The Shell Detective

Objectives

1. Compare and contrast non-native rapa whelk (*Rapana venosa*) shells with native channelled (*Busycotypus canaliculatus*) and knobbed (*Busycon carica*) whelk shells.
2. Identify diagnostic characters of each species.

Skills: Observation, communication, graphing.

Relevant Virginia Standards of Learning

6.9 Living systems
LS.7 Ecosystem relationships
A.5 Create and use graphs

Materials

1. Clean, dry rapa whelk shells (2 of each per group), channelled whelk shells, knobbed whelk shells (at least one per group)
2. One copy of *Rundown on the Rapa* Instructional booklet per student.
3. Measuring instruments including: calipers (mm), spring balances (up to 500 g), graduated cylinders (up to 250 ml), and tap water.

Procedure

1. Ask students to read the *Rundown on the Rapa* Instructional booklet.
2. Divide students into small research groups or teams.
3. Distribute rapa, channelled, and knobbed whelk shells to each group.
4. Have each research team complete Part A of *The Shell Detective* Student Worksheet (page 4) with measurements from all three species. Students should identify each of the major diagnostic features described (Figure 1) on their rapa whelk specimen and compare the rapa whelks with the native whelks on the basis of these features.
5. Have students make basic measurements of shells from each of the three species. These measurements should include:

shell length (mm): maximum dimension from spire to siphonal canal
shell shoulder width (mm): maximum dimension perpendicular to the central axis across the shell shoulders at the broadest point.

The citation for this Activity Booklet is:

Harding, J.M. and V.P. Clark. 2006. The Shell Detective. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-11-05, VIMS-ES-59. 12/2005.

shell weight (g): weight of dry shell
shell shoulder thickness (mm): thickness of shell at shell shoulder directly adjacent to opercular opening
shell volume (ml): volume of water contained in the shell when it is laid flat and filled to the opercular edge

6. Have each research team present their data to the class.

7. Pool the class data and make graphs (Part B of *The Shell Detective* Student Worksheet, p. 5) comparing the morphologies of these species. Suggested (x,y) graphs include: shell length, shell shoulder width; shell length, shell weight; and shell length, shell volume.

