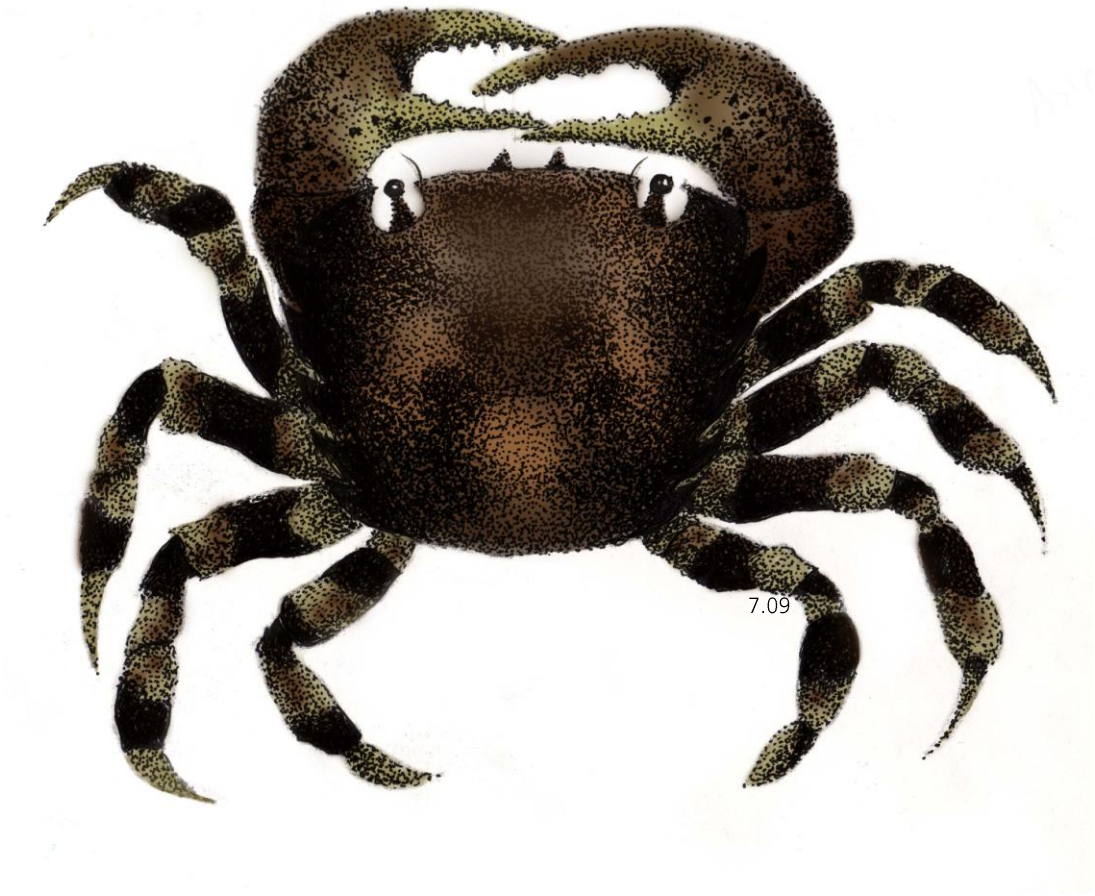
National Park Service
U.S. Department of the Interior

National Parks of New York Harbor Education Center

Marine Invaders… or Marine Immigrants?

Teacher Guide



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On the cover:

Asian Shore Crab. *Illustration by AGillustration.com. Used by permission.*

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What Every Teacher Needs to Know

We welcome your class to the **National Parks of New York Harbor Education Center!**

Program Location: The program takes place at the NPNH Education Center on Staten Island, a fully accessible site located on the third floor of the old Army barracks at 210 New York Avenue in Fort Wadsworth. Classes can eat lunch either at our **Learning Lunchroom,** where children learn about recycling, or at an outdoor picnic area. **(Food, vending machines, microwaves and refrigerators are *not* available.)**

Cancellation Policy: If your plans change, please contact us ***as early as possible.***

Teacher and Chaperone Roles: In our program, ***everyone participates***—including teachers and chaperons! You are ***essential*** to the success of this program. That is why we **REQUIRE *one adult for every six to eight students*** to attend with your class. Please give chaperons the **Chaperon Job Description,** found on the left side of this folder, prior to the day of the trip.

