelosi | | | | | | | X | | | | |
| | Carlton | X | X | X | X | X | X | X | X | X | | |

| Country | Name | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crawford | | | X | | | | | | | | |
| | Dehalt | | | | | | | | X | | | |
| | Goldman | | | X | | | | | | | | |
| | Gollamudi | | | | | | X | | | | | |
| | Harbison | | | X | | | | | | | | |
| | Holohan | | | | | | | X | | | | |
| | Joseph | | | X | | | | | | | | |
| | Kern | | | X | | | | | | | | |
| | Kopp | | | | | | | X | X | | | |
| | Levine | | X | | X | X | X | | X | | | |
| | Lindell | | | X | | | | | | | | |
| | Mann | | | | | | | | X | | | X |
| | Miller | | | | | | | X | | | | |
| | Pederson | | | | | | | X | | | | X |
| | Ruiz | | | | | | | | | | X | X |
| | Smith | | | X | | | | | | | | |
| | Tinsman | | | X | | | | | | | | |
| International Maritime Organization | Nauke | | | | | X | X | X | X | | | |
| **Total** | | **15** | **19** | **21** | **17** | **27** | **28** | **37** | **30** | **18** | **18** | **13** |

# Annex 9: Alien Species Alert: on *Undaria pinnatifida* (wakame or Japanese kelp)

The following image is the authors suggestion for the title page pf the report.

*Undaria pinnatifida* in Monterey, California, USA

Photo by courtesy of Steve Lonhart, Monterey Bay National Marine Sanctuary, USA

# Alien Species Alert: on *Undaria piNnatifida* (wakame or Japanese kelp)

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## 1 Introduction

The Japanese kelp, *Undaria pinnatifida* (Harvey) Suringar 1873, is native to the NW Pacific. It first turned up on another continent (for details see Section 4), as an unintentional introduction, when oysters were brought from Japan to the French Mediterranean coast. In the early 1980s it was intentionally introduced from the Mediterranean Sea for farming in Brittany, NW France, from where it later dispersed to other European countries. In the late 1980s it was recorded both from New Zealand and Australia, being brought by shipping from Asia, which was also the vector for its spread to Argentina in the early 1990s. In the early 2000s it occurs on all continents except – so far – in Africa and the Antarctica (Table 1).

**Table 1. Distribution of *Undaria pinnatifida* in early 2006**

| Ocean | Area | Vector | 1st record | Eradication / management tried |
|---|---|---|---|---|
| NW Pacific | Japan (excl. N & E Hokkaido) | *Native* | – | – |
| | Korea | *Native* | – | – |
| | SE Russia | *Native* | – | – |
| | NE China | *Native* | – | – |
| | China, elsewhere | Farming | 1930s | – (?) |
| | Taiwan | Farming | 1981 | – (?) |
| N Mediterranean | S France | With oysters | 1971 | – |
| | NE & S Italy | With oysters or shipping | 1992 | Tried experimentally in Venice, failed but recommended |
| NE Atlantic | NW France | Farming | 1983 | – |
| | N Spain | With oysters | 1990 | – (?) |
| | S U.K. | Recreational boats | 1994 | Tried and failed |
| | The Netherlands | With oysters or shipping | 1999 | Cleared in mussel harvest areas |
| | Belgium | Boats? | 1999 | – |
| | Portugal | ? | 200X | ? |
| SW Pacific & Tasman Sea | New Zealand | Shipping (ballast or hull) | 1987 | Tried, limited success |
| | Australia | Shipping (ballast) | 1988 | Tried in marine reserve + harvest |
| SW Atlantic | Argentina | Shipping | 1992 | Not tried; recommended |
| E Pacific | California | Shipping | 2000 | Tried in some harbours |
| | Mexico | ? | 2003 | ? |

The size of this canopy species and its beltforming growth pattern, its great tolerance for surviving adverse conditions, and its high affinity to grow on artificial substrates, have made it one of the main target species for biosecurity (see also e.g. Hewitt *et al.*,, 2005; GISD, 2006). Fletcher and Farell (1998) listed eight characters, which have contributed to its success:

* Ability to rapidly colonize new or disturbed substrate (pioneering species)

* Ability to colonize a wide range of artificial structures
* Ability to colonize a wide range of substrate, including plants and animals
* Fast growth rate, resulting in sporophytes with a large canopy
* Large reproductive output, where spore release may occur all year round
* Plants may be present all year
* Wide physiological tolerances for temperature, light and salinity
* Wide vertical distribution

For a summary of ecological interactions found in different areas see Table 2 (at the end).

In a paper ranking specific traits of 113 seaweeds introduced into Europe for the three main categories: dispersal, establishment and ecological impact, *U. pinnatifida* overall was the third most invasive seaweed (Nyberg and Wallentinus, 2005). When ranking introduced marine animals and algae with the highest human, economic and environmental impacts for all species already present in Australia, *U. pinnatifida* would rank ninth, if the maximum scores were used (Hayes *et al.*, 2005).

However, *U. pinnatifida* is also the third most harvested and cultivated seaweed, being used for human consumption (e.g. Yamanaka and Akiyama, 1993, Zemke-White and Ohno, 1999, Wu *et al.*, 2004). It is also used as food item for cultured abalone (e.g. Lee, 2004).

Voisin and coworkers (2005), using two intergenic noncoding mitochondrial loci, studied within-species genetic variation of *U. pinnatifida*, and 25 haplotypes were found over the whole dataset (524 individuals and 24 populations). In the native range, there was a low diversity within, and a high differentiation among populations, a pattern not observed in the introduced range of this species. Contrary to classical expectations of founding effects associated with accidental introduction of exotic species, most of the introduced *U. pinnatida* populations showed high genetic diversity. At the regional scale, genetic diversity and sequence divergence showed contrasting patterns in the two main areas of introduction (Europe and Australasia), suggesting different processes of introduction in the two regions. Gene genealogy analyses pointed to aquaculture as a major vector of introduction and spread in Europe, but implicated maritime traffic in promoting recurrent migration events from the native range to Australasia. The multiplicity of processes and genetic signatures associated with the successful invasions, confirmed that multiple factors, e.g., aquaculture practices (e.g. several strains can have been imported), alteration of habitats, and increased traffic, have acted in synergy at the worldwide level, facilitating successful pandemic introductions. That different processes were involved in different areas, was confirmed by Daguin and coworkers (2005), who used microsatellite markers, for populations from Japan, France and New Zealand.

# 2 IDENTIFICATION

| | |
|---|---|
| Phylum: | Heterokontophyta |
| Class: | Phaeophyceae |
| Order: | Laminariales |
| Family: | Alariaceae |
| Genus: | **Undaria** |
| Species: | *pinnatifida* |

**Old synonyms:**
*Alaria pinnatifida* Harvey 1860
*Ulopteryx pinnatifida* (Harvey) Kjellman 1885

Common names (according to GISD, 2006):

Wakame (Japanese); miyeuk (Korean); haijiecai, qundaicai (Chinese); Japanese kelp, Asian kelp, apron-ribbon vegetable (English).

## 2.1 Characteristics of different stages of *Undaria pinnatifida*

Like other kelps in the order Laminariales, the species has a heteromorphic, diplohaplontic life cycle (Figure 1), with a large sporophyte and separate, microscopic female and male gametophytes. In most areas the sporophyte reaches a total length (Figure 2a) of 1 to 2 or even 3 metres (Okamura, 1926; Peréz *et al.*, 1984; Hay, 1990; Sanderson 1990; Floc'h *et al.*, 1991; Hay and Villouta, 1993; Casas and Piriz, 1996; Castric-Fey and L'Hardy-Halos, 1996; Castric-Fey *et al.*, 1999a, 1999b). However, it is usually less than 1 metre in the Mediterranean Sea (Boudouresque *et al.*, 1985; Curiel *et al.*, 1998, 2002), on the Spanish coast (Santiago Caamaño *et al.*, 1990), in some populations in New Zealand (Hay and Villouta, 1993; Brown and Lamare, 1994), and in Victoria, Australia (Campell and Burridge, 1998), as well as in waters with high turbidity (e.g. Floc'h *et al.*, 1996; Curiel *et al.*, 2002).

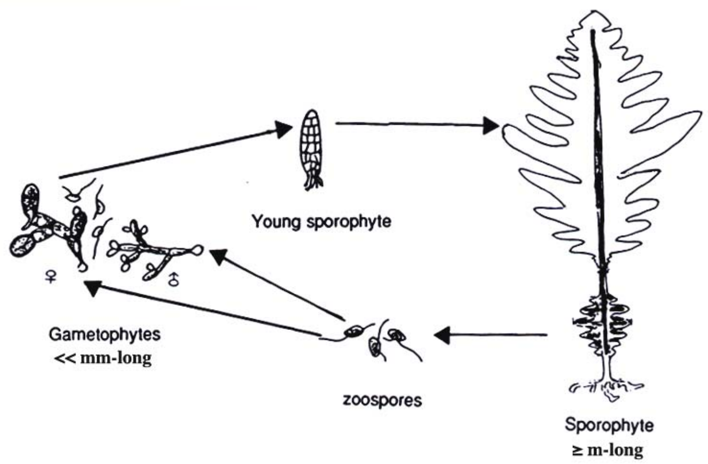


**Figure 1. The life cycle of *Undaria pinnatifida***

The sporophyte has a yellowish-brown to brown, membraneous to leathery lamina, becoming greenish olive when drying. The stipe, forms with short or long stipes can occur together (e.g. Castric-Fey *et al.*, 1999a), is lighter in colour and attached by root-like hapters, as for most other kelps (Figure. 2b). The length of the stipe, in some introduced areas, is around 10 to 50 % of the total length (Castric-Fey *et al.*, 1999b, Stuart *et al.*, 1999).

a) b)

**Figure 2. *Undaria pinnatifida*. a) Mature alga, almost 2 m long, with sporophylls all along the stipes, Monterey, California. Photo by courtesy of Steve Lonhart, Monterey Bay National Marine Sanctuary; b) Details of hapters and sporophylls on the base of the stipes on sporophytes from Venice. Photo by courtesy of Davide Tagliapietra, ISMAR CNR, Venezia.**

The ca. 50–80 cm broad lamina is pinnate, but the forming of lobes can sometimes be surpressed (Okamura, 1926), with an evident midrib all way through, which can be up to 1–3 cm wide. Very young plants (cm-long) lack a midrib (Figure 3b). As in other kelps, the growing zone is located between the top of the stipe and the lamina, making the top of the lamina the oldest part. The basal part of the mature sporophyte develops two undulated, winglike, frilly sporophylls (one along each side of the stipe, but they may become interleaved and look like one unit; Figure 2 b) with zoosporangial sori, producing millions of spores per gram tissue (Saito, 1975; but cf. also 4.4.4).

*U. pinnatifida* has an annual life cycle. Photosynthesis slows down and growth stops in most areas at high water temperatures (see below), when most of the lamina deteriorates, and the stipe and holdfast usually disappear during the end of summer (Saito, 1975;Boudouresque *et al.*, 1985; Brown and Lamare, 1994; Casas and Piriz, 1996; Oh and Koh, 1996; Castric-Fey *et al.*, 1999b), but may also persist (Hay and Villouta, 1993; Thornber *et al.*, 2004). Some introduced populations have two to several generations during a year, i.e. both small and large sporophytes are found together (Hay, 1990; Floc'h *et al.*, 1991; Castric-Fey *et al.*, 1993; Hay and Villouta, 1993; Casas and Piriz, 1996; Castric-Fey *et al.*, 1999b). The species is not known to reproduce vegetatively by fragmentation. However, asexual reproduction through unfertilized eggs, which can develop into parthenogenetic sporophytes, has been recorded in laboratory experiments (Yabo, 1964; Fang *et al.*, 1982). During the early 1990s, a technique, using mass cultivation of fragmented gametophytic clones, was developed to produce new young sporophytes for cultivation (Liu *et al.*, 2004; Wu *et al.*, 2004).

The microscopic gametophytes (Figure 1) are very difficult to spot in the field due to their minute size. There are also reports that they may sometimes occur endophytically in some filamentous red algae (Kim *et al.*, 2004). The female gametophytes consist of only one to a few cells, bearing the oogonia, and the male of some more, smaller cells, bearing antherida. The gametophytes may have a dormancy period and thus could act as a seed bank (Thornber *et al.*, 2004; Hewitt *et al.*, 2005), especially at low light, and they are capable of surviving adverse conditions as thick-walled resting stages (Saito, 1975). After fertilization young sporophytes develop, at first attached to the female gametophyte. Liu and coworkers (2004) showed that disturbance by light, as low as 5–6 µmol photons $m^{-2}$ $s^{-1}$, caused detachment of eggs from the female gametophytes, and those eggs did not develop into sporophytes. Very young sporophytes (<5–10 cm) lack a midrib (Figure 3b), but from a size of about 1 cm they are distinguishable from those of other kelps through their glandular cells (Yendo, 1909, 1911; Okamura, 1926; Castric-Fey *et al.*, 1999a), appearing as small dark dots visible at close inspection (Figure 4).

