VIMS Scientists to Explore Human Imprint of Pollution on Antarctic Sea Ice

For many, Antarctica represents an unpolluted refuge from the modern world. With no industry and only 4,000 temporary inhabitants dotting an icy expanse larger than the United States, it seems the continent would retain a primal purity.

Recent research suggests otherwise.

Indeed, some volatile pollutants, such as the pesticide hexachlorobenzene, occur in higher concentrations in Antarctica than in the temperate and tropical latitudes where they are produced and used.

VIMS researchers Rebecca Dickhut and Hugh Ducklow will travel to Antarctica next September with graduate student Amy Chiuchiolo to begin investigating the role that sea ice plays in injecting these "persistent organic pollutants," or POPs, into polar food webs.

Their visit to the waters of the Antarctic Peninsula will be the first in a pair of trips down under, courtesy of a 2-year grant from the U.S. National Science Foundation. The work builds on research conducted in the Chesapeake Bay during the last several years by Dickhut's current graduate student Padma Venkatraman.

Previous work on polar pollution has focused on the Arctic, due to concerns by Arctic governments about the effects of such contaminants on indigenous peoples. Because people such as the Inuit occupy the top of the food chain, feasting on polar bears and other marine mammals, they face a serious threat of biomagnification—the process by which contaminants become increasingly concentrated as the food pyramid narrows from the large number of primary producers at its base to the few predators at its peak.

Arctic research shows that levels of polychlorinated biphenyls (PCBs), a known carcinogen, are 2-10 times higher in Inuit newborns than in babies born further south. PCBs were once widely used in electrical equipment, but their manufacture was banned in the U.S. in 1977 because of evidence that they build up in the environment and cause harmful effects.

Dickhut and Ducklow's research turns the Arctic work on its head, both in geography and ecology. Instead of concentrating on the effects contaminants may have on top predators, Dickhut says they seek to understand "the mechanisms by which POPs are getting into the base of the Antarctic food web."

They hypothesize that sea ice plays a crucial role. A skirt of sea ice slowly expands around Antarctica each austral winter (from May through September) and then quickly contracts with the warmer temperatures of the austral spring. This floating fringe of sea ice is huge, and can at its maximum extent nearly double the solid surface of the continent.

Dickhut and Ducklow reason that POPs condense from the air onto the vast sheet of sea ice during the long winter, and then melt along with the sea ice into the surrounding seawater come spring.

Rebecca Dickhut and Hugh Ducklow of VIMS will begin a new study in Antarctica in Fall 2001.

Scientists extract an ice core during a Ross Sea expedition.

Unfortunately, release of contaminants in this manner would coincide with Antarctica's renowned spring phytoplankton bloom. During this bloom, increasing daylight and a rich supply of nutrients fuel algae, also released from the melting sea ice, to generate a population explosion among the tiny marine plants that nourish the rest of the Antarctic ecosystem.

Thus in Dickhut and Ducklow's proposed scenario, phytoplankton growth and POP concentrations peak in seawater simultaneously.

"You've had six to eight months of deposition all injected at once into the plankton system," says Ducklow. From there, the pair suspect the contaminants could quickly and efficiently infiltrate up the Antarctic food chain, passing from phytoplankton to zooplankton such as krill, then to fish, and on to apex predators such as Adelie penguins, skua seabirds, seals, and whales.

Ducklow is also interested in looking down the food chain, to explore how decomposition by marine bacteria affects the longer-term fate of persistent organic pollutants in Antarctic waters. As their name implies, POPs persist in nature for a long time—10s to 100s of years. They are ultimately broken down by sunlight and the action of microbes. Studying the mechanisms by which marine bacteria break down POPs may thus one day help scientists accelerate the process.

To test their sea-ice hypothesis, the VIMS team must sample POP concentrations in each suspected reservoir—air, sea ice, seawater, and the tissues of plankton and microbes. Because their work will focus on the base of the food chain, Dickhut and Ducklow expect to encounter contaminant concentrations that are very low.

"We'll be measuring in parts per billion and lower," says Dickhut. "That's like trying to find a coffee table in the state of Texas," adds Ducklow.