Questions: Please contact us at NPNH_Ed_Center@nps.gov or call us at 718-354-4530.

Program Overview and Objectives

Overview

This program focuses on finding out more information on Asian Shore Crabs. Scientists need more research about this species. By finding the ratio between native and non-native data analysis overtime, we can answer such questions as:

- Are these species endangering the native species?
- Are the crabs eating what's under the rock and taking over?
- Or, are they eating enough to co-exist with the native crabs?

Essential Question

Are Asian Shore Crabs a threat or an addition to the native species of New York Harbor?

Objectives

- Learn about Asian Shore crabs. Where they are from? How did they get here?
- Identify several native and non-native aquatic species of Jamaica Bay collected during field sessions.
- Predict the effects of non-native species on the Jamaica Bay ecosystem, are they harmful or not?

All About Invasive Species

Reprinted from: Draft Jamaica Bay Watershed Protection Plan Volume 1, 2007, New York City Department of Environmental Protection

Native, Non-Native vs. Invasive

Native species are identified as species that existed in a landscape prior to colonization or agriculture. Nonnative and exotic species have been identified as species that have been introduced to an ecosystem by humans, either intentionally or non-intentionally. An invasive species can be identified as having the ability to thrive under adverse conditions. Invasive species can be native or non-native. Their ability to out-compete native organisms for limited sunlight, nutrients and space disrupts the natural balance of an ecosystem. Jamaica Bay is an excellent location for invasive species to find a home due to the high level of disturbance from land alteration and development, and an abundant seed-bank of exotic plants in residential gardens. (Biohabitats, Inc)

Many plant and animal species in the Jamaica Bay watershed are living and reproducing outside of their native ranges. These non-native, exotic organisms are generally considered to be invasive species, although some native species may also be considered invasive. Many invasive organisms were deliberately brought to the region for food, fiber, landscaping purposes, or for the pet trade, while others arrived as contaminants in shipments of grain, in ballast water of ships, or as packing material. It is estimated that approximately 5,000 plant species introduced in the United States have escaped into the natural environment (Pimentel *et al.*, 2000). A small subset of these species actively and aggressively colonize new areas and pose risks to native ecosystems.

How Invasive Species Harm the Environment

Along with habitat destruction and fragmentation, invasive species collectively rank as one of the top global threats to biological diversity in natural areas (Randall, 1995). They can affect multiple levels of biological organization (species, communities, ecosystems, and landscapes). These impacts include changes in ecosystem structure and function, species extinctions, species declines, and changes in community composition. The most fundamental effects are alterations of ecosystem structure and function. Problems that arise from invasive species are sometimes permanent (at least in human time scales) and may be the most pervasive influence on biological diversity in many systems (Coblenz, 1990). Gateway National Recreation Area has a goal to surpass or eradicate exotic invasive species in selected areas to ensure pockets of high biodiversity.

The most significant invasive plant species found in the wetter portions of the Jamaica Bay watershed is common reed (*Phragmites australis*). This species produces large quantities of seeds and also spreads vegetatively by sprouting new growth from its roots. *Phragmites* has a native form although the non-native form is much more aggressive, readily invading disturbed, wet areas such

as degraded wetlands, roadside ditches, and even piles of dredged material. While it is typically found in areas of standing fresh water, it can tolerate moderate salinities (up to 18 ppt) and forms dense monocultural stands, suppressing and killing native vegetation (Byer *et al.* 2004).

Purple loosestrife (*Lythrum salicaria*) is a very attractive freshwater wetland plant imported from Europe as an ornamental in the late 19th century. It can take over freshwater marshes and crowd out native plant species, drastically altering wetland composition and structure. This plant has spread throughout the US in freshwater wetland habitats, especially throughout the Northeastern states. It is of no threat to waters with any salinity. Because Jamaica Bay has so few remaining freshwater wetlands areas, it is currently not threatened by purple loosestrife, but it is worth noting that any freshwater restoration efforts in the watershed will have to contend with this plant.

Invasive Species That Threaten Jamaica Bay

The Jamaica Bay watershed currently has substantial populations of invasive shrubs and trees, including tree of heaven (*Ailanthus altissima*), Oriental bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*), Japanese barberry (*Berberis thunbergii*), and autumn olive (*Eleagnus umbellata*). These species rapidly invade remnant patches of native forest. Garlic mustard (*Alliaria petiolata*) is an herbaceous perennial that rapidly invades shrublands, woodlands, and forests. All of these species tend to crowd out native plant species and compromise wildlife habitat.