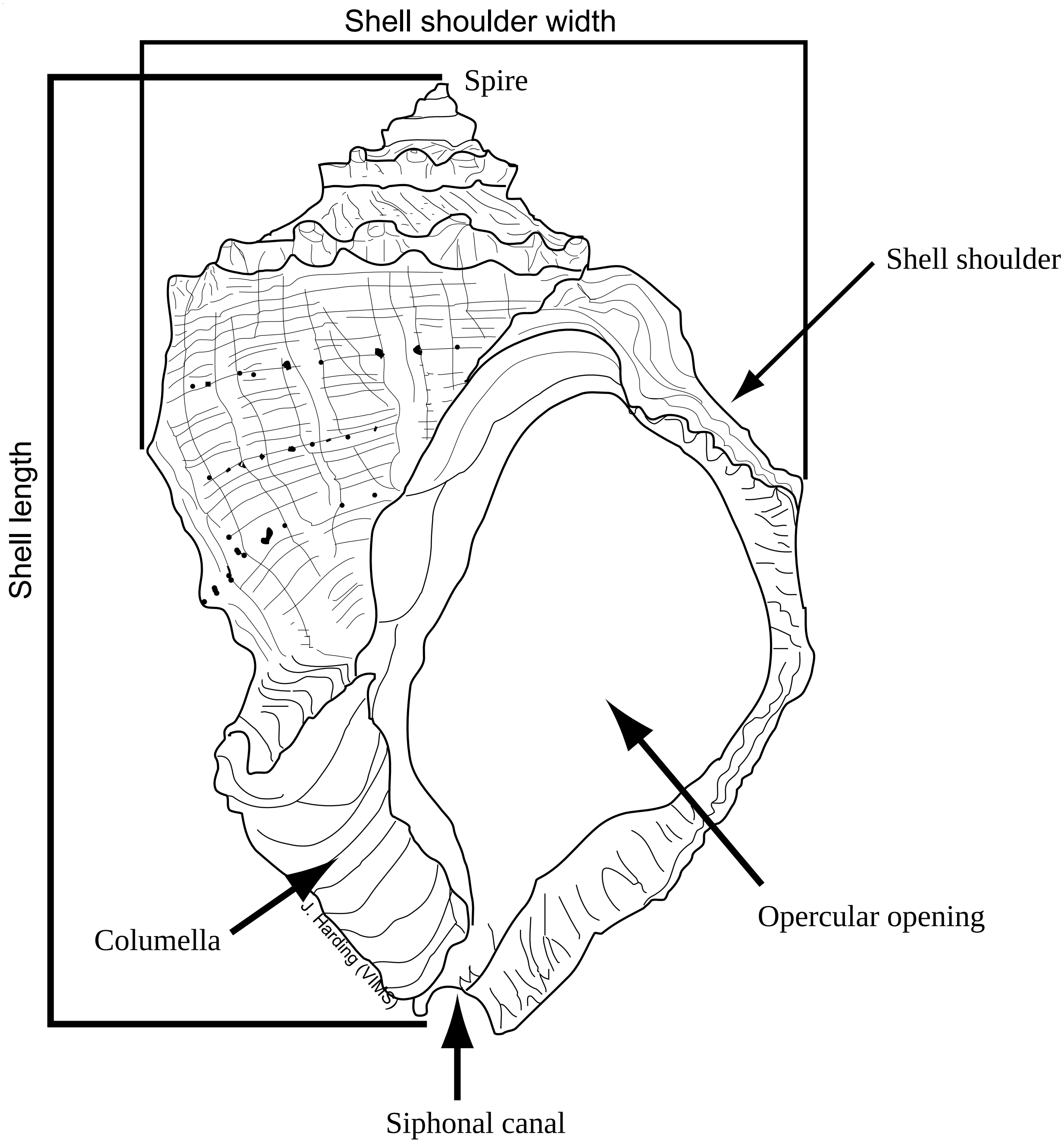
Related vocabulary

columella: the central pillar of a coiled gastropod shell.
operculum: the hard chitonous plate used by gastropods to protect their soft tissue from damage and dessication when the animal is retracted or pulled into its shell.
opercular opening: the opening in a gastropod shell through which the gastropod retracts into its shell which is sealed by the operculum.
siphonal canal: the protective channel in a gastropod shell through which the animal extends its siphon out into the environment.
spire: the top or apex of a gastropod shell.

Suggested discussion questions

1. What is the relationship between shell length and shell volume?
2. How does shell volume relate to the biomass and physiology of the animal?
3. What is the relationship between shell length and shell shoulder width?
4. Are there shell length - shell shoulder width relationships that are more efficient physiologically than others? If yes, describe these relationships and explain how they might confer a competitive advantage to individuals.
5. Do you think that these morphological relationships (shell length - shell shoulder width, etc.) are always the same for a species? Consider how developmental stage and environmental conditions might impact shell morphology at a moment in time.
6. Is there a difference in shell weight of individuals of approximately the same shell length from different species? How do you think these morphological differences might translate into vulnerability to predators that damage or crush the shell?