Previous Arctic researchers, who sampled from the blubbery tissues of top predators where POPs tend to concentrate, had a much easier time, working with concentrations a thousand times higher.

Because of the low concentrations in the reservoirs they plan to study, the VIMS team must sample large volumes to obtain a detectable signal. "We might have to get a cubic meter of ice per sample," says Ducklow.

"We have to make sure we get measurable levels," adds Dickhut. "And since you only get one or two trips to Antarctica, you don't have a lot of time to play with, so you'd rather overkill and collect even more." All the team's samples will be returned to VIMS for analysis.This will further complicate the logistics of an already rigorous expedition.

To reach their study site at 64º south latitude, the VIMS' scientists will sail from Punta Arenas, Chile aboard the 308-foot research ice-breaker *Nathaniel B. Palmer*. The voyage will bring them across notoriously windy and wave-tossed seas that sailors have dubbed the "roaring forties."

Ducklow tells of watching a solid wave of cold green water roar past his 6th-deck porthole during a 1996 Antarctic passage aboard the *Palmer*, then falling to the floor as the ship dropped 70 feet into the trough of the next wave. His stomach followed a few moments later.

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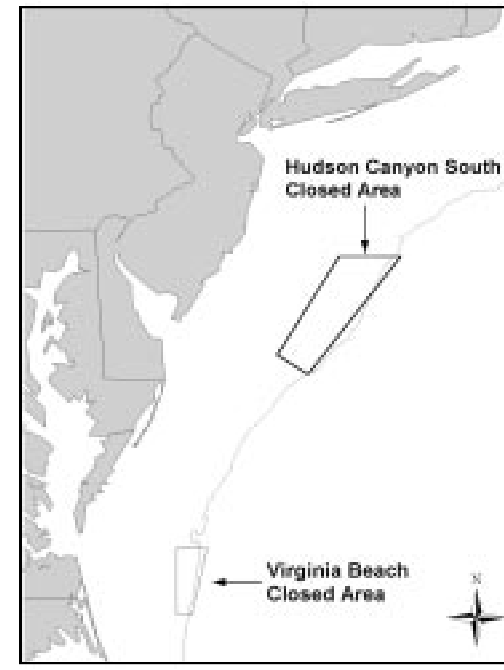
Mid-Atlantic Scallop Closed Areas Set to Reopen

By Dr. William DuPaul

Two sea scallop resource areas in the mid-Atlantic closed since 1998 to protect concentrations of small scallops are set to reopen in the spring of the 2001-2002 fishing year, which started on March 1st. The two areas, Hudson Canyon South and the Virginia Beach Closed Area, have an estimated total scallop biomass of 65.7 million lbs., of which 14.5 million lbs. are scheduled for harvest in 2001 and 14.7 million lbs., in 2002. The harvest estimates were obtained from the August 2000 survey conducted by the National Marine Fisheries Service and the June and September 2000 surveys conducted by VIMS scientists and students on the F/V *Alice Amanda* from Hampton, Virginia. As currently envisioned, each fishing vessel with a full-time scallop permit will be initially awarded three fishing trips in 2001, with a maximum catch up to 17,000 lbs. of scallops per trip. The mid-Atlantic Closed Areas are historic fishing areas frequented by scallop vessels from Virginia, New Jersey, and New York.

The year 2000 was a very successful year for the Virginia scallop industry. More than 8.9 million lbs. of scallops were landed in Virginia ports, worth more than $37.3 million. This does not include several hundred thousand pounds of scallops landed by Virginia-based boats in the Port of New Bedford after fishing on Georges Bank. Portions of the Georges Bank Closed Area I and the Nantucket Lightship Closed Area were reopened in 2000 to a limited harvest of 4.5 million pounds after a six-year closure.

The reopening of mid-Atlantic areas, along with good recruitment in other fishing areas, portends good news for Virginia's scallop industry.



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"I'll probably get seasick, but I'm still going!" laughs Dickhut.

Unfettered by land, the intense winds of the roaring forties drive the surface of the Southern Ocean in a huge circumpolar current that effectively isolates Antarctica's coastal waters from the rest of the world ocean.