The Jamaica Bay watershed harbors a number of invasive, non-native animal species, including Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), feral cat (*Felis silvestris*), and feral dog (*Canis familiaris*). Feral and house cats are estimated to kill over one billion birds annually in the U.S. (Stallcup, 1991). The mute swan (*Cyngus olor*) is a European species of waterfowl that is territorially aggressive and threatens nesting native waterfowl (Mockler, 1991).

Two native mammals have successfully exploited their proximity to the human environment and become invasive nuisance species. The opossum (*Didephis virginiana*) and the raccoon (*Procyon lotor*) have been targeted for further research by the NPS at Jamaica Bay. These animals are considered nuisances in the area due to their large numbers, with raccoons threatening the eggs of reproducing terrapins and birds around Jamaica Bay.

The ribbed mussel (*Geukensia demissa*) is a native invasive invertebrate that can achieve densities up to 10,000 individuals per square meter in Jamaica Bay (Cohen, 2005). Researchers have speculated that berms formed by large numbers of ribbed mussels create ponds of salt water on top of salt marsh islands, leading to salt marsh cordgrass death and the further erosion of salt marsh islands (Franz and Friedman, 2004).

Hungry Invader... or Harmless Immigrant?

HOW DID THE ASIAN SHORE CRAB FIND ITS WAY TO NEW YORK?

Ships need to be both light and heavy: light enough to glide across the water, yet heavy enough not to tip over. Ships sailing in salt water are even more *buoyant* than in fresh water, so they take in gallons and gallons of salt water to weigh themselves down and not tip over. But when the ship loads up on cargo or fuel, it gets heavier and no longer needs the extra salt water, or *ballast*. So the crew dumps it out.

That means water from Dubai or London, Shanghai or Singapore, is emptied out every day in New York Harbor. The trouble is, that water includes fish, seaweed, crabs, barnacles and invertebrates. Most of these forms of life die when released into new waters, but not all of them. The Asian shore crab (also called the Japanese shore crab) seems to have found a way to survive and flourish in our waters.

WHY ARE ASIAN SHORE CRABS SO SUCCESSFUL?

"They've got all the right cards," Tara Casanova, a biologist at Southern Connecticut State University, states. "They tolerate low and high salinity and a wide range of temperatures. Some would call it a super crab. One female can lay more than 50,000 eggs, hundreds of times more than other species, and if only 50 eggs survive, they are already ahead in numbers as they enter the larval stage."[1]

The Asian shore crab seems to have no natural enemies. It has no discernable impact on commercial fisheries and is of no commercial value itself. But, as ecologist Robert Buchsbaum of the Massachusetts Audubon Society observes, the crab is also "very aggressive, very predatory, very adaptable." It also reproduces rapidly and "will eat just about anything from algae to shellfish seedlings."[2]

Its huge appetite *could* devour food sources for other species, such as native crabs. This would upend the ecodiversity of nearby shore populations. Like a multi-car accident on a freeway, if one species is hurt or endangered, the entire food chain is affected.

WHY ARE SOME SPECIES CONSIDERED "INVASIVE"?

Sometimes invasive species can devastate an ecosystem, especially predators. The Pacific island of Guam is one example. According to the US Geological Service, the invasive Brown Treesnake has eliminated all the island's breeding populations of seabirds, 10 of 13 species of native forest birds, two of three native mammals, among other losses.[3]

But successful adaptation does not necessarily mean that the Asian shore crab is crowding out native species of crab or mussels. The apple tree, for example, has found its own niche in the ecosystem.

[1] McQuiston, John. Tiny Invader Becomes a Bully In Local Waters. *New York Times*, June 10, 2001. Consulted March 20, 2009. http://www.nytimes.com/2001/06/24/nyregion/pacific-crab-is-becoming-a-local-bully.html
[2] Blake, Andrew. Small Crab May Pose Big Threat: Visitor From Asia is Voracious. *Boston Globe*, May 20, 2001. Consulted March 20, 2009. http://www.highbeam.com/doc/1P2-8647429.html
[3] US Geological Service website: http://www.fort.usgs.gov/resources/education/bts/invasion/intro_pred.asp