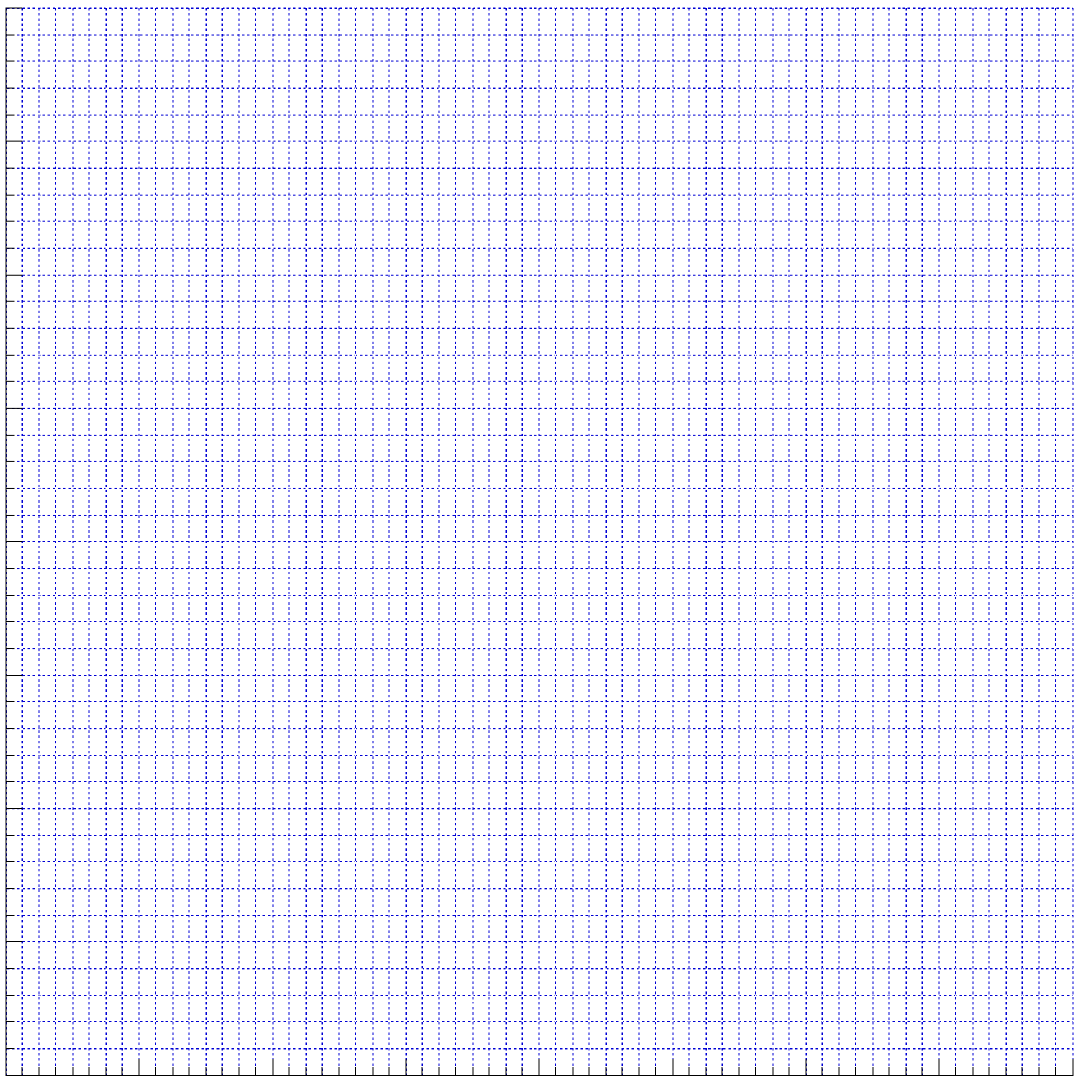
Figure 1: Sketch of a rapa whelk shell showing the locations for basic morphological measurements. Rapa whelks are distinguished from channelled and knobbed whelks by 1) the broad flat columella, 2) presence of distinct horizontal black lines (veins) in the shell, 3) shell shoulder widths almost equal to shell lengths, and 4) a “D” shaped opercular opening with bright red or orange coloration.



Student Worksheet A

Genus	Specimen number	Shell length (mm)	Shell shoulder width (mm)	Shell weight (g)	Shell volume (ml)
Rapana	1				
Rapana	2				
Rapana	3				
Rapana	4				
Rapana	5				
Busycon	1				
Busycon	2				
Busycon	3				
Busycon	4				
Busycon	5				
Busycotypus	1				
Busycotypus	2				
Busycotypus	3				
Busycotypus	4				
Busycotypus	5				

Student Worksheet B



The Shell Detective

Answer Key: Suggested discussion questions

1. What is the relationship between shell length and shell volume?

Shell volume increases as the cube of shell length.

2. How does shell volume relate to the biomass and physiology of the animal?

There is a direct relationship between shell volume and the biomass of the animal. Ectothermic invertebrates like rapa whelks tend to have lower physiological rates as they get older.

3. What is the relationship between shell length and shell shoulder width?

The shell length: shell shoulder width relationship should follow a power function of the form:

Shoulder width = a * shell length^b

where a is a normalization constant and b is a scaling constant. A power function is a curve when graphed on a linear axis.

This relationship is an allometric relationship. Allometry is defined as the relationship between the growth rates of different parts of an organism[1] within a species and between adults of related species[2]. In allometric growth, parts of an individual increase out of proportion to one another[2]. In other words, growth is not a 1:1 relationship and the "b" value in the power function is not equal to 1. Allometric relationships, described by power functions, are important tools that biologists used to describe scaling relationships in physiological and morphological studies.