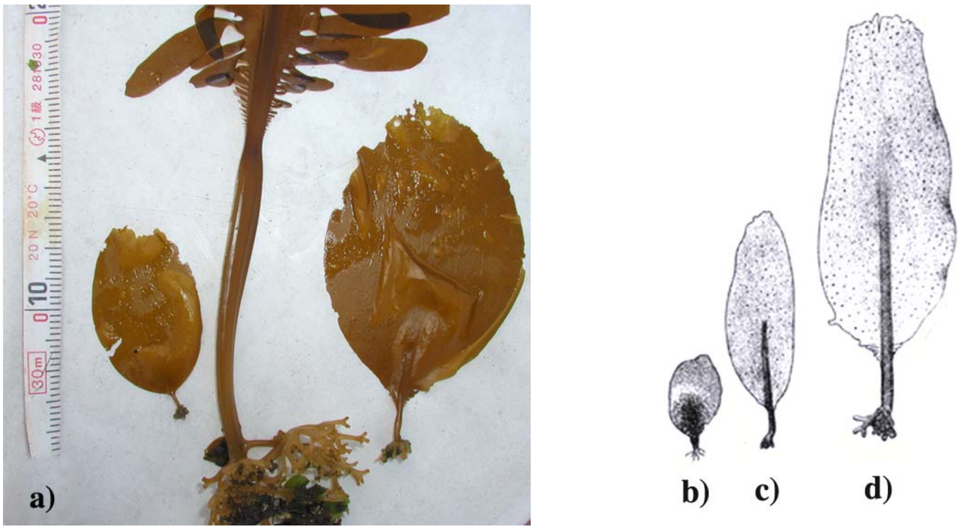


**Figure 3. a) Sporophytes of different ages, Monterey, California. Photo by courtesy of of Steve Lonhart, Monterey Bay National Marine Sanctuary; b) Very young sporophyte without a midrib (Okamura, 1926), c–d) young sporophytes with a midrib (Yendo, 1911).**

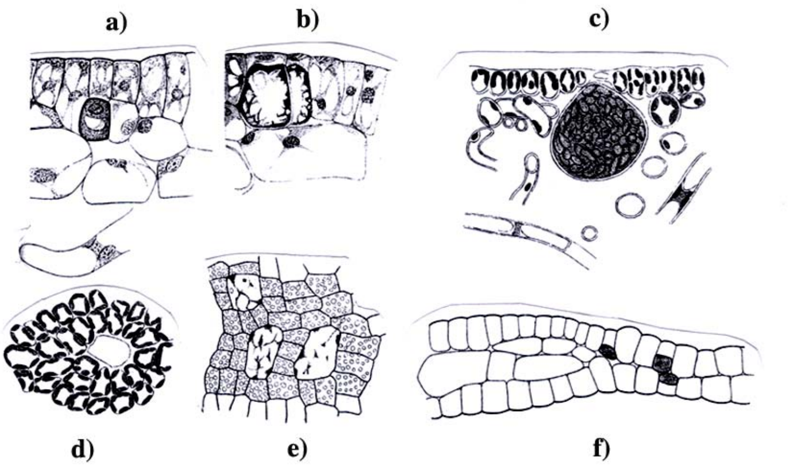


**Figure 4. a) Young gland cell in transverse section, b) two older gland cells in transverse section, c) mature gland cell in transverse section, d) young gland cell seen from the surface, e) older gland cells seen from the surface, f) three gland cells in a transverse section of a pinnula. [a-d) from (Yendo, 1909); e) from Okamura, 1926; f) from (Yendo, 1911)]. See also drawings by Castric-Fey and coworkers (1999a).**

The species include at least two morphological forms f. *typica* Yendo and f. *distans* Miyabe and Okamura, the latter with a longer stipe and its sporophylls often do not reach all the way up to the lamina (Okamura, 1926). Guiry and coworkers (2006) listed two varieties *U. pinnatifida* var. *vulgaris* Suringar 1872 and *U. pinnatifida* var. *elongata* Suringar 1872, which may correspond to the two forms above. It has been discussed, if these forms may also be genetically different (Hay and Villouta, 1993; Castric-Fey *et al.*, 1999a). However, according to Uwai and coworkers (2006) genetic analyses did not support the two forms. Furthermore, Stuart and coworkers (1999) studied the effects of seasonal variation in growth rate on the morphology of *U. pinnatifida* to define the form growing in Otago Harbour, New Zealand, by using correspondence analysis. They found that the variation in morphology was largely accounted for by varying growth rates. Thus, they considered it equivocal to define the form of *U. pinnatifida* growing in Otago Harbour, since morphological characteristics of both f. *typica* and f. *distans* could be found at different times of the year.

## 2.2 Species that can be misidentified as *Undaria pinnatifida*

There are two other species of the genus *Undaria*: *U. undarioides* (Yendo) Okamura 1915, occurring in Japan, being broader and more ovate with less lobes (e.g. Okamura, 1926), and *U. crenata* Y-P Lee and JT Yoon 1998, described from Korea. A third species in these areas, *U. peterseniana* (Kjellman) Okamura 1915, has later been moved to the genus *Undariella* (Guiry *et al.*, 2006). Compared to *U. pinnatifida* this species has a long, rounded or oblong-shaped lamina with entire margins (e.g. Okamura, 1926). These species might be misidentified as *Undaria pinnatifida*, but they are not known to have been introduced to other regions.

The grown-out sporophytes of *U. pinnatida* are very characteristic, with an evident, midrib (Figure 2a) and can hardly be misidentified in European waters. The only other European kelp with a midrib in the lamina is the much more narrow and up to 4 m long plant of *Alaria esculenta* (L.) Greville 1830, with an entire lamina not split into pinnate lobs, although the lamina might look lobed in an eroded state. The two species are also easy to separate by the form of the sporophylls. The genus *Alaria*, comprising several circumboreal species (Guiry *et al.*, 2006; also images available) ranging from 0.15 to 15 m, of which *A. marginata* is common along the North-American west coast, is characterized by several dm-long, thick, leaflike sporophylls at the base of the stipe, protruding from each side, being much different from the undulated “frills” of *U. pinnatida.* However, the margin of the lamina of *A. marginata* may be winged. Undulated, winglike sporophylls along the stipe are also developed in the genus *Saccorhiza*, especially on *S. polyschides* (Lightfoot) Batters 1902, while they may not occur on *S. dermatodea* (Bachelot de la Pylaie) J. Agardh 1868 (for distributions and images, see Guiry *et al.*, 2006). *S. polyschides* is often growing together with *U. pinnatifida* in European waters. However, *S. polyschides* lacks a midrib and has a lamina deeply cleft into many linear, vertical segments and young plants do not have glands cell. Furthermore, its characteristic bell-shaped, warted basal area above the disc, with short attaching hapters, differs much from the long, branched, root-like hapters of *Undaria* and other kelps. For very young *Undaria* sporophytes, without a well-developed midrib, see above about the special gland cells. A midrib, but no separate sporophylls at all, is also seen in some other North-American Pacific kelps, such as *Pleurophycus gardneri* Setchell and Saunders ex Tilden 1900, and *Dictyoneuropsis reticulata* (Saunders) G.M. Smith 1942 (for images see Guiry *et al.*, 2006). Some smaller species of the genus *Ecklonia*, which above all is common in the warm temperate areas of the southern hemisphere, but also in the NW Pacific (for distribution and images, see Guiry *et al.*, 2006), might be mistaken for *U. pinnatifida*. However, they do not have a midrib, but the often quite narrow primary blade (e.g. *E. radiata* (C. Agardh) J. Agardh 1848) has rows of lateral blades, which superficially might look like *Undaria*. Furthermore, there are no separate sporophylls at the base of the *Ecklonia* plants, and the reproductive sori are formed primarily, but not exclusively, on the secondary blades.

# 3 Biology in the native range

*Undaria pinnatifida* is native along the northwestern Pacific shores: along most of the coasts of Japan, excl. N and E Hokkaido (Okamura, 1926; Saito, 1975; Uwai *et al.*, 2006), Korea

(Kang, 1966), some northeastern parts of China (Tseng, 1981; Zhang *et al.*, 1984) and in southeast Russia in Peter the Great Bay near Vladivostok (Funahashi, 1966; 1974, Prestenko, 1980) and in the Okhotsk Sea (Zinova, 1954).

## 3.1 Current status, population demographics and growth rate

Most of the recent literature from the native areas deals with farmed *U. pinnatifida*, and thus more information is needed to elucidate densities, population dynamics and growth rates of wild plants today (see next paragraph on hybridization between wild and farmed plants).

Uwai and coworkers (2006) studied the intraspecific genetic diversity of the kelp *U. pinnatifida* in plants from 21 localities along the Japanese coast, using DNA sequences of the mitochondrial cytochrome oxidase subunit 3 (cox3) gene and internal transcribed spacer 1 (ITS1) of nuclear ribosomal DNA. They found 9 haplotypes (106 plants analyzed) that differed from each other by 1–7 base-pairs, Haplotype I was distributed in Hokkaido and on the northern Pacific coast of Honshu, while haplotype III was found along the Sea of Japan coast of Honshu. Other types were found along the central and southern coasts of Honshu. Along the Sea of Japan and on the northern coasts, there was a lower genetic differentiation, which might be due to the recent establishment (after the middle of the last glacial period) of the flora of the Sea of Japan. The haplotype of cultivated plants was found also in natural populations occurring close to cultivation sites, which suggested that cultivated plants possibly had escaped and spread or crossed with wild plants. There were no correlations between morphological characters and cox3 haplotypes.

In the South Korean Yeongil Bay, Yoo (2003) reported *U. pinnatifida* to be one of three brown algae dominating the biomass in the subtidal, occurring both in the upper and mid subtidal zone.

At the northern distribution limit of *U. pinnatifida* in Peter the Great Bay, the Sea of Japan, Russia, the growth, morphology, alginate yield and composition of *U. pinnatifida* were studied from March to August by Skriptsova and coworkers (2004), who found an average sporophyte growth rate of 2–5% d-1 and that sporulation caused changes in morphology, alginate yield and composition.

## 3.2 Natural history (tolerance limits for abiotic factors) in the native region

### *Substrate and depth*

According to Saito (1975), *U. pinnatifida* grows naturally at rocks and reefs from ca. 1–15 m depth. On the coast of Hokkaido, Japan, Agatsuma and coworkers (1997) found that areas grazed by sea urchins, constituting coralline flats, after removal of sea urchins were recolonized in order by attaching diatoms, small annual algae such as the green alga *Ulva pertusa* and the red alga *Polysiphonia morrowii* (also introduced into Europe), large annual brown algae such as *Undaria pinnatifida* and *Desmarestia viridis*, and small perennial algae such as the brown alga *Dictyopteris divaricata*, followed by the large perennial brown alga *Sargassum confusum*.

### *Temperature*

Since *U. pinnatifida* is widely distributed along the Japanese coasts, the growing and maturing times differ due to temperature (Saito, 1975). He considered optimal growth of young sporophytes to be between 15 and 17 °C, whereas old thalli grew better at somewhat lower temperatures. Akiyama and Kurogi (1982) gave a total range of 4–25 °C for growth of sporophytes from NE Honshu, Japan, where plants appear in October-November and disappear in July-August, but they may stay until September (-October) in some northern areas (Kurogi and Akiyama, 1957). Later experimental studies, measuring growth rates of young sporophytes (Morita *et al.*, 2003a), showed that the sporophytes had an optimum of 20 °C (a relative growth rate of ca. 25% per day), an upper level of 27°C and that the lower limit was less than 5°C (a relative growth rate of ca. 8% per day at 5°C). On the east coast of Korea, the sporophyte growth period is between December and June (Koh, 1983). In NE Honshu, Japan, maturation of zoospores occurs in March to July, at a temperature range of 7-23°C (Akiyama and Kurogi, 1982), while Saito (1975) stated that zoospore release needed a ten-day average temperature of ≥14°C and that 17–22°C was optimal. The microscopic gametophytes could survive a temperature range of –1–30°C (Saito, 1975), and he stated that gametophyte growth was possible between 15–24 °C. However, according to Akiyama (1965) it was possible for gametophytes to grow, mature and release male gamets in a total temperature range of 5–28°C, but that their optimum was at 15–20°C. Morita and coworkers (2003b) showed that growth of gametophytes had an upper critical level of 28°C and that growth was optimal at 20°C (lower limit not determined). For maturation of gametophytes, the optimum was at 10–15°C, which also was the major factor explaining the geographical border in Japan between *U. pinnatifida* and the more warm-temperate species *U. undarioides* that had an optimum at around 20°C.

***Light***

The light saturation levels ($I_k$) of photosynthesis in sporophytes vary with season (Matsuyama 1983, Oh and Koh 1996) ranging from around 120–500 µE $m^{-2}$ $s^{-1}$ (Matsuyama, 1983: Figure 1) or even around or below 100 µE $m^{-2}$ $s^{-1}$ (Oh and Koh 1996). The light compensation point ($I_c$), i.e. below which no net photosynthesis occurs, is very low and only amounts to around some few µE $m^{-2}$ $s^{-1}$ (Wu *et al.*, 1981; Matsuyama, 1983; Oh and Koh, 1996) and it has very low respiration rates (Oh and Koh, 1996). The gametophytes are able to survive in darkness for at least seven months (Kim and Nam, 1997), and continuous darkness between 17 and 25° C was recommended by them, as the best way of preserving gametophytes. Experiments in Japan showed that gametophytes and very young sporophytes exposed to 50–100% direct sunlight, and from 16–28 % and upwards of natural UV radiation, died within hours (Akyiama, 1965). He also found that in some populations gametophytes matured under both long and short nights, while others needed long nights.

***Salinity***

Most of the experiments reported in the literature have been performed in normal seawater, but salinities above 15‰ Cl (> 27 PSU) was quoted by Saito (1975) as necessary for growth of sporophytes, and gametophyte development, although zoospores could attach above 10‰ Cl (>19 PSU).

***Nutrients***

Tests with slow-leaking fertilizers (ammonium) increased both yield and number of harvests in Japanese farms (Ogawa and Fuijita, 1997). In spring the low supply of inorganic nitrogen in the water was found to decrease the growth rate (Yoshikawa *et al.*, 2001). In experiments with juvenile sporelings, Wu and coworkers (2004) found that inorganic nutrient concentrations around 300 µmol nitrate-N $l^{-1}$ and 20 µmol phosphate-P $l^{-1}$ were sufficient to maintain a high daily growth rate.

## 3.3 Reproduction

For relation of temperature to reproductive stages, see above. According to Saito (1975) current velocities above 14 m $s^{-1}$ make the zoospores drift away from the substrate, and any establishment then depends on if the spores within 1–2 days come across a new surface to settle on.

## 3.4 Ecological impact

In many native areas, *U. pinnatifida* is just one of many large canopy species, often growing together with others, and thus there is little information available on its impact. In southern Korea, Kim and coworkers (1998) examined shelf, crest and drop off areas and found that the maximum species diversity occurred during winter with the large algae, including the red alga *Gracilaria textorii*, the brown algae *Ecklonia cava* and *Undaria pinnatifida*, becoming particularly abundant in spring. As autumn approached, the cover of large perennial species decreased. The brown algae *Sargassum horneri, S. confusum, Undaria pinnatifida* and *Myagropsis myagroides* had high cover in the crest habitat, while the subtidal shelf habitat showed an assemblage of bushy or thin-bladed forms such as the green alga *Ulva pertusa*, the brown alga *S. thunbergii* and the red alga *Corallina officinalis*.

## 3.5 Grazers and disease agents

Along the SE Korean coast, farmed *U. pinnatifida* has been attacked by harpacticoid copepods (*Thalestris* sp.), punching holes in the fronds, as well as by amphipods (*Ceinina japonica*), making tunnels in the midrib (Kang, 1981). He also reported of green spots accelerating the decaying of the plants and being caused by many different bacterial strains. A white rot disease, caused by the phycomycet *Olpidipopsis*, can attack cultivated *Undaria* plants in Japan (Akiyama, 1977).

## 3.6 Utilization and aquaculture

A thorough description of the farming of *U. pinnatifida* in Japan was given by Saito (1975), although the techniques used probably has changed much since then. Akiyama and Kurogi (1982) reported that the harvest of natural plants had decreased, since cultivation (which was described in detail) increased during the 1970s, producing about 5–10 kg ww per metre line. Proceedings from a Workshop in Pusan, Korea, in 1991, gave a status report of cultivation and processes at that time (FAO, 2006). Production and erosion of the commercially mass-cultured kelp *U. pinnatifida* f. *distans* were investigated in spring 1998 in Otsuchi Bay, NE Japan (Yoshikawa *et al.,* 2001). They measured a steady growth in total kelp length from January to March, with rates of 1.1 to 1.8 cm day$^{-1}$. In the same bay, maximum growth rates of 3.5 cm day $^{-1}$ were measured in early February by Saitoh and cowokers (1999). Yoshikawa and coworkers (2001) also measured erosion rates of the thalli, being consistently low in January and February, but increased to 0.5 cm day$^{-1}$ in March, when erosion rate was comparable to the growth rate in April. Biomass erosion represented 30–40% of production in March and over 80% in April. The greater erosion in April was attributed to a low supply of dissolved in-organic nitrogen and aging of the alga, leading to that 81% of total net production could be harvested, while 19% was lost due to erosion. In terms of nitrogen, 33% of total production was eroded, while 67% was harvested.