"I hate the 'exotics are evil' bit, because it's so unscientific," claims Dov Sax, ecologist at Brown University. Along with Steven D. Gaines, marine biologist at the University of California, Santa Barbara, Sax has written a paper that observes how exotic (non-native) species do not necessarily lead to mass extinctions. On the contrary, they can trigger the evolution of new species diversity. Plant species may interbreed to form new species. Bugs or toads may evolve to eat a new food source that was not available to them before.[4]

But Anthony Ricciardi of McGill University notes that humans have changed the scale of invasive species. As humans move 7,000 species a day, species come into contact in greater numbers than ever before. "If you pour on more species, you don't just increase the probability that one is going to arrive that's going to have a high impact. You also get the possibility of some species that triggers a change in the rules of existence." [5]

In other words, the Asian shore crab is only one of an ever-changing set of species coming to out waters. Is it a hardy but harmless immigrant? Or is it a vicious invasive, remaking the biodiversity of New York Harbor?

STUDENTS AS CITIZEN SCIENTISTS

To find out if the Asian shore crab is invasive, scientists need a lot of data. As "**citizen scientists**," students can conduct the *systematic scientific research* needed to create this data. Compiling this data will allow scientists to:

- observe changes at specific locations over time;
- estimate population size of the crab;
- estimate what is happening with other organisms as a result, and;
- create a baseline for further comparisons later.

However, it is important that students follow the methods, or *protocols*, designed by scientists. Turning over rocks willy-nilly will not give scientists the information they need. Scientists need to compare results from the same places over time. Classes must:

- examine the correct size rocks, and only those rocks, within the area of study;
- examine the same part of the beach over time;
- record what's under the rock with the crabs (because this might be what the crabs are eating);
- compare numbers of males vs. females;
- compare the ratio of Asian shore crabs, native crabs and mussels and green crabs (another non-native species);
- compare data over time when they return to school.

Once scientists gather enough information, they can help lawmakers and citizens decide what to do next. If Asian shore crabs really are damaging the ecological balance of rocky coastlines, what should we do about it? If not, should we just leave them alone?

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[4] Zimmer, Carl. Friendly Invaders. *New York Times*, September 9, 2008. Consulted March 20, 2009. http://www.nytimes.com/2008/09/09/science/09inva.html.
[5] "Friendly Invaders."

Job Responsibilities

Each job assignment is equally important when conducting this field work. Everyone has a different job. It takes the entire team to gather useful data as Citizen Scientists. Please keep in mind the importance you have in the program, and perform your job to the best of your ability. Decisions by the teacher (Principle Scientist) are final.

Tosser(s)

- Tosses beanbag over the shoulder
- Creates a *quadrat* by placing meter sticks in a square area surrounding the beanbag
- Designates each of the three sampling areas (rocks) by placing a CD on each
- Tells the group which rocks are samples A, B, and C

Habitat Handler(s)

- Moves rocks for samples A, B, and C revealing the *footprints*
- Along with Collector, replaces crabs back under rocks and moves rocks back to their original place

Collector(s)

- Gets collection pans A, B, and C ready by each corresponding sample (rock)
- Collects all crabs found under each rock and places them in the correct collection pan
- Along with Habitat Handler, replaces crabs back under rocks and moves rocks back to their original places

Technician(s)

- Measures dimensions of the footprints and gives these measurements to the Sketch Artist
- Determines gender of each of the crabs and measures the size
- Tells Data Keeper what coastal organisms are found in the footprint

Data Keeper(s)

- Records all data involving crabs and coastal organisms on the data sheets
- Uses the GPS unit to record the latitude and longitude of each quadrat

Sketch Artist(s)

- Records dimensions of footprints on the quadrat data sheet
- Maps out area within the quadrat, sketching everything that can be seen inside this area using the quadrat data sheet

On-Site Program Description

Purpose: to find out how many of these crabs are on a rocky beach in a given month. What is the relationship between males and females? What does it mean to have one large male and dozens of small female crabs live under one rock? What else lives with them?

I. Creating a Quadrat/Marking Your Sampling Areas

-***Tosser*** tosses the bean bag over his/her shoulder so it lands on a haphazard section of the rocky seashore *(see arrow)*.

-***Tosser*** places four meter sticks on the grid around the bean bag, creating a ***quadrat*** of one cubic meter in size.

-***Tosser*** chooses three "large rocks" within the quadrat for sampling and designates them as samples A, B, and C by placing a CD on each.