4. Do you think that these morphological relationships (shell length - shell shoulder width, etc.) are always the same for a species? Consider how developmental stage and environmental conditions might impact shell morphology at a moment in time.

Morphological relationships may change within or between habitats in response to food availability or predators as well as other factors. For example, individuals with that reach a size refuge from predation by attaining larger shell lengths or approximately equal shell length: shell shoulder width ratios have a higher chance of surviving to reproduce than other individuals.

5. Is there a difference in shell weight of individuals of approximately the same shell length from different species? How do you think these morphological differences might translate into vulnerability to predators that damage or crush the shell?

Thicker shells offer more protection from predators that crush shells but cost more physiologically to carry and make. In habitats with few predators that crush shells, it is energetically more advantagous to grow larger with a thinner shell than it is to invest in a thicker shell that may not be needed. Snails like rapa whelks react to the effluent or chemical signatures of predators and may build their shells accordingly. Experiments that have transplanted snails from one site to another have documented morphological changes in the snail shells in the presence and absence of predators. Comparisons of different natural communities have yielded similar results.

[1] Walker, P. (ed.) 1989. Cambridge Dictionary of Biology. Cambridge University Press, Cambridge, UK.

[2] Li, J. 2000. Scaling and invariants in cardiovascular biology. p. 113-128. In: Scaling in Biology (eds. J. Brown and G.West). Oxford University Press, New York, NY.

Related educational resources

Harding, J.M., Mann, R., and V.P. Clark. 1999. Oyster Reef Communities in the Chesapeake Bay: A Brief Primer. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-99-05, VIMS-ES-44. 4/1999.

Harding, J.M., Mann, R., and V. P. Clark. 1999. Oyster Reef Communities in the Chesapeake Bay [CD-ROM]. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-99-06, VIMS-ES-45. 6/1999. (see the ORCCB CD website: http://www.vims.edu/mollusc/meeduc.orccb.html for release notes and CD updates).

Harding, J.M., Mann, R., and V.P. Clark. 1999. Shell Games. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-99-13, VIMS-ES-47. 11/1999.

Harding, J.M., Clark, V.P., and Mann, R. 2002. Rundown on the Rapa. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-02-19, VIMS-ES-51. 10/2002.

Harding, J.M., Clark, V.P., and Mann, R. 2002. Rundown on the Rapa: Activity Booklet for Educators. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-02-20, VIMS-ES-52. 10/2002.

Harding, J.M., V.P. Clark, and R. Mann. 2002. Shellfish Stalkers: Threats to an Oyster. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-02-21, VIMS-ES-53. 10/2002.

Harding, J.M., V.P. Clark, and R. Mann. 2002. Shellfish Stalkers: Threats to an Oyster Activity Booklet for Educators. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-02-22, VIMS-ES-54. 10/2002.

Harding, JM, VP Clark, and Mann, R. 2003. Predators in Action: Rapa whelks vs. Hard clams. Virginia Institute of Marine Science, Gloucester Point, Virginia. VORTEX WAVE No. 1. VSG-03-01. VIMS-ES - 55. 1/2003.

Harding, J.M., V.P. Clark, and R. Mann. 2003. Veined rapa whelks: Aliens in the Chesapeake. [CD-ROM]. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-03-14, VIMS-ES-56. 5/2003.

Harding, J.M. and V.P. Clark. 2006. Rapa River Watch: Activity Booklet for Educators. Virginia Institute of Marine Science, Gloucester Point, VA. VSG-05-09, VIMS-ES-58. 12/2005.

The VORTEX (Virginia's Oyster Reef Teaching EXperience) website. http://www.vims.edu/mollusc/meeduc/vortex.html (provides regular updates on VORTEX program activities and resource materials).

The Bridge: An On-Line Ocean Science Resource Center for Teachers. http://www.vims.edu/bridge/ (see "biology" section for a list of links to websites on oysters and other molluscs).

The VIMS Molluscan Ecology Program website. http://www.vims.edu/mollusc (provides a technical overview of ongoing invasive species, oyster reef research and restoration activities in Virginia).