Tseng (1981) reported that most populations utilized today in China were introduced for aquaculture during the 1930s from Japan to Dalian, and in the early 1940s plants were brought from Korea to Qingdao (Tseng, 2001). *U. pinnatifida* is now the third most important cultivated species in China (Wu and Meng, 1997; Wu *et al.*, 2004) and experiments with tip-cutting of the lamina has shown an increase in production by 9 % (Wu and Meng, 1997). Clones of gametophytes are produced to enhance production of young sporophytes (Wu *et al.*, 2004). During the 1990s Chinese scientists were engaged in developing genetically modified seaweeds, among them *U. pinnatifida* (Qin *et al.*, 2004), by using promotors from other organisms and virus, causing transient expression of the GUS reporter gene. Furthermore, they have also used foreign genes to induce zygotic sporophytic formation of gametophytes and it seems that some of those GMO plants also had been cultivated in the sea.

In 1981 it was intentionally introduced to Taiwan from Japan for farming (Liao and Liu, 1989).

Skriptsova and coworkers (2004) considered the conditions at its northern distribution limit in Peter the Great Bay, the Sea of Japan, Russia, to be favourable for farming of this species, with the optimum month for harvesting in June. Highest alginate content (51% d. wt) was obtained from the lamina, with lower values from sporophylls and midribs, and with an increase occurring before sporulation.

In Korea, *U. pinnatifida* thalli have been used traditionally to promote maternal health, which works through the seaweed's scavenging effect of free radicals (Han *et al.*, 2002).

# 4 Non-native distribution

For details of the European distribution see Figure 5.

## 4.1 The Mediterranean Sea

### 4.1.1 Date and mode of introduction and source region

The first European record of *Undaria pinnatifida* is from the Thau lagoon at the French Mediterranean coast in 1971, most likely as a result from imports of oysters from Japan (Peréz *et al.*, 1981; Boudouresque *et al.*, 1985; Floc'h *et al.*, 1991; Wallentinus, 1999). This vector has also resulted in establishment of several other unintentionally introduced Japanese algae in that area (e.g. Boudouresque *et al.*, 1985; Verlaque, 1996, 2001; Wallentinus, 1999, 2002). It later spread outside the lagoon (Boudouresque *et al.*, 1985), and was in 1988 found close to the Spanish coast at Port Vendres (Floc'h *et al.*, 1991), but so far it has not been reported from the Spanish Mediterranean coast (Wallentinus, 1999; Guiry *et al.*, 2006).

*U. pinnatifida* occurs in Venice since 1992 (Curiel *et al.*, 1994, 1998, 2002), and was first recorded along the banks in Choggia, a site where oysters are cultivated, and thus might be due to an unintentional introduction with mollusc for farming. However, shipping cannot be excluded as a vector (Floc'h *et al.*, 1996), since it grows in several dock areas (Curiel *et al.*, 1998). In 1998 the species was found in the polluted Mar Piccolo, at Taranto, in the Ionian Sea, S Italy, pro bably having arrived there by oysters imported from France (Cecere *et al.*, 2000; Occhipinti Ambrogi, 2002).

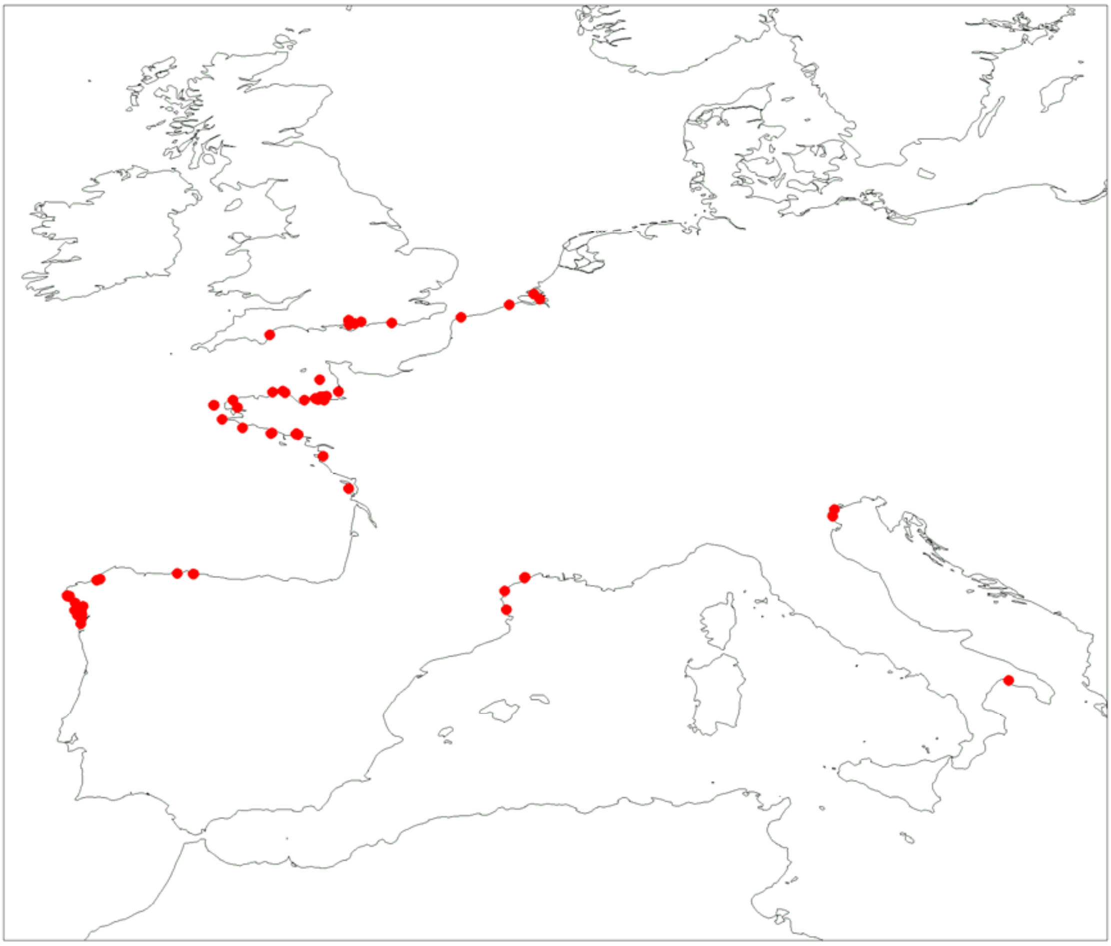

**Figure 5. Details of the distribution of *Undaria pinnatifida* in Europe. Compiled by Frederic Mineur, Queen's University of Belfast (unpublished data)**

### 4.1.2 Current status, population demographics and growth rate

According to Verlaque (2001) *U. pinnatifida* was still occurring in the Thau lagoon in the late 1990s. However, it does not seem to persist at the localities outside the lagoon (F. Mineur pers. comm.). In Venice, Curiel and coworkers (2002) considered it to be continuously expanding in the canals in 1999. A density of more than 10 plants $m^{-2}$ could be found, most of them 50–80 cm long, but reaching up to 2 m in more current-exposed areas, while at low-current sites they only were 20–30 cm long with 1–3 indivuals $m^{-2}$ (Curiel *et al.*, 2002). At Giudecca island they found densities around 100 plants $m^{-2}$, reaching a peak in biomass of >1 kg dw $m^{-2}$ in May. It was observed to be abundant in the canals in the city in spring 2004 (Wallentinus pers. obs.).

### 4.1.3 Natural history (tolerance limits for abiotic factors) in the region

***Substrate and depth***

*U. pinnatifida* grows on both stones (patchy to dense) and artificial substrate, including supporting structures used in aquaculture (Peréz *et al.*, 1981; Boudouresque *et al.*, 1985; Floc'h *et al.*, 1991), and embankments of the canals and other objects in Venice (Figure 6), where it is confined to the upper 1.5 m below LWM (Curiel *et al.*, 1998, 2002).

a) b)

**Figure 6.** ***Undaria pinnatifida*** **in Venice canals growing on: a) a wall and pole; b) an iron cable. Photo by courtesy of Davide Tagliapietra, ISMAR CNR, Venezia.**

### *Temperature*

So far, no introduced populations seem to have reached the upper temperature limit of 30°C for survival of gametophytes (Akiyama, 1965), and gametophytes from the Mediterranean had an upper survival limit of 29.5°C (Peters and Breeman, 1992). However, high summer temperatures lead to a lower growth rate of the sporophytes. On the French Mediterranean coast the sporophytes appear in autumn (November) with a maximal growth in March, and sporophytes disappear in July, with zoospores being released in May–June (Peréz *et al.*, 1981, 1984; Floc'h *et al.*, 1991). In Venice, young sporophytes appear in December and become dominant in February, with a maximum in April–May, and occur until July, when they become senescent (Curiel *et al.*, 1998, 2002). The range of water temperature in the Venice area is between 5 and 26°C. They also reported that fertility is at the peak in spring, and since only senescent plants occur in July, there seems to be no overlap in generations.

### *Salinities*

Salinities of 27 PSU can occur occasionally in the Thau lagoon, but they are usually higher (Verlaque, 1996). In Venice, the species grows also in waters with a salinity that occasionally can be as low as around 20 PSU, although mainly in waters above 28 PSU (Curiel *et al.*, 2002). This seems to be the lowest salinity in which it has become established. Considering its establishment also in the less saline parts of Venice, adaptation to slightly brackish water cannot be ruled out.

### *Nutrients*

In Venice, *U. pinnatifida* is found growing close to discharges of urban waste water and thrives in nutrient-rich polluted water (e.g. Curiel *et al.*, 1998, 2002), as it also does in southern Italy (Cecere *et al.*, 2000). Prosperous growth among farmed mussels and oysters also indicates enhancement by nutrients, which are recirculated by these animals.

## 4.1.4 Reproduction

The species is reproductive in the areas where it has been recorded (see also 4.1.3). On the French Mediterranean coast, the sporophylls are mature from May to July (Peréz *et al.*, 1981, 1984, Floc'h *et al.*, 1981). In Venice, plants may not become fertile in the inner canals (Curiel *et al.*, 2002).

### 4.1.5 Ecological impact

On the French Mediterranean coast, it mostly co-occurs with species of the brown algal genera *Sargassum*, *Cystoseira*, and *Dictyota*, and the red algal genus *Gracilaria* (Peréz *et al.*, 1981, Boudouresque *et al.*, 1985). In the lagoon of Venice, *U. pinnatifida* has gradually expanded along the banks of the canals, both at Chioggia and Venice, and has become the dominant species (mainly from February to July) in the local algal community (Curiel *et al.*, 2002). The kelp first colonized the main canals and, subsequently, the small inner ones. Several co-occurring species decrease between April and June–July, when *U. pinnatifida* becomes dominant.

### 4.1.6 Grazers and disease agents

The main grazer in the Thau lagoon seems to be sea urchins (Peréz *et al.*, 1981; Boudouresque *et al.*, 1985). In Venice, grazing pressure on *U. pinnatifida* seems very low (Curiel *et al.*, 2002).

### 4.1.7 Utilization and aquaculture

There were less successful trials of cultivation on the French Mediterranean coast, which were not continued. There are no published reports on utilization of *U. pinnatifida* in Italy.

### 4.1.8 Management and control

In Venice, eradication made during the fertile period, in fact, permitted *U. pinnatifida* development during the following year (Curiel *et al.*, 2002). However, when eradication was performed after the reproductive period, they found that recolonisation started two years later. A signi ficant decrease in the surface covered by other species has been observed in Venice, and thus in order to limit the spreading of *U. pinnatifida*, it was suggested that mechanical eradications should be made on a large spatial scale and before the zoospores are released (Curiel *et al.*, 2002).

## 4.2 European Atlantic coast

### 4.2.1 Date and mode of introduction and source region

In France, *Undaria pinnatifida* was transferred from the Mediterranean by IFREMER (Institut français de recherche pour l'exploitation de la mer) scientists for farming in northern France at three sites around Brittany in 1983; at the islands of Groix and Ouessant, and in the Rance estuary (Peréz *et al.*, 1984; Floc'h *et al.*, 1991), after less successful trials in the Mediterranean. Later some new sites were used (Peréz *et al.*, 1984; Floc'h *et al.*, 1991; Castric-Fey *et al.*, 1993; Hay and Villouta, 1993; Wallentinus, 1999), also by CEVA (Centre d'Etude et de Valorisation des Algues). In the 1990s it was also cultivated further south on the Isle of Oleron (Castric-Fey *et al.*, 1993), which was later given up. In 1987 reproducing individuals (Figure 7a) were found grow ing on mussel lines outside the seaweed farm on Ouessant (Floc'h *et al.*, 1991, 1996), and later also naturally recruited plants were found in other districts at St. Malo and in the Rance estuary, (Castric-Fey *et al.*, 1993; Hay and Villouta, 1993; Castric-Fey and L'Hardy-Halos, 1996; Castric-Fey *et al.*, 1999a, 1999b), even in areas where farming had been abandoned. A record in 1998 from the harbour of Calais, northern France (Stegenga, 1999) might also be due to shipping, as well as the records in the harbours of Brest and Grandville in northwestern France in the early 1990s (Floc'h *et al.*, 1996).

a) b)

**Figure 7. a) Mature sporophyte of *Undaria pinnatifida* with well-developed sporophylls found in a mussel farm on the island of Ouesson, Brittany, NW France, in late spring 1987. Photo Inger Wallentinus. b) Sporophytes on display (in the centre) in an aquarium tank, La Rochelle, France. Photo by courtesy of Xavier Minguez.**

In northern Spain *U. pinnatifida* was reported from Ria Ariosa in 1990 (Santiago Caamaño *et al.*, 1990), probably as a result of oyster movements, and later from other parts of northern Spain (for references see Hewitt *et al.*, 2005). Through farming it has later been spread along the N Spanish Atlantic coast down to the Portuguese border, and thus it can be expected to arrive in Portugal in the near future (José Rico pers. comm.). It is still not listed as occurring in Portugal by Guiry and coworkers (2006), but there is some information that it has been found in some estuaries on the Portuguese coast (Jesus Cabal pers. comm.).