Based on this isolation, scientists assume that the POPs detected in Antarctica's resident marine organisms are reaching the continent through the air—via what they call the "grasshopper effect." Dickhut and Ducklow's research will help to test this assumption.

Understanding how the grasshopper effect might help pollute Antarctic marine ecosystems requires a brief foray into the world of contaminant chemistry.

Some POPs are relatively non-volatile, which means that they are unlikely to evaporate into the air at normal surface temperatures. These include polycyclic aromatic hydrocarbons (PAHs), produced by incomplete burning of fossil fuels, and Kepone, the pesticide that began entering the James River during the 1960s.

Non-volatile POPs tend to stay put, adhering to mud and clay particles and thus accumulating in river and coastal sediments near where they are produced or used. Dickhut and her students, as well as others at VIMS, have previously studied these types of POPs in sediments and organisms from the James, York, and Elizabeth rivers.

However, other POPs—such as the pesticides hexachlorobenzene (HCB) and hexachlorocyclohexane (HCH), as well as some PCBs—evaporate relatively easily at normal surface temperatures. Because of this property, these compounds are lifted into the air by the same processes that carry water vapor skyward to produce clouds and rain. And like water vapor, which on a global basis enters the atmosphere in the tropics and exits at the poles, these compounds cycle slowly but consistently poleward through time.

Individual POP molecules may rain out of the atmosphere during their poleward voyage, but if the underlying water or land is warm, they quickly "hop" back into the air through renewed evaporation— hence the "grasshopper effect." Yet as an air mass travels away from the tropics into colder and colder climes, the proportion of molecules that hop back into the air continually decreases. By the poles, the grasshopper aren't hoppin', and any gaseous pollutants that condense and fall to the frigid surface remain trapped there.

The grasshopper effect may help explain the troubling fact that HCH levels in polar regions exceed those in the tropical zones where this insecticide is primarily used. After a farmer in India or other tropical lands sprays his or her rice fields with HCH, residual molecules may simply evaporate and then slowly but surely cycle poleward through the atmosphere to accumulate in polar zones.

By comparing samples taken from different reservoirs and during different seasons, Ducklow and Dickhut should be able to calculate a budget that can be used to track the passage of these grasshoppered POPs through Antarctic sea ice and into the local food chain.

September provides a particularly important window of opportunity for the team's research effort. This is when the sea ice begins to melt and relatively high concentrations of POPs flood the surrounding seawater. "Our cruise is purposefully scheduled to catch the end of the winter season," notes Ducklow.

The VIMS team will follow their September 2001 cruise with another trip in January and February 2002 to the Palmer Research Station. During the second trip the team will work both on land and sea to collect samples that they can tie into the long-term scientific databases available via Palmer's Long Term Ecological (LTER) Program.

Ducklow says that the project "is the best example I've ever had of a new idea that just kind of floated up to me that became a proposal that got funded. I was on Padma's thesis committee with Becky and I started to think about sea ice melting, and that pollutants probably accumulate on the ice. It was just an out-of-the-blue thing."

Both agree that formulation of their sea-ice hypothesis represents a "great example of teamwork" between Dickhut, a contaminant geochemist, and Ducklow, a biological oceanographer.

Within a month of their initial brainstorming, the two had submitted a formal proposal to NSF's Office of Polar Programs that combined Ducklow's research experience from four previous Antarctic trips with Dickhut's expertise in contaminant chemistry. The proposal that led to their upcoming work was funded in December 2000.

If that work proves successful, the pair plan a future return trip to Antarctica to trace the movement of POPs into the upper levels of the Antarctic marine ecosystem.

Student Receives NSF Graduate Fellowship

Chris Earnhart, a Ph.D. student in the Department of Environmental Sciences, recently received a three year NSF graduate fellowship which pays for an $18,000 stipend and $10,000 per annum towards tuition and educational costs. He received it under the discipline of immunology focusing on oyster defense mechanisms.

Ph.D. student Chris Earnhart in the VIMS Immunology lab.