In southern U.K., *U. pinnatifida* was recorded in 1994, probably spread by vessels from France or the Channel Islands (Fletcher and Manfredi 1995, Fletcher and Farrell, 1998), and it later spread to other sites on the south coast and has been confirmed on the Channel Islands (Eno *et al.*, 1997). A thorough review on the occurrence and ecology of the species in the U.K., and in the North Atlantic, was given by Fletcher and Farrell (1999). Since all records were from isolated marinas, they suggested that it probably had arrived in England with small boats, having visited Brittany, France, and then being anchored in marinas on the English south coast. They also presented details on when different areas were colonized and reported that the local dispersal was slow, amounting to ca. 750 m in three, and 2000 m in four years, and that the main dispersal was by small boats in coastal traffic. During 1998 it occurred between Brighton and Torquay, a distance of 270 km, which was reached in a shorter period of time than for the introduced Japanese brown alga *Sargassum muticum.*

In March 1999, for the first time in the Netherlands, 60 cm long sporophytes of *U. pinnatifida* were recorded on shells in an oyster pond near Yerseke, and in May the same year one plant was found near Strijenham, both sites in the Oosterschelde (ICES WGITMO, 2000). There was a rapid colonization and in some places 5–6 ha were covered in the Oosterschelde, and plants were also washed ashore on the N side (Stegenga, 1999). The latter, so far, are the northernmost sites in Europe. *U. pinnatifida* was also found in smaller densities in the saltwater Lake Grevlingen, probably being transported there by oyster pots. In the Oosterschelde it grows mainly on *Crassostrea gigas,* but also on mussels, and being slippery, *U. pinnatifida* causes problems for fishermen to retrieve the oysters, and the pots need to be cleaned before harvest (ICES WGITMO, 2001). Although no vector was stated, oyster and mussel harvesting is common in the Oosterschelde (H. Stegenga pers. comm.), but shipping probably cannot be ruled out, since ships frequently enter the area.

In 1999 the species was also reported from Zeebrugge, Belgium (Dumoulin and De Blauwe, 1999), and was still present at the marina of Zeebrugge in 2003, but had not spread since 2000, and was grazed by coots (*Fulicra atra*) (ICES WGITMO, 2004). According to F. Kerckhof (pers. comm.) it was still found there in 2005.

### 4.2.2 Current status, population demographics and growth rate

In the St. Malo area, the populations increased during 1996–1997, after a period with decrease following heavy grazing (Castric-Fey *et al.*, 1999a). The same scientists (1999b) found a maximum growth rate of 2.13 cm per day (average 1.56 cm per day) and a maximum plant size of 150 cm, the thallus weighing 1.47 kg ww. They found the maximum longevity of plants to be 7.5 months and that plants recruited in spring lived on average for ca. five months, while those appearing in winter lived for six months.

On the English south coast, plants grow quite large (> 2m in length, ca 1 kg ww) and biomasses may reach up to 25 kg ww $m^{-2}$.

### 4.2.3 Natural history (tolerance limits for abiotic factors) in the region

#### *Substrate and depth*

In W Brittany, France, *U. pinnatifida* has been found both on rocks, growing together with native large canopy species down to 18 m depth, and on lines in mussel farms down to 5 m depth (Floc'h *et al.*, 1991). It can also be found in the intertidal up to +1.5 m and seems to have a preference for artificial substrate (Floc'h *et al.*, 1996). Further east on the French coast, in the St. Malo and Dinard area, it was also common on periodically overturned cobbles and boulders, and grew mainly in the lower littoral and upper sublittoral zones (Castric-Fey *et al.*, 1999a), but could also be found down to 12 m depth (Castric-Fey *et al.*, 1993).

In S England, 4 years after its introduction in that area, it mainly occurs on vertical sides of floating structures, such as pontoons, hulls of small boats, buoys, ropes and tyres, as well as on the introduced ascidian *Styela clava*, and very seldom on materials having a fixed position in the water. This probably is due to the sediment load and high turbidity in the water there. In the Torquay marina, however, it growths also on fixed objects and has colonized walls, where native kelps such as *Laminaria digitata* and *L. saccharina* occur, and in places also occurs together with the annual kelp *Saccorhiza polyschides*, scattered fucoids and the introduced Japanese brown alga *Sargassum muticum* (Fletcher and Farrell, 1998). They also stated that it is more common than native species in sheltered and turbid areas, and that in more exposed areas the competition from native canopy species is quite high.

#### *Temperature*

Lowest temperature for sporophyte recruitment in the Dinard area, N France, was 5°C and highest 20°C (Castric-Fey *et al.*, 1999b), but they found that the peaks in recruitment occurred during October and May-June, at temperatures of 13–17°C, with two generations succeeding each other during a year. They found fully grown sporophytes all year round with a mixture of young and old ones, but most plants deteriorated in late summer, and that the sporophylls could appear all year through. According to Floc'h and coworkers (1991) sporophytes can appear all year round in Brittany, with release of zoospores from May until late autumn. On the south coast of England, plants grow tall and occur almost all year through, with some senescens in late summer (Fletcher and Farrell, 1998).

***Salinity***

Most reports of introductions are from areas having salinities well above 30 PSU (e.g. in St. Malo, N France a mean of 34 PSU, with a range of 31–35; Castric-Fey *et al.,* 1999b). Some populations also exist at lower salinities and 27 PSU can occur during February at the localities in Spain, where it has been recorded (Santiago Caamaño, 1990).

***Nutrients***

As on the Mediterranean coast, *U. pinnatifida* has also in N France been found growing close to discharges of urban sewage plants (Castric-Fey *et al.,* 1999a, 1999b).

### 4.2.4 Reproduction

For appearance and maturity see 4.2.3.

### 4.2.5 Ecological impact

In the study by Floc'h and coworkers (1996), *U. pinnatifida* was only sporadically found on rocky substrates, whether denuded from native algae or not, and seemed to be less competitive versus the native, opportunistic kelp *Saccorhiza polyschides*, which was the one dominating on the rocks. However, they found it co-occurring with the native fucoid *Himanthalia elongata*. Since *U. pinnatifida* prefers artificial substrate, the negative effects might be mainly on the economic side as a fouling organism. On the English south coast, Fletcher and Farrell (1998) did not report on any ecological impact on native seaweeds, even when occurring together in some areas. On the whole, they considered the final outcome on rocky substrates less predictable, and that *U. pinnatifida* mainly will establish in the shallow sublittoral, but having a low competitive ability there. However, it probably will be a major fouling alga in harbour areas. They also pointed out that since *U. pinnatifida* grows even in areas with high sediment load and lower salinities, where less native vegetations occurs, it may even be beneficial to the ecosystem by providing a nursery ground for small fish and shelter for macrofauna. In Belgium, Dumoulin and De Blauwe (1999) reported that the thalli of *U. pinnatifida* often were overgrown by fouling ascidians (especially *Botryllus schlosseri)*, bryozoans, hydroids and small seaweeds, which may enhance the decay of the lamina.

### 4.2.6 Grazers and disease agents

The main grazers on the coast of Brittany, France, are fish and crustaceans and the grazing pressure on the sporophytes is quite high (Floc'h *et al.,* 1991; Floc'h pers. comm.). In Belgium, birds such as coots may be important grazers (ICES WGITMO, 2004), but also some fish eat it. In S England, there is hardly any grazing on *U. pinnatifida* (Flecher and Farrell, 1998).

### 4.2.7 Utilization and aquaculture

At least one company is cultivating *U. pinnatifida* in N France, in the St. Malo area, where it is farmed in the sea on long-lines (C-Weed Aquaculture 2006). Established wild populations of *U. pinnatifida,* a result of unintentional introductions, have been harvested for wakami products in northern Spain. It is also cultivated in northern Spain as far south as close to the Portuguese border (ICES, 1993, José Rico pers. comm.). It has been seen on display, together with native seaweeds, in the public aquarium at La Rochelle, W France (F. Mineur pers. comm.; Figure 7b). Such activites might pose an increased risk, if the species is not already firmly established in the area.

### 4.2.9 Management and control

When *U. pinnatifida* was first recorded on the English south coasts, all plants found were removed, but since the plants were already fertile, eradication failed and new plants appeared (Fletcher and Farrell, 1998). In the Netherlands, efforts have been made to clear *U. pinnatifida*, because it hinders mussel harvest (Wetsteyn in ICES WGITMO, 2001).

## 4.3 New Zealand

### 4.3.1 Date and mode of introduction and source

*Undaria pinnatifida* was reported as introduced by Japanese ships to New Zealand at Wellington 1987 and Timaru 1988 (Stapleton, 1988; Hay, 1990), and spread by local coastal traffic to Oamaru in 1988 and Lyttleton 1989 (Hay, 1990; Hay and Villouta, 1993), and later also to the harbours of Otaga, Porirua, Picton and Napier (Hay and Villouta, 1993). Further dispersal by coastal traffic was predicted already in 1990 (Hay, 1990), and plants fouling ships' hulls were found to survive a voyage of more than 4000 km and during that time (about a month) had grown 10–20 cm. He also concluded that drifting mooring buoys and towed navigational buoys can be responsible for dispersal, directly or by infested vessels, as well as the cleaning of ships' hulls at the seaside with pressure hoses, which should be avoided.

Dispersal of zoospores by water movements might be limited, since no plants were found on the opposite side of a New Zealand harbour until ships fouled with *U. pinnatifida* were moved and anchored there (Hay pers. comm.). Trailed boats may also disperse the species into new waters, due to the extreme tolerance and survival of the microscopic gametophytes for days up to a month in small crevices (Hay 1990, pers. comm.), making many new areas susceptible, especially if the boats are left with a constant water line at the new site for the time it takes sporophytes to mature.

### 4.3.2 Current status, population demographics and growth rate

The overall distribution has not changed (ICES WGITMO, 2004), and it has not been recorded from the Fiordland, the Chatham Islands, or from the Sub-Antarctic islands. Hurd and coworkers (2004) considered *U. pinnatifida* to be the most serious pest of the 22 alien seaweeds in New Zealand, and also gave details of its distribution in New Zealand at that time.

**4.3.3 Natural history (tolerance limits for abiotic factors) in the region**

In New Zealand, the lowest temperatures for sporophyte recruitment are 7–8°C (Hay and Villouta, 1993; Stuart and Brown, 1996), and plants occur throughout the year. At some localities in New Zealand, salinity values can in extreme cases be as low as 22–23 PSU, while usually being higher (Hay pers. comm.). In a New Zealand study (Dean and Hurd, 1996) nutrient kinetics were measured, the values resulting in about the same uptake rates for nitrate as for other kelp species.

### 4.3.4 Reproduction

Studies in New Zealand (Forrest *et al.*, 2000) have revealed that, although zoospores may be viable for 5–14 days, spore dispersal from *U. pinnatifida* stands primarily has occurred only at the scale of metres to hundreds of metres, while spread at the scales of hundreds of metres to kilometres must depend on dispersal of fertile fragments or whole sporophytes.

### 4.3.5 Ecological impact

Forrest and Taylor (2002) emphasized the difficulties of assessing the impact of this invasive species, since it was difficult to find the correct experimental design to measure it. Overall it seemed to be little impact from *U. pinnatifida* in low shore communities, and that, in comparison to controls, effects that could be interpreted as plausible impacts probably as well could reflect natural causes. Due to the uncertainty in extrapolating impact information to other places and times, they suggested that the precautionary principle should be applied, and worst-case impacts assumed, until the level of scientific uncertainty is reduced. However, they considered that such an approach should only be applied after an evaluation of the feasibility, costs and benefits of managing a particular pest in relation to other priorities for invasive species.

### 4.3.6 Grazers and disease agents

In New Zealand, the grazers are mainly abalone, sea slugs, crustaceans and some fish (Hay and Luckens, 1987; C. Hay pers. comm.).

### 4.3.7 Utilization and aquaculture

A pilot farming programme has been undertaken in areas in New Zealand, which already had been colonized by *U. pinnatifida* (Anon., 1998). Furthermore, established wild populations of *U. pinnatifida* have been harvested (e.g. Sinner *et al.,* 2000; Forrest and Blakemore, 2003).

### 4.3.8 Management and control

In New Zealand, where *U. pinnatifida* has spread around the coasts since the late 1980s, the main emphasis has been on trying to stop it from entering the Sub-Antartic and the Chatham Islands. Thus, when a fishing vessel with *U. pinnatifida* on the hull sank near a remote island in 2000, the Biosecurity Act forced an eradication of the plants from the hull and a monitoring of the area for three years (ICES WGITMO, 2004; Wotton *et al.*, 2004). Great efforts have also been made to clear *U. pinnatifida* to protect the biodiversity, but often with limited success (e.g. Sinner *et al.,* 2000; Stuart and Chadderton, 2001). The problem with *U. pinnatifida* is also described on Internet (e.g. Hilhorst, 2006).

## 4.4 Australia

### 4.4.1 Date and mode of introduction and source

*Undaria pinnatifida* was first recorded in eastern Tasmania (Rheban-Triabunna) in 1988, presumably brought in ballast tanks of Japanese ships. Later it has spread along the coast (Sanderson, 1990; AQIS, 1994), and further dispersal to other coastal areas was predicted in 1990 (Sanderson, 1990). The dispersal rate was estimated to 10 km year$^{-1}$, but secondary introductions have also occurred in Tasmania, since some areas are more than 40 km apart (Hewitt *et al.,* 2005). In 1996 it was reported from Port Philips Bay, Victoria, Australia, probably coming with ships from Japan or New Zealand, since the plants had a different form than the Tasmanian population (Campell and Burridge, 1998; Campbell *et al.,* 1999). In 1997 it was reported from a marine reserve south of Hobart, Tasmania (Hewitt *et al.,* 2005).

### 4.4.2 Current status, population demographics and growth rate

No change has been seen in its distribution in Australia since the late 1990s (ICES WGITMO, 2004), and in 2002 *U. pinnatifida* was reported to have spread 150 km north and 80 km south of the initial site (Hewitt *et al.,* 2005 and references therein). According to Department of Primary Industries, Water and Environment (2005a), it occurs from the D'Entrecasteaux Channel to north of St. Helens.

In Tasmania, Valentine and Johnson (2003) found that disturbance of native canopy algae was crucial for the establishment of *U. pinnatifida*, while very few plants grew, when there was a large cover of natives. Furthermore, the timing of the disturbance was important, and highest densities of *U. pinnatifida* were found when clearing was done just before the sporophyte growth started in winter. The response of *U. pinnatifida* to a natural disruption of a native algal canopy was examined after a significant dieback of a common native canopy forming brown alga (*Phyllospora comosa*) on the east coast of Tasmania (Valentine and Johnson, 2004). They found that *U. pinnatifida* sporophytes established at high densities (ca 7 stipes m-2) in dieback areas, but remained rare or entirely absent in control areas, where the native canopy was intact, confirming the importance of disturbance events for the successful establishment of high densities of *U. pinnatifida*. When sea urchins were removed, Valentine and Johnson (2005) found an average biomass of ca 55 g dw m-2 (5.2 plants). Hewitt and coworkers (2005) estimated growth rates from width of the stipe, by using correlation to total length, and found that plants on average grew 1.2 cm day-1 (ranging from 0.2 to 4.7 cm day-1) in transects where *U. pinnatifida* had been removed, while they grew 2.4 cm day-1 (ranging from 1.2 to 4.1 cm day-1) in control areas (figures not comparable due to differences in time). They measured the maximum growth over 30 days to 1.41 m (removal transects) and 1.23 m in controls.

### 4.4.3 Natural history (tolerance limits for abiotic factors) in the region

***Substrate and depth***

On the eastern Tasmanian coast, *U. pinnatifida* mainly occupies the sheltered to moderately exposed sublittoral, where it is a conspicuous seaweed mainly found in sea urchin grazed areas, covering 100% of the rocks (Valentine and Johnson, 2005). Hewitt and coworkers (2005) reported it from both rocks and boulders, as well as growing in low abundances on sand and on seagrass leaves.

***Temperature***

In Tasmania, sporophytes appear in August (Australian late winter) and disappear in late summer (December) with a peak in growth in November (Sanderson, 1990; Valentine and Johnson, 2005). For releases of zoospores see 4.4.4. In Port Phillip Bay, Victoria, sporophytes grew rapidly from winter (July) through to spring (September) and became scenescent in early summer, with no sporophytes left in January (Campbell *et al.*, 1999).

***Light***

Campbell and coworkers (1999) measured photosynthetic performance, dark respiration, pigment concentration, tissue nutrient concentration and fresh:dry weight ratios in juvenile and adult sporophytes of *U. pinnatifida* from Port Phillip Bay throughout the growing season. They found that photosynthetic rates (15 to 42 mg $O_2$ $g^{-1}$ dw $h^{-1}$) of sporophyte stages were higher on a dry weight basis in spring compared to in summer, coinciding with rapid growth of juvenile sporophytes in spring. Higher dw:fw ratios were found in adult sporophytes compared to in young sporophytes. Characters of the production versus irradiance curve, $P_{max}$ and alpha (the angle of the intitial slope of the curve) on a Chl *a* basis, were found to have seasonal trends in juvenile plants and could be explained by higher pigment (Chl *a*, *c*, fucoxanthin) concentraions in spring than summer. Differences in pigment content, and their ratios, between sporophyte life stages may be indicative of light adaptation by juvenile plants. Lower saturated light requirements ($I_k$) and compensation points ($I_c$) were observed in spring compared to in summer plants and lower $I_k$ values of juvenile sporophytes compared to adult sporophytes were also found during spring. Spring and summer compensation points in this study mostly ranged from 7.63 to 15.49 µmol $m^{-2}$ $s^{-1}$. Low $I_k$ and $I_c$, and high $P_{max}$, alpha, and pigment contents may enhance the capacity of juvenile *U. pinnatifida* to utilise low photon flux rates. No seasonal differences were found between respiration rates on a dry weight basis or between respiration in young and adult sporophytes. Respiration rates normalised to Chl *a*, were 2–3 times higher in summer in both young and adult stages.

***Nutrients***

In Port Phillips Bay, Victoria, Campbell (1999) found that *U. pinnatifida* had an intermediate capacity for ammonium uptake, which was dependent on blade maturity. Furthermore, they considered that the relationships between nutrient uptake and growth would afford mature *U. pinnatifida* a competitive advantage for ammonium uptake in winter, when there was a high N availability. Campbell and coworkers (1999) found that the C:N ratios were higher in summer in both juvenile and adult sporophytes, indicating N limitation in summer, and generally higher in juveniles, pointing to a higher accumulation of reserve carbohydrates. Low N:P ratios in spring and summer for both stages also suggested N limitation. The overall high N availability in Port Phillip Bay, and the low-light adapted physiological characteristics of *U. pinnatifida*, would provide it with a competitive advantage over other fast growing macroalgae.

### 4.4.4 Reproduction

Reproductive phenological studies (Schaffelke *et al.,* 2005) were undertaken in Tasmania to provide the much-needed quantitative information to support pest management. For most of the growing season, zoospore release was limited to the larger size classes of the annual sporophytes (> 55 cm length) with the proportion of mature sporophytes increasing towards the end of the season. Small sporophytes with mature sporophylls were not observed until late in the growing season, i.e. after November (late spring). The maximum zoospore release of *U. pinnatifida* was $62 * 10^3$ zoospores $cm^{-2}$ sporophyll tissue $h^{-1}$, corresponding to a maximum release of $4.3 * 10^8$ zoospores $sporophyte^{-1} h^{-1}$, being similar or lower compared to other kelps. The two largest size classes released the majority of zoospores. Tagged sporophytes released zoospores for about three months, before they became senescent and disintegrated. The smallest mature sporophyte, hypothetically, would have a stipe width of 0.6 cm, corresponding to about 33 cm in total length, with a sporophyll circumference of 7.6 cm and a sporophyll biomass of 0.2 g dw. The zoospore release from a stand of *U. pinnatifida* was estimated to be $2 * 10^9$ zoospores $m^{-2} h^{-1}$ in January (summer in the southern hemisphere), the majority coming from the two largest size classes. Thus management efforts, involving the manual removal of *U. pinnatifida* to control this species, could be rationalized by concentrating on the removal of only larger sporophytes (>55 cm), potentially resulting in significant cost savings. Hewitt and coworkers (2005) suggested that a seed bank of microscopic stages with a significant longevity seems likely, since sporophytes reappeared early in season, also when all sporophytes had been removed and few plants were fertile.

### 4.4.5 Ecological impact

On eastern Tasmania, Edgar and coworkers (2004) during a year studied the effects of algal canopy clearance on plant, fish and macroinvertebrate communities, for blocks cleared of fucoid, laminarian and dictyotalean algae in comparison to controls. When they removed canopy-forming plants there was less a change to biotic assemblages than reported in other studies elsewhere, with the magnitude of change for fish and invertebrate taxa lower than variation between sites and comparable to variation between months. *U. pinnatifida* exhibited the only pronounced response to canopy removal amongst algal taxa, with a fivefold increase in cleared blocks compared to control blocks. Marine reserves were suggested to assist reef communities in resisting invasion by *U. pinnatifida,* through an indirect mechanism, involving increased predation pressure on sea urchins and reduced formation of urchin barrens, which are subject to *U. pinnatifida* propagation.

### 4.4.6 Grazers and disease agents

The main grazers in Tasmania are sea urchins (Sanderson, 1990; Valentine and Johnson, 2005). To answer the questions about the mechanisms enabling *U. pinnatifida* to persist on the sea urchin (*Heliocidaris erythrogramma*) 'barrens', Valentine and Johnson (2005) made a factorial manipulative experiment over a 30-month period. The dense stands of *U. pinnatifida* on sea urchin barrens, suggest that disturbance in the form of grazing by sea urchins prevents recovery of native canopy-forming species. By using treatments comprising all possible combinations of +/- urchins, +/- *U. pinnatifida* and +/- enhanced native algal spore inoculum, they found that the sea urchin *H. erythrogramma* can have a significant impact on *U. pinnatifida* abundance. The response was most dramatic in the 2001 sporophyte growth season, when sea urchins destructively grazed *U. pinnatifida* sporophytes in experimental plots on the urchin barren. In other years, when there was higher recruitment of *U. pinnatifida* sporophytes, urchins reduced sporophyte abundance, but did not prevent development of a *U. pinnatifida* canopy. Removal of sea urchins resulted in a slow increase in cover of understorey red algae, but only limited recovery of native canopy-forming species. In treatments, where both sea urchins and *U. pinnatifida* were removed, cover of canopy-forming species did not exceed 6% over the study period. Thus, in the absence of sea urchin grazing, there was no evidence of inhibition of *U. pinnatifida* by native algae. While the intensity of sea urchin grazing may directly influence the extent of the *U. pinnatifida* canopy, recovery of native canopy-forming species was apparently influenced by a combination of factors, including sea urchin grazing, depth and, most importantly, the degree of sediment accumulation on the rocky substratum. The manipulations showed that removal of sea urchin grazing that ostensibly facilitated replacement of native canopy-forming algae by *U. pinnatifida*, did not result in recovery of native canopy-forming algae.

### 4.4.7 Utilization and aquaculture

Unintentionally introduced populations has been commercially utilized in Tasmania (AQIS, 1994). In 2005 there are harvest operations on the east coast of Tasmania (Department of Primary Industries, Water and Environment, 2005a) and they pointed out that one does not need to feel concerned about the sustainability of this fishery, but also that the harvest, so far, has not been enough to slow the spread. There is no farming of *U. pinnatifida* in Tasmania (M. Gregg pers. comm.).

### 4.4.8 Management and control

According to the Department of Primary Industries, Water and Environment (2005b) it was already in the mid 1990s realized that an eradication program was not feasible for the whole eastern Tasmanian coast, and harvest was started as a control measure, however, not sufficient (Department of Primary Industries, Water and Environment, 2005b). In the late 1990s removal experiments were carried out to at the Tinderbox Marine reserve, south of Hobart, Tasmania, to reveal if eradication by divers were sufficient in significantly reducing the sporophyte abundances of *U. pinnatifida*, which it did when carried out on a monthly bases (Hewitt *et al.*, 2005; see more under section 7). Because of the possibilities of a seed bank of microscopic stages they considered it necessary to find a treatment to remove those persistent stages. Several Internet based information campaigns have been launched (e.g. CSIRO 2000, Department of Primary Industries, Water and Environment, 2005b), the latter also providing advices to boat owners on how to act.

## 4.5 Argentina

### 4.5.1 Date and mode of introduction and source

*Undaria pinnatifida* is assumed to have arrived with cargo or fishing vessels from Korea or Japan into the Neuvo Gulf, Argentina in 1992 (Casas and Piriz, 1996; Orensanz *et al.*, 2002; Casas *et al.*, 2004), where it was recorded close to the international dock at Puerto Madryn in central Patagonia. During the first two years it had spread along ca. 2 km of the coast (Casas and Piriz, 1996).

### 4.5.2 Current status, population demographics and growth rate

Close to Puorto Madryn, Casas and coworkers (2004) found that *U. pinnatifida* could make up 65% of the total seaweed biomass with on an average 3 kg ww $m^{-2}$. In 1999 it had spread ca. 20 km to the north and 18 km to the south of Puerto Madryn (Orensanz *et al.,* 2002), and they also reported that it had been recorded at Caleta Malaspina, ca 500 km to the south, where it may pose a serious threat to economically utilized seaweeds. It may also pose a threat to the marine park at Golfo San José, north of Nuevo Gulf (Orensanz *et al.,* 2002). They also predicted that it, due to the benign water temperatures, would spread further along the coast.

### 4.5.3 Natural history (tolerance limits for abiotic factors) in the region

In the Nuevo Gulf, sporophytes can be seen in the sublittoral from 2 to 15 m depth, at an annual temperature range of around 8.7–18 °C (Casas and Piriz, 1996). They found it growing on various substrates such as rocks, boulders, wharf pilings, on the hull of a wrecked ship and on ascidians in not too exposed conditions. Also in this area, *U. pinnatifida* seems to be enhanced by discharges of secondary treated sewage plants (Torres *et al.,* 2004).

### 4.5.4 Reproduction

The recruitment occurs in autumn (April-May) and by summer (December) the plants become senescent (Casas and Piriz, 1996; Casas *et al.,* 2004) and only midribs, sporophylls and holdfasts remain during the late S hemisphere summer (January–February). Sporophylls occurred from winter (July to August) to summer, but were seen only on plants larger than 70 cm (Casas and Piriz, 1996). They also reported that small, young sporophytes were seen together with large ones.

### 4.5.5 Ecological impact

In south Patagonia, Argentina, the dominance of *U. pinnatifida* has also changed the composition of beach-cast seaweeds. Since 1998 it has replaced the green algae *Ulva* spp., which have decreased in the beach-cast, as have native species such as the red alga *Gracilaria gracilis* and the kelp *Macrocystis pyrifera* (Piriz *et al.,* 2003). The results of a 7-month manipulative experiment in Nuevo Gulf, with removal of *Undaria pinnatifida* (to be precautious no additions were used in non-colonized areas), showed that it significantly reduced the species richness and diversity of native seaweeds in comparison to controls (Casas *et al.,* 2004). The most common subtidal seaweed in the area, the green alga *Codium vermilara,* however, was little affected by the presence of *U. pinnatifida*, and it has been suggested that *C. vermilara* might not be native there, but introduced. Orensanz and coworkers (2002) considered *U. pinnatifida* to rapidly be modifying the nearshore benthic communities in central Patagonia, since it is the only kelp species and the native seaweeds are relatively small, and the canopies reduce light and the holdfasts may cover other vegetation. Furthermore, when being dislodged and dragged along the bottom by the tides, also other species may be lost by this disturbance.

### 4.5.6 Grazers and disease agents

According to Orensanz and coworkers (2002) *U. pinnatifida* could be a potential food item for the native gastropod *Tegula patagonica,* and the sea urchins *Arbacia dufresnii* and *Pseudechinus magellanicus*.

### 4.5.7 Utilization and aquaculture

It was suggested (Casas and Piriz, 1996; Orensanz *et al.,* 2002) that it could be attractive for local industries to use *U. pinnatifida*, but no published reports have been found on any utilization from these areas.

### 4.5.8 Management and control

Orensanz and coworkers (2002) emphasized that it may become a threat to the economically important seaweeds, such as the red algae *Gracilaria gracilis*, *Gigartina skottsbergii* and the kelp *Macrocystis pyrifera*. However, there seems to have been no trials to eradicate *U. pinnatifida*, and it has been considered a futile enterprise (Casas and Piriz, 1996; Orensanz *et al.*, 2002).

## 4.6 California and Mexico

### 4.6.1 Date and mode of introduction and source region

In the US, *U. pinnatifida* was first recorded in Los Angeles Harbor in 2000 (Silva *et al.*, 2002; Thornber *et al.,* 2004) and was later found at several sites in S California. In 2001 it had been established at Santa Barbara Harbor, Cabrillo Beach at San Pedro and at Channel Islands Harbor at Oxnard and at Santa Catalina Island, there growing down to 25 m depth, and as far north as Monterey Bay, (Figure 8; Silva *et al.*, 2002; Lonhart, 2003). It probably had arrived with shipping. In 2003 it had increased its abundance in the Monterey area (Lonhart, 2003, ICES WGITMO, 2004). Thornber and coworkers (2004) predicted a further spread along the coast, where small boats could be an important vector. Silva and coworkers (2002) considered it possible that *U. pinnatifida* could establish from at least Baja California (see below) to British Columbia, Canada, especially in sheltered to partially sheltered waters.

At Todos Santos Islands, in Baja California, Mexico, *U. pinnatifida* was found growing attached to small rocks on a sandy bottom in the subtidal zone at 12–14 m depth in September 2003. The population consisted of 15 sporophytes, with an average length of 50 cm and with mature sporophylls (Aguilar-Rosas *et al.*, 2004).

a) b)

**Figure 8. *Undaria pinnatifida* from Monterey, California. a) Sporophytes of different ages; b) plants on a floating dock in the harbour. Photo by courtesy of Steve Lonhart, Monterey Bay National Marine Sanctuary.**

### 4.6.2 Current status, population demographics and growth rate

The population ecology of both macro- and microscopic stages of the species has been studied in Santa Barbara harbour, where two different recruitment pulses were seen in one year, depending on temperature (Thornber *et al.*, 2004). They found great differences in survival to maturity, size and growth rate, and considered these variations in demography, as well as in grazing pressure, to be important for the future spread of *U. pinnatifida* along the Pacific coast of North America. By using tagged plants and the punch-hole technique, they found growth rates in autumn to vary between 1 to 14 cm week$^{-1}$, with a maximum of 25 cm week$^{-1}$, until the plants became 15 weeks old, when growth was negligible. At Monterey, having colder water currents, recruitment might be continuous with an overlap of generations (Lonhart, 2003).

### 4.6.3 Natural history (tolerance limits for abiotic factors) in the region

Silva and coworkers (2002) described populations on various artificial substrates from shallow waters in harbours, and down to at 25 m depth at Santa Catalina Island where it grew on polychaete tubes on sandy bottoms, but also on tires at 6 m depth. In S California. *U. pinnatifida* occurs in shallow, wave-protected areas, mainly on floating docks in harbours at a temperature range of 12–21°C (Thornber *et al.*, 2004). They found recruits on concrete, on solitary ascidians, on old *Undaria* holdfasts and on the plastic used for tagging the plants. Both field data and laboratory experiments suggested that warmer water inhibited the development and survival of the gametophytes. Furthermore, they noted that zoospore release occurred at lower temperatures than those Saito (1975) claimed to be necessary (but see also Akiyama and Kurogi, 1982; at 7–23°C). At Santa Catalina Island in California, Thornber and coworkers (2004) reported that *U. pinnatifida* grew together with several other kelps, including *Macrocystis pyrifera* and *Pelagophycus porra*. At Long Beach, S California, it grew on steep subtidal banks among a dense stand of the green alga *Ulva* sp. (Silva *et al.*, 2002).

### 4.6.4 Reproduction

At Santa Barbara,Thornber and coworkers (2004) saw two distinct recruitment periods, a small one in autumn from August until September, with densities of up to 0.8 individuals m$^{-2}$, and plants surviving until February; and a larger one from February to May with densities of up to 3 individuals m$^{-2}$, and plants surviving until mid-June. Both recruitment periods seemed to be triggered by cold water (< 15°C), with a lag period of about eight weeks. In the laboratory they found that zoospores settled after three days, and after eight days they had developed into gametophytes, with higher densities at 13 compared to at 21°C. The time from recruitment to maturity could be as short as four weeks, with a mean of six weeks, and plants as small as 17 cm were found to be fertile.

### 4.6.5 Ecological impact

So far the ecological impact seems to have been small. In many areas the species is still manly found in harbours, and, even when growing together with other kelps at Santa Catalina Island, those were not yet negatively affected (Thornber *et al.*, 2004). They also suggested that the impact might become stronger in the colder waters further north, where the *Undaria* populations could persist all year round, compared to further south, where there are gaps between the generations.

### 4.6.6 Grazers and disease agents

In Santa Barbara harbour, Thornber and coworkers (2004) found that almost all plants recruited during winter–spring were quite heavily grazed by the native, common kelp crab, *Pugettia producta*, while only half of the population recruited during autumn was eaten. The high grazing pressure in spring prevented most of the plants becoming fertile, and the crabs could quite efficiently control the population dynamics in spring. The only other grazers noted were occasionally amphipods. By using laboratory experiments they found that *U. pinnatifida* was as much eaten as the otherwise preferred food by the crab the giant kelp, *Macrocystis pyrifera*, and that the crab preferred the lamina of *U. pinnatifida* before the sporophylls.

## 4.6.7 Utilization and aquaculture

There are no published reports of any utilization of the introduced populations in these areas. According to Lonhart (2003) it has been suggested that *U. pinnatifida* should be harvested in winter–early spring to feed abalone, especially since the native species are less abundant during that time.

## 4.6.8 Management and control

There has been some eradication in minor areas such as in the harbour of Santa Barbara (Silva *et al.*, 2002; Thornber *et al.*, 2004) and in the harbour of Monterey (Lonhart, 2003; Hewitt *et al.*, 2005).

**Table 2. Summarized ecological interactions of *Undaria pinnatifida***

| Ocean | Area | Grazing pressure | Effects on native ecosystem |
|---|---|---|---|
| NW Pacific | Japan (excl. N & E Hokkaido) | Information not available (diseases in farms) | *Part of native seaweed communities* |
| | Korea | <u>Farms</u>: amphipods & harpacticoids (+diseases) | *Part of native seaweed communities* |
| | SE Russia | Information not available | *Part of native seaweed communities* |
| | NE China | Information not available | *Part of native seaweed communities* |
| | China, elsewhere | Information not available | ? |
| | Taiwan | Information not available | ? |
| N Mediterranean | S France | Sea urchins | Co-occurring with native seaweeds |
| | NE & S Italy | Very low | Decrease of native seaweeds (spring–summer) |
| NE Atlantic | NW France | High by fish & crustaceans | Less competitive than native seaweeds; fouling problem, beach cast |
| | N Spain | ? | ? |
| | S U.K. | Hardly any | Less competitive than native seaweeds, fouling problem; also positive for fauna |
| | The Netherlands | ? | Fouling on molluscs |
| | Belgium | Birds (coots), some fish | Several fouling organisms on *Undaria* |
| | Portugal | ? | ? |
| SW Pacific & Tasman Sea | New Zealand | Abalone, sea slugs, crusta-ceans, some fish | ? |
| | Australia | High by sea urchins | Less competitive than native seaweeds; mainly on grazed & disturbed areas |
| SW Atlantic | Argentina | Potentially gastropods, sea urchins | Reduced seaweed diversity, changes in composition |
| E Pacific | California | High by kelp crabs; amphipods | Not yet seen but might be stronger further north |
| | Mexico | ? | ? |

# 5 Limited records, not suggestive of established introductions

There have been no published reports on records of the species from areas, where it has not later become established.

# 6 Prospects of further invasions

In general, brackish water areas may be less at risk, if salinities are well below 18 PSU. The high affinity for artificial substrate also makes areas with sediments susceptible, although soft substrate is not colonized, and plants could also grow there on small stones, shells, polychaete tubes and on other plants. Disturbed rocky shores are likely more at risk than those with a dense perennial vegetation, if not too exposed (Hay and Villouta,1993). Great care should be taken when using temperature limits to predict areas of no concern for future establishment, since the species has been able to settle in areas with temperatures far from the optimal ranges given in literature.

***European Atlantic coasts (cf. Hay, 1990; Floc'h et al., 1991)***

All the rest of England, Wales, Isle of Man, Scotland with the Orkneys and Hebrides, Ireland, W Scandinavia (excl. the Baltic Sea proper, which has too low salinities), all the rest of the North Sea coast, and all the rest of France, Spain and Portugal.

***Mediterranean coasts (incl. the Black Sea basin)***

Presumably all the rest of the western Mediterranean area (Spain, France, Italy) as well as theE Adriatic, N Aegean and probably also the N Jonian Sea, and coasts of W Turkey incl. the Marmara Sea and the Dardanelles, however, surface salinities in the Black Sea are probably too low except in the central pelagic zone. The W part of the north African coast. It is less easy to predict, if also the eastern part of the Mediterranean is at risk.

***African coasts***

Cold and warm temperate areas, which would exclude most of the African east coast.

***American coasts***

Atlantic and Pacific warm and cold temperate coasts of North and South America (cf. Orenanza *et al.*, 2002; Silva *et al.*, 2002).

***Australia and New Zealand***

All the rest of the warm and cold temperate coasts of Australia (cf. Sanderson, 1990; AQIS, 1994) and most of New Zealand.

# 7 Prospects for control and management where introductions occur

Since the microscopic gametophytes are very tolerant and not visible to the naked eye, eradication is extremely difficult. Studies on effects of herbicides and antifouling paint have shown that some antifouling paints are efficient in stopping zoospore germination or cause gametophyte mortality, while some herbicides are not (Burridge and Gorski, 1997). However, patches not painted (e.g. covered by supporting structures during painting) or single corroded plates may develop dense lumps of sporophytes (Hay, 1990). Hulls of ships should only be cleaned out of the water and detached organisms must be dumped out of the reach of the sea (AQIS, 1994). Since sporophytes have been found surviving and growing on the hulls for voyages over 4000 km (Hay, 1990), they should be removed before sporophylls are developed (in some cases sporophylls are small and difficult to see) to avoid seeding of other areas. If fertile, detached plants should be kept in containers when removed (see also Hewitt *et al.*, 2005), to avoid release of zoospores, since slightly dried sporophylls, which are reimmersed, release zoospores very quickly (Saito, 1975; Liu *et al.*, 2004).

Gametophytes can survive temperatures around 30°C for up to 10–40 days (Kim and Nam, 1997), and thus high temperature treatment is needed for cleaning boat hulls, and one must be reassured that the hot water penetrates into crevices and other openings. Gametophyte survival in small moist crevices in the hulls, anchor wells etc. can make them survive even dry docking, as well as transportation on land for days up to at least about a month (Hay, 1990, pers. comm.). Since they can stand darkness for over seven months (Kim and Nam, 1997), ballast transport is also a plausible vector, especially as the gametophytes may form thick-walled resting stages (Saito, 1975), with a potential of surviving also in the sediment. High temperatures, well above 30°C, thus are needed to be a treatment option for ballast water. Exposure to UV light may also be an efficient treatment for growing gametophytes (cf. Akyiama, 1965), although it is not known if this affects the thick-walled resting stages.

Also pontoons, towed buoys or drifting objects, such as plastics, ropes etc., may contribute to the dispersal and those should be taken out of water and cleaned more efficiently than just by scraping off plants (cf. Hay, 1990) or be disposed of, when carrying *Undaria* plants. In several cases attempts of manual eradications have not been successful (see Table 1 and details in Section 4).

According to Hewitt and coworkers (2005), the ability to make decisions, as to when and where a response should occur, is limited by poor knowledge of the efficacy and costs. They evaluated manual removal of *U. pinnatifida* sporophytes in a new incursion in the Marine Reserve in Tasmania over a 2.5 year study period. Plants from a 800 $m^2$ area were removed, on a monthly basis, to minimise the likelihood of maturation of sporophytes and subsequent release of zoospores. While manual removal appeared to have significantly reduced the number of developing sporophytes, the persistence of hot spots through time suggested that either microscopic stages (zoospores, gametophytes or sporelings) create a seed bank that persists for longer than 2.5 years, or selective gametophyte survival in microhabitats occurs. In order for manual removal of *U. pinnatifida* to be effective, a long-term commitment to a removal activity needs to be coupled with vector management and education initiatives to reduce the chances of re-inoculation and spread. Further needed is monitoring (and response) on a larger spatial scale for the early detection of other incursion sites, and a treatment to remove persistent microscopic stages.

McEnnulty and coworkers (2002) made a thorough literature review on options of how to get rid of established introduced macroalgae. They also discussed if disease agents and endophytic algae could be an option, but considered that too little is known about any host specificity, and many organisms may be harmful also to native seaweeds, especially kelps.

In aquaculture, proper quarantine treatment, allowing only release of the next generation, should be used to avoid that mussels or oysters act as vectors. New rules for free trade and movements of shellfish for fattening between disease-free coastal areas within Europe may bring in *U. pinnatifida* from areas where it occurs, and might especially be a threat for the Irish and British coasts, where such movements have frequently occurred. Farming of *Undaria* should not be considered in areas where it does not yet grow (Anon., 1998), nor should lines and supporting structures in aquaculture be moved from sites with *Undaria* to areas where it does not occur (Hay, 1990; AQIS, 1994).

*U. pinnatifida* should not be on display in public aquaria, if a flow-through system is used, and even if the water is treated and recirculated, there might be a risk that fertile parts may reach the sea, if material is taken from the aquarium when cleaning the tank or at emergency situations.

Great care should be taken not to perform scientific experiments in the field or in open flow-through systems in areas, where the species does not yet occur. Also material brought in for demonstrations should be carefully disposed of on land, especially when plants with sporophylls are used.

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# 9 REFERENCES

Agatsuma, Y., Matsuyama, K., Nakata, A., Kawai, T., Nishikawa, N. 1997. Marine algal succession on coralline flats after removal of sea urchins in Suttsu Bay on the Japan Sea coast of Hokkaido, Japan. Nippon Suisan Gakkaishi, 63 (5): 672–680.

Aguilar-Rosas, R., Aguilar-Rosas, L.E., Avila-Serrano, G., Marcos-Ramirez, R. 2004. First record of *Undaria pinnatifida* (Harvey) Suringar (Laminariales, Phaeophyta) on the Pacific coast of Mexico. Botanica Marina, 47:255–258.

Akiyama, K. 1965. Studies of ecology and culture of *Undaria pinnatifida* (Harv.) Sur. Environmental factors affecting the growth and maturation of gametophyte. Bulletin of Tohoku Regional Fisheries Research Laboratory 25: 143–170. (In Japanese with English summary and legends).

Akiyama, K. 1977. On the *Olpidiopsis* disease of *Undaria pinnatifida* in field culture. Bulletin of Tohoku Regional Fisheries Research Laboratory 37: 43–49. (In Japanese with English summary and legends).

Akiyama, K., Kurogi, M. 1982. Cultivation of *Undaria pinnatifida* (Harvey) Suringar, the decrease in crops from natural plants following crop increase from cultivation. Bulletin of Tohoku Regional Fisheries Research Laboratory, 44: 91–100.

Anon. 1998. Aquaculture of *Undaria.* http://www.frst.govt.nz/textsearch/rr9697/caw602.htm (visited in April 2005).

AQIS. 1994. An epidemical review of possible introductions of fish diseases, northern Pacific seastar and Japanese kelp through ships' ballast water. AQIS Ballast Water Research Series, 3: 241–259, Canberra, Australia.

Boudouresque, C.F., Gerbal, M., Knoepffler-Peguy, M. 1985. L´algue japonnaise *Undaria pinnatifida* (Phaeophyceae, Laminariales) en Méditerranée. Phycologia, 24:364–366.

Brown, M.T., Lamare, M.D. 1994. The distribution of *Undaria pinnatifida* (Harvey) Suringar within Timaru Harbour, New Zealand. Japanese Journal of Phycology, 42: 63–70.

Burridge, T.R., Gorski, J. 1997. The use of biocidal agents as potential control mechanisms for the exotic kelp *Undaria pinnatifida.* CRIMP Technical Rep. 16, CSIRO, Australia.

Campbell, S.J. 1999. Uptake of ammonium by four species of macroalgae in Port Phillip Bay, Victoria, Australia. Marine and Freshwater Research, 50: 515–522.

Campbell, S.J., Burridge, T.R. 1998. Short note: Occurrence of *Undaria pinnatifida* (Phaeophyta: Laminariales) in Port Philip Bay, Victoria, Australia. Marine Freshwater Research 49: 379–381.

Campbell, S.J., Bite, J.S., Burridge, T.R. 1999. Seasonal patterns in the photosynthetic capacity, tissue pigment and nutrient content of different developmental stages of *Undaria pinnatifida* (Phaeophyta : Laminariales) in Port Phillip Bay, south-eastern Australia. Botanica Marina, 42: 231–241.

Casas, G.N., Piriz, M.L. 1996. Surveys of *Undaria pinnatifida* (Laminariales, Phaeophyta) in Golfo Nuevo, Argentina. Hydrobiologia, 326–327: 213–215.

Casas, G., Scrosati, R., Piriz, M.L. 2004. The invasive kelp *Undaria pinnatifida* (Phaeophyceae, Laminaariales) reduces native seaweed diversity in Nuevo Gulf (Patagonia, Argentina). Biological Invasions 6(4) : 411–416.

Castric-Fey, A., L'Hardy-Halos, M.T. 1996. L'Expansion d'*Undaria pinnatifida* (Laminariales, Alariaceae) dans la region Malouine, premieres observations. In: Ribera M.A., Ballesteros E. Boudouresque C.F., Gómez A. and V. Gravez (eds) Second Intern. Workshop on *Caulerpa taxifolia*, Barcelona Spain, 15–17 December 1994. Publ. Univ. Barcelona, pp. 407–412.

Castric-Fey, A., Girard, A., L'Hardy-Halos, M.T. 1993. The distribution of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the coast of St Malo (Brittany, France). Botanica Marina 36: 351–358.

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., L'Hardy-Halos, M.T. 1999a. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Morphology and growth of the sporophyte. Botanica Marina 42: 71–82.

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., L'Hardy-Halos, M.T. 1999b. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Growth rate and longivity of the sporophyte. Botanica Marina 42: 83–96.

Cecere, E., Petrocelli, A., Saracino, O.D. 2000. *Undaria pinnatifida* (Fucophyceae, Laminariales) spread in the central Mediterranean: its occurrence in the Mar Piccolo of Taranto (Ionian Sea, southern Italy). Cryptogamie Algologie, 21: 305–309.

CSIRO. 2000. Marine Pest Information Sheet: Japanese seaweed (*Undariapinnatifida*) http://www.marine.csiro.au/crimp/Reports/Infosht12_Und0700S3.pdf (visited on March 6, 2006).

C-Weed Aquaculture. 2006. Avilable at http://c-weed-aquaculture.com/algues/culture-en-mer.htm (visited on February 20, 2006).

Curiel, D., Rismondo, A., Marzocchi, M. Solazzi, A. 1994. Distribuzione di *Undaria pinnatifida* (Harvey) Suringar (Laminariales, Phaeophyta) nella Laguna di Venezia. Soc. Veneziana Sci. Nat. Lavori, 19: 121–126. (In Italian with English abstract).

Curiel, D., Bellemo, G., Marzocchi, M., Scattolin, M., Parisi, G. 1998. Distribution of introduced Japanese macroalgae *Undaria pinnatifida, Sargassum muticum* (Phaeophyta) and *Antithamnion pectinatum* (Rhodophyta) in the Lagoon of Venice. Hydrobiologia, 385: 17–22.

Curiel, D., Guidetti, P., Bellemo, G., Scattolin, M. and Marzocchi, M. 2002. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the lagoon of Venice. Hydrobiologia, 477: 209–219.

Daguin, C., Voisin, M., Engel, C., Viard, F. 2005. Microsatellites isolation and polymorphism in introduced populations of the cultivated seaweed *Undaria pinnatifida* (Phaeophyceae, Laminariales) Conservation Genetics, 6 (4): 647–650.

Dean, P.R., Hurd, C.L. 1996. Nitrate and ammonium uptake by the introduced kelp *Undaria pinnatifida*. http://nzmss.rsnz.govt.nz/conf96/abstrs2s.html.

Department of Primary Industries, Water and Environment. 2005a. Seaweed Fishery. http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/LVAE-4ZP99F?open (visited on February 23, 2006).

Department of Primary Industries, Water and Environment. 2005b. *Undaria pinnatifida* (Japanese seaweed Action Plan. http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/LVAE-4ZP99F?open (visited on March 6, 2006).

Dumoulin, E. and De Blauwe, H. 1999. Het bruinwier *Undaria pinnatifida* (Harvey) Suringar, (Phaeophyta: laminariales) aangetroffen in de jachthavenvan Zeebruge met gegevens over het voorkomen in Europa en de wijze van verspreiding. De Strandvlo, 19 (4): 182–188.

Edgar, G.J., Barrett, N.S., Morton, A.J., Samson, C.R. 2004. Effects of algal canopy clearance on plant, fish and macroinvertebrate communities on eastern Tasmanian**.** Journal of Experimental Marine Biology and Ecology, 312 (1): 67–87.

Eno, N.C., Clark, R.A., Sandersson, W.G. 1997. Non-native marine species in British waters: a review and directory. Joint Nature Conserv. Comm., Peterborough, pp. 72–74.

Fang. T.C., Dai, J. and Chen, D. 1982. Parthenogenesis and the genetic properties of parthenosporophytes of *Undaria pinntifida*. Acta Oceanologica Sinica, 1: 107–111.

FAO. 2006. Proceedings from Workshop on the cultivation and processing of *Undaria*, Pusan, Republic of Korea, 24–29 April 1991 http://www.fao.org/docrep/field/003/AB733E/AB733E00.htm (visited on February 23, 2006).

Fletcher, R.L., Farell, P. 1998. Introduced brown algae in the North East Atlantic with particular respect to *Undaria pinnatifida* (Harvey) Suringar. Helgoländer Meeresuntersuchungen 52: 259–275.

Fletcher, R.L. and Manfredi, C. 1995. The occurrence of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the south coast of England. Botanica Marina, 38: 355–358.

Floc'h, J.-Y., Pajot, R. and Wallentinus, I. 1991. The Japanese brown alga *Undaria pinnatifida* on the coast of France and its possible establishment in European waters. J. Cons. int. Explor. Mer, 47: 379–390.

Floc'h, J.-Y., Pajot, R., V. Mouret, V. 1996. *Undaria pinnatifida* (Laminariales, Phaeophyta) 12 years after its introduction into the Atlantic. Hydrobiologia 326–327: 217–222.

Forrest, B.M., Blakemore, K. 2003. Guidelines to reduce the inter-regional spread of the Asian kelp *Undaria* via marine farming activities. Cawthron Report 773 prepared for the (NZ) Ministry of Fisheries.

Forrest, B.M., Taylor, M.D. 2002. Assessing invasion impact: survey design considerations and implications for management of an invasive species. Biological Invasions, 4: 375–386.

Forrest, B.M., Brown, S.N., Taylor, M.D., Hurd, C.L., Hay, C.H. 2000. The role of natural dispersal mechanisms in the spread of *Undaria pinnatifida* (Laminariales, Phaeophyceae). Phycologia, 39: 547–553.

Funahashi, S. 1966. Marine algae from Vladivostok and its vicinity. Bull. Jap. Soc. Phycol., 14: 127–145. (In Japanese with English summary).

Funahashi, S. 1974. Distribution of marine algae in the Japan Sea, with reference to the phytogeographical positions of Vladivostok and Noto Peninsula districts. Journ. Fac. Sci. Hokkaido Univ. Ser. V (Botany), 10: 1–31.

GISD. 2006. Global Invasive Species Database. http://www.issg.org/database (visited on 20 February, 2006).

Guiry, M.D., Rindi, F., Guiry, G.M. 2006. *AlgaeBase version 4.0*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org (visited on 20 February, 2006)).

Han, J., Kang, S., Choue, R., Kim, H., Leem, K., Chung, S., Kim, C., Chung, J. 2002. Free radical scavenging effect of *Diospyros kaki, Laminaria japonica* and *Undaria pinnatifida*. Fitoterapia, 73 (7–8): 710–712.

Hay, C.H. 1990. The dispersal of sporophytes of *Undaria pinnatifida* by coastal shipping in New Zealand and implications for further dispersal of *Undaria* in France. British Phycological Journal, 25: 301–314.

Hay, C.H., Luckens, P.A. 1987. The Asian kelp *Undaria pinnatifida* (Phaeophyta, Laminariales) found in a New Zealand harbour. New Zealand Journal of Botany, 25: 329–332.

Hay, C.H., Villouta, E. 1993. Seasonality of the adventive Asian kelp *Undaria pinnatifida* in New Zealand. Botanica Marina, 36: 461–471.

Hayes, K., Sliwa, C., Migus, S., McEnnulty, F., Dunstan, P. 2005. National priority pests: Part II. Ranking of Australian marine pests. An independent report for the Department of Environment and Heritage by CSIRO Marine Research.

Hewitt, C.L., Campbell, M.L., McEnnulty, F., Moore, K.M., Murfet, N.B., Robertson, B., Schaffelke, B. 2005. Efficacy of physical removal of a marine pest: the introduced kelp *Undaria pinnatifida* in a Tasmanian Marine Reserve. Biological Invasions, 7: 251–263.

Hilhorst, M. 2006. *Undaria*. https://www.biodiv.org/doc/case-studies/ais/cs-ais-nz-undaria-en.pdf (visited on February 23, 2006).

Hurd, C.L., Nelson, W.A., Falshaw, R., Neill, K.F. 2004. History, current status and future of marine macroalgal research in New Zealand: Taxonomy, ecology, physiology and human uses. Phycological Research, 52 (2): 80–106.

ICES. 1993. Report of the Working Group on Introductions and Transfers of Marine Organisms, Aberdeen, 26–28 April 1993. ICES C.M. 1993/F:3.

ICES WGITMO. 2000. Report of the Working Group of Introductions and Transfers of Marine Organisms, Parnu, Estonia, 27–29 March 2000. ICES CM 2000/ACME:07.

ICES WGITMO. 2001. Report of the Working Group of Introductions and Transfers of Marine Organisms, Barcelona, Spain, 21–23 March 2001. ICES CM 2001/ACME: 08. (available at: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO).

ICES WGITMO. 2002. Report of the Working Group of Introductions and Transfers of Marine Organisms, Gothenburg, Sweden, 20–22 March 2002. ICES CM 2002/ACME:06. (available at: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO).

ICES WGITMO. 2004. Report of the Working Group of Introductions and Transfers of Marine Organisms, Cesenatico, Italy, 25–26 March 2004. ICES CM 2004/ACME: 05. (available at: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO).

Kang, J.W. 1966. On the geographical distribution of marine algae in Korea. Bull. Pusan Fish. Coll. 7: 1–136.

Kang, J.W. 1981. Some seaweed deseases occurred at seaweed farms along the south-eastern coast of Korea. Bull. Korean Fish. Soc., 14: 165–170 (In Korean with English summary).

Kim, Y.S., Nam, K.W. 1997. Temperature and light responses on the growth and maturation of gametophytes of *Undaria pinnatifida* (Harvey) Suringar in Korea. J. Korean Fish. Soc., 30: 505–510. (In Korean with English summary).

Kim, K.Y., Choi, T.S., Huh, S.H., Garbary, D.J. 1998. Seasonality and community structure of subtidal benthic algae from Daedo Island, Southern Korea. Botanica Marina, 41 (4): 357–365.

Kim, K.Y., Choi, T.S., Yi, Y.H. 2004. Host specificity of kelp gametophytes. Algae, 19 (1): 31–37.

Koh, C.H. 1983. Community structure and productivity of phytobenthos in Juckdo eastern coast of Korea. 2. Seasonal changes of algal vegetation in relation to annual growth of large brown algae. Korean Journal of Botany, 26: 181–190. (In Korean with English summary).

Kurogi, M., Akiyama, K. 1957. Studies of ecology and culture of *Undaria pinnatifida* (Sur.) Harriot. Bulletin of Tohoku Regional Fisheries Research Laboratory, 10: 95–117 (In Japanese with English summary and legends).

Lee, S.M. 2004. Utilization of dietary protein, lipid, and carbohydrate by abalone *Haliotis discus hannai:* A review. Journal of Shellfish Research, 23 (4): 1027–1030.

Liao, I.C. and Liu, H.-C. 1989. Exotic species in Taiwan. In: De Silva S.S. (ed.) Exotic aquatic organisms in Asia. Asian Fish. Soc. Spec. Publ., 3: 101–115.

Liu, J.X., Dong, L.F., Shen, Y.Q., eWu, C.Y. 2004. Effect of light period on egg-discharge of gametophyte clones of *Undaria pinnatifida* (Phaeophyta). Journal of Applied Phycology, 16 (6): 519–521.

Lonhart, S. 2003. Frequently asked questions regarding the *Undaria* invasion of Monterey Bay. http://www.mbnms-simon.org/docs/build/undaria_faqs.pdf (visited on February 23, 2006).

Matsuyama, K. 1983. Photosynthesis of *Undaria pinnatifida* Suringar f. *distans* Miyabe et Okamura (Phaeophyceae) from Oshoro Bay. I. Seasonal changes of photosynthetic and respiratory rates. Sci. Rep. Hokkaido Fish. Exp. Stn. 25: 187–193. (In Japanese with English summary and legends).

McEnnulty, F.R., Bax, N.J., Schaffelke, B. and Campbell, M.L. 2000).A literature review of rapid response options for the control of ABWMAC listed species and related taxa in Australia. In: Bax, N.J. and McEnnulty, F.R. Rapid response options for managing marine pest incursions. Final Report for NHT/C&CS project 21249.

Morita, T., Kurashima, A., Maegawa, M. 2003a. Temperature requirements for the growth of young sporophytes of *Undaria pinnatifida* and *Undaria undarioides* (Laminariales, Phaeophyceae). Phycological Research, 51 (4): 266–270.

Morita, T., Kurashima, A., Maegawa, M. 2003b. Temperature requirements for the growth and maturation of the gametophytes of *Undaria pinnatifida and U. undarioides* (Laminariales, Phaeophyceae). Phycological Research, 51 (3): 154–160.

Nyberg, C.D., Wallentinus, I. 2005. Can species traits be used to predict marine macroalgal introductions? Biological Invasions, 7: 265–279.

Occhipinti Ambrogi, A. 2002. Current status of aquatic introductions in Italy. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): *Invasive Aquatic Species of Europe: Distributions, Impacts and Management.* Kluwer Acad. Publ., Dordrecht, pp 311–324.

Ogawa, H., Fuijita, M. 1997. The effect of fertilizer application on farming of the seaweed *Undaria pinnatifida* (Laminariales, Phaeophyta). Phycological Research, 45: 113–116.

Oh, S.-H., Koh, C.-H. 1996. Growth and photosynthesis of *Undaria pinnatifida* (Laminariales, Phaeophyta) on a cultivation ground in Korea. Botanica Marina, 39: 389–393.

Okamura, K. 1926. Icones of Japanese algae. 5 (7) Kazama Shobo, Tokyo, pp. 117–122, pl. 231–235.

Orensanz, J.M., Schwindt, E., Pastorino, G., Bortolus, A., Casas, G., Darrigran, G., Elías, R., López Gappa, J.J., Obenat, S., Pascual, M., Penchaszadeh, P., Piriz, M.L., Scarabino, F., Spivak, E.D., Vallarino, E.A. 2002. No longer the prestine confines of the world ocean: a survey of exotic marine species in the south western Atlantic. Biological Invasions, 4: 115–143.

Peréz, R., Lee, J.Y., Juge, C. 1981. Observations sur la biologie de l'algue japonaise *Undaria pinnatifida* (Harvey) Suringar introduite accidentellement dans l'Etang de Thau. Sci. Pêche, 315: 1 –12.

Pérez, R., Kaas, R., Barbaroux, O. 1984. Culture expérimentale de l´algue *Undaria pinnatifida* sur les Côtes de France. Sci. Pêche, 343: 3–15.

Peters, A.F., Breeman, A.M. 1992. Temperature responses of disjunct temperate brown algae indicate long-distance dispersal of microthalli across the tropics. Journal of Phycology, 28: 428–438.

Piriz, M.L., Eyras, M.C., Rostagno, C.M. 2003. Changes in biomass and botanical composition of beach-cast seaweeds in a disturbed coastal area from Argentine Patagonia. Journal of Applied Phycology, 15: 67–74.

Prestenko, L.P. 1980. Wodorosli Zaliva Petra Weilikogo. Izd. Akad. Nauk SSSR, Leninggrad 232 pp.

Qin, S., Jiang, P., Tseng, C.K. 2004. Molecular biotechnology of marine algae in China. Hydrobiologia, 512: 21–26.

Saito, Y. 1975. *Undaria*. In: Tokida J. and H. Hirose (eds) Advance of Phycology in Japan, Junk., The Hague. pp. 304–320.

Saitoh, M.S., Takeuchi, I., Otobe, H. 1999. Growth of cultivated *Undaria pinnatifida* blades in Otsuchi Bay, Iwate Prefecture. Japanese Journal of Phycology, 47 (2): 113–117.

Sanderson, J.C. 1990. A preliminary survey of the distribution of the introduced macroalga, *Undaria pinnatifida* (Harvey) Suringar on the east coast of Tasmania, Australia. Botanica Marina, 33:153–157.

Santiago Caamaño, J., Duran Neira, C. and Acuña Castroveijo, R. 1990. Aparicion de *Undaria pinnatifida* en las coastas de Galicia (España). Un nuevo caso en la problematica de introduccion de especies foraneas. Inf. Tec. Del Centro de Investigaciones Submarinas. 3, 44 pp.

Schaffelke, B., Campbell, M.L., Hewitt, C.L. 2005 Reproductive phenology of the introduced kelp Undaria pinnatifida (Phaeophyceae, Laminariales) in Tasmania, Australia. Phycologia, 44: 84–94.

Silva, P.C., Woodfield, R.A., Cohen, A.N., Harris, L.H., Goddard, J.H.R. 2002. First report of the Asian kelp *Undaria pinnatifida* in the northeastern Pacific Ocean. Biological Invasions, 4: 333–338.

Sinner, J., Forrest, B., Taylor, M. 2000. A strategy for managing the Asian kelp *Undaria*. Final Report to the (NZ) Ministry of Fisheries, Cawthron Report No 578.

Skriptsova, A., Khomenko, V., Isakov, V. 2004. Seasonal changes in growth rate, morphology and alginate content in *Undaria pinnatifida* at the northern limit in the Sea of Japan (Russia). Journal of Applied Phycology, 16: 17–21.

Stapleton, J.C. 1988. Occurrence of *Undaria pinnatifida* (Harvey) Suringar in New Zealand. Japanese Journal of Phycology, 36:178–179.

Stegenga, H. 1999. *Undaria pinnatifida* in Nederland gearriveerd. Het Zeepard, 59: 71–73. (In Dutch with English summary).

Stuart, M.D., Brown, M.T. 1996. Phenology of *Undaria pinnatifida* (Harvey) Suringar in Otago Harbour, New Zealand. http://nzmss.rsnz.govt.nz/conf96/abstrs2s.html .

Stuart, M.D., Chadderton, W.L. 2001. Attempted eradication of the adventive Asian kelp, *Undaria pinnatifida,* in New Zealand. Phycologia, 40 (4) Supplement: 20 (abstract).

Stuart, M.D., Hurd, C.L., Brown, M.T. 1999. Effects of seasonal growth rate on morphological variation of *Undaria pinnatifida* (Alariaceae, Phaeophyceae). Hydrobiologia, 399: 191–199.

Thornber, C.S., Kinlan, B.P., Graham, M.H., Stachowicz, J.J. 2004. Population ecology of the invasive kelp *Undaria pinnatifida* in California: environmental and biological controls on demography. Marine Ecology Progress Series, 268: 69–80.

Torres, A.I., Gil, M.N., Esteves, J.L. 2004. Nutrient uptake rates by the alien alga *Undaria pinnatifida* (Phaeophyta) (Nuevo Gulf, Patagonia, Argentina) when exposed to diluted sewage effluent. Hydrobiologia, 520: 1–6.

Tseng, C.K. 1981 Commercial cultivation. In: Lobban C.S. and M.J. Wynne (eds) The biology of seaweeds. Blackwell Sci. Publ., Oxford, pp. 680–725.

Tseng, C.K. 2001. Algal biotechnology industries and research activities in China. Journal of Applied Phycology, 13: 375–380.

Uwai, S., Yotsukura, N., Serisawa, Y., Muraoka, D., Hiraoka, M., Kogame, K. 2006. Intraspecific genetic diversity of *Undaria pinnatifida* in Japan, based on the mitochondrial cox3 gene and the ITS1 of nrDNA. Hydrobiologia, 553: 345–356.

Valentine, J.P., Johnson, C.R. 2003. Establishment of the introduced kelp *Undaria pinnatifida* in Tasmania depends on disturbance to native algal assemblages. Journal of Experimental Marine Biology and Ecology, 295 (1): 63–90.

Valentine, J.P., Johnson, C.R. 2004. Establishment of the introduced kelp *Undaria pinnatifida* following dieback of the native macroalga *Phyllospora comosa* in Tasmania, Australia. Marine and Freshwater Research, 55: 223–230.

Valentine, J.P., Johnson, C.R. 2005. Persistence of the exotic kelp *Undaria pinnatifida* does not depend on sea urchin grazing. Marine Ecology Progress Series, 285: 43–55.

Verlaque, M. 1996. L'Étang de Thau (France), un site majeur d'introduction d'espèces en Mediterranée – Relations avec l'ostreiculture. In: Ribera M.A., Ballesteros E., Boudouresque C.F., Gómez A. and V. Gravez (eds) Second Intern. Workshop on *Caulerpa taxifolia*, Barcelona Spain, 15–17 December 1994. Publ. Univ. Barcelona, pp. 423–430.

Verlaque, M. 2001. Checklist of the macroalgae of Thau Lagoon (Hérault, France), a hot spot of marine species introduction in Europe. Oceanologica Acta, 24: 29–49.

Voisin, M., Engel, C.R. and Viard, F. 2005. Differential shuffling of native diversity across introduced regions in a brown alga: Aquaculture vs. maritime traffic effects. Proc. National Academy of Sciences, 102 (15): 5432–5437.

Wallentinus, I. 1999. Introduction and transfer of plants. In: Munro, A.L.S., Utting S.D. and I. Wallentinus (eds) Status of introductions of non-indigenous marine species to North Atlantic waters 1981–1991. Cooperative Research Reports, 231: 1–43.

Wallentinus, I. 2002. Introduced marine algae and vascular plants in European aquatic environments. *In*: Leppäkoski E, Olenin S, Gollasch S (eds): Invasive Aquatic Species of Europe: Distributions, Impacts and Management. Kluwer Acad. Publ., Dordrecht, pp 27–54 (+ 1 App. available at http://www.ku.lt/nemo/EuroAquaInvaders.htm).

Wotton, D.M., O'Brian, C., Stuart, M., Fergus, D.J. 2004. Eradication success down under: Heat treatment of a sunken trawler to kill the invasive seaweed *Undaria pinnatifida*. Marine Pollution Bulletin, 49 (9–10): 844–849.

Wu, C. and Meng, J. 1997. Translocation of assimilates in *Undaria* and its cultivation in China. Hydrobiologia, 352: 287–293.

Wu, C., Wen, Z., Peng, Z., Zhang, J. 1981. Preliminary study on the productivity of some economic marine algae. Phycologia, 20:118 (Abstr.).

Wu, C.Y., Li, D.P., Liu, H.H., Peng, G. and Liu, J.X. 2004. Mass culture of *Undaria* gametophyte clones and their use in sporeling culture. Hydrobiologia, 512 (1–3): 153–156.

Yabo, H. 1964. Early development of several species of Laminariales in Hokkaido. Mem. Fac. Fish., Hokkaido Univ., 12: 1–72.

Yamanaka, R., Akiyama, K. 1993. Cultivation and utilization of *Undaria pinnatifida* (wakame) as food. Journal of Applied Phycology, 5 (2): 249–253.

Yendo, K. 1909. On the mucilage glands of *Undaria*. Annals of Botany 23: 614–621+ Plate XLIII.

Yendo, K. 1911. The development of *Costaria, Undaria* and *Laminaria*. Annals of Botany, 25: 691–715 + Plate LIII–LV.

Yoo, J.S. 2003. Structural characteristics of benthic algal community in the subtidal zone of Yeongil Inner and Outer Bay. Algae, 18 (4): 365–369.

Yoshikawa, T., Takeuchi, I., Furuya, K. 2001. Active erosion of *Undaria pinnatifida* Suringar (Laminariales, Phaeophyceae) mass-cultured in Otsuchi bay in northeastern Japan. Journal of Experimental Marine Biology and Ecology, 266: 51–65.

Zemke-White, W.L., Ohno, M. 1999. World seaweed utilisation: An end-of-century summary. Journal of Applied Phycology, 11 (4): 369–376.

Zhang, D.M., Miao, G.R., Pei, L.O. 1984. Studies on *Undaria pinnatifida*. Hydrobiologia, 116/117: 263–265.

Zinova, E.S. 1954. Wodorosli Ochoskogo Mora. Trudy Bot. Inst. Akad. Nauk SSR, Ser 2, 9: 259–310.

# Annex 10: Recommendations to the Council

WGITMO unanimously recommends that Dr Judith Pederson (USA) be appointed as Chair of the WGITMO.

WGITMO recommends that the working group meet at least two days in Dubrovnik, Croatia in the week starting with March 19th 2007 in conjunction with the meeting of the ICES/IOC/IMO Working Group on Ballast and other Ship Vectors (WGBOSV) to:

- synthesise and evaluate National Reports, after intersessionally restructuring the report format to ensure consistency for ease of assessment and to include geographic information (latitude and longitude) for rapid tracking of the spread of invasive species;
- develop a 5 year summary of National Reports (2003–2007) with the aim to prepare a 25 year summary based on earlier reports at a future meeting (intersessional preparation of draft material is essential),
- finalize a report for rapid response and control options, including
  - i ) invitation of an internationally recognized expert to develop a risk assessment strategy for the rapid response including likelihood of success of eradication, impact of the invasive species on species in the area of introduction and impact of control methods (e.g. chemical eradication) on non-target species and habitat in the receiving environment;
  - ii ) contribute intersessionally to the database (Excel spreadsheet) for the rapid response account (e.g. case histories).
- develop Alien Species Alert reports including evaluation of impacts and to increase public awareness. WGITMO suggests to prepare intersessionally a Species Alert Report on the Pacific oyster *Crassostrea gigas* with the aim to finalize the report at next years meeting. Other candidate species are the Chinese mitten crab and *Didemnum* sp. (intersessional preparation of draft material is essential),
- review the impact of targeted fisheries on non-indigenous species (e.g. King crab, Chinese mitten crab, Green crab, Manila clam)

The various intersessional activities make a meeting obligatory in 2007 to reach final agreement.

Supporting information:

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| Priority: | The work of the Group is essential to prevent future unintentional movements of invasive and/or deleterious aquatic species including disease agents and parasites with the legitimate trade in species required for aquaculture, table market, ornamental trade, fishing and other purposes and to assess the potential of species moved intentionally to become a nuisance in the area of introduction. Commercial movements of organisms increase over time highlighting that a very high priority must be given to the development and implementation of precautionary actions to avoid unwanted impacts. Appropriate protocols are outlined in the Code of Practice. Vectors others than shipping and effects of invasive species are purview of WGITMO. The work of this Group supports the core role of ICES in relation to planned introductions and transfers of organisms. |

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|---|---|
| Scientific Justification: | The work is needed for the working group to maintain an overview of relevant activities in Member Countries and other areas from which species could be spread to Member Countries. The work on rapid response and control options will provide guidance on what to do in case a new species is recorded. The preparation of Aliens Species Alert Reports including an evaluation of impacts is an awareness raising instrument.<br>Further work is needed to keep the Code of Practice on the Introductions and transfer of marine organisms up-to-date. As a result of this initiative the comprehensive appendices of the Code, published on the Internet, may need to be updated.<br>The impact review of targeted fisheries on non-indigenous species may support a cost/benefit analysis of planned species introductions and may also facilitate the use of the ICES Code of Practice on the Introductions and Transfers of Marine Organisms. |
| Relation to Strategic Plan: | |
| Resource Requirements: | Normal meeting facilities provided by host country and participation of national members. |
| Participants: | WGITMO members and invited experts from, e.g., Australia, New Zealand, Mediterranean countries that are not members of ICES, representatives of relevant PICES WGs. Further, for the development of the rapid response and control options report it is recommended to invite an internationally recognized expert to develop a risk assessment strategy for the rapid response including likelihood of success of eradication, impact of the invasive species on species in the area of introduction and impact of control methods (e.g. chemical eradication) on non-target species and habitat in the receiving environment.<br>WGITMO recommends to invite experts with relevant expertise to contribute to the Aliens Species Alert reports and experts from countries which have developed/are developing rapid response plans. |
| Secretariat Facilities: | None required |
| Financial: | None required |
| Linkages to Advisory Committees: | ACME |
| Linkages to other Committees or Groups: | WGHABD, WGEIM, WGBOSV, WGAGFM, WGMASC Mariculture Committee. |
| Linkages to other Organisations: | Recognising the potential risk from introductions of aquatic species into the coastal waters, inland seas and waterways of Member Countries through freshwater routes, WGITMO urges ICES to encourage and support joint meetings between WGITMO and EIFAC, in addition to a continued dialogue between WGITMO and BMB, PICES, IMO, IOC, EU, HELCOM, EIFAC, BMB, CIESM. |
| Cost share | ICES 100 % |