- ***Tosser*** tells the group which rocks are samples A, B, and C.

II. Finding Footprints

- ***Habitat Handlers*** move the rocks for samples A, B, and C and reveals the *footprints*.

III. Crab Collection

- ***Collectors*** station themselves by one of the three rocks designated by the ***Tosser*** for flipping. The ***Collectors*** get collection pans A, B and C ready by each rock. The ***Habitat Handler*** will flip a rock to reveal sand under rock. **QUICKLY**, the ***Collectors*** catch all of the crabs they find and place them into the collection pan for that specific rock.

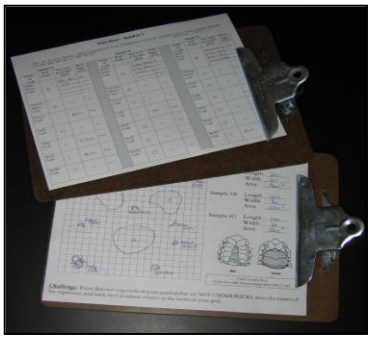
IV. Observing Life in the Footprints

- ***Technicians*** look into the footprint and call out to the ***Data Keeper*** which plants and living organisms they find in the footprint.
- ***Technicians*** determines gender of the crabs and measures the size
- ***Technicians*** measure the dimensions of the footprint and call out the measurements to the ***Sketch Artist***.

V. Recording Data

-***Data Keepers*** write down information about size and gender of the crabs on the data sheet.

-***Data Keepers*** enter all information on data sheet. If the organisms listed on the data sheet are not present, enter "0." **DO NOT LEAVE ANYTHING BLANK.**



-***Sketch Artist*** will work on the Quadrat worksheet. They will map the area, sketching everything that they find within the Quadrat, and write down dimensions of the footprint given by the ***Technician***.

VI. Leaving Your Sampling Area The Way You Found It

- ***Habitat Handler***s and ***Collectors*** will replace the crabs back under the rock and turn the rock back to its original position.
- Repeat this entire procedure in three different sampling areas.

FAQs: Facts about Asian Shore Crabs

Where did these Asian Shore Crabs come from and how did it get here?

They came from the waters of Southern Russia to Hong Kong. They arrived here in Cape May County, New Jersey in 1988 through incoming ships of global trade via ballast water discharge.

How can you tell males from females?

The underside of males looks like the Washington Monument. The underside of females doesn't.

Why do we know about them so far?

They are actively breeding and expanding their population. They are very reproductive. They breed from May to September and they are twice the length of native crabs.

What *don't* we know?

There are several things we don't know about these crabs. What eats them? Do they out-compete native organisms or disrupt habitats? What do they eat? What is the relationship between the male and female genders? What else lives with them?

What can we do?

We can help National Park Service Scientists do research and collect data. You are the first Citizen Scientists to do this research. Your research is highly valued!

How should we do it?

Work in collaborative groups, assign jobs, and carefully collect data and record data according to the scientific protocol. Also make good observations and report findings and come up with more questions.

Pre-Visit Activity: Check Out Those Crabs!

In preparation for your on-site visit review with your class the marine invaders power point presentation. The power point will introduce your class to the origin of Asian shore crabs to the New York area. Your class will also be introduced in the PowerPoint presentation to the various jobs they will be assigned to out in the field and the protocol for observing the shore crabs.

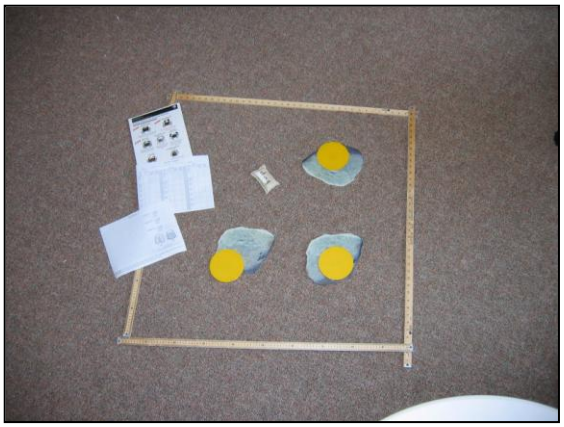
Pre-visit collection game:

Using the protocol described in this guide and in the PowerPoint presentation, divide the class in half.

1) Assign jobs to each of the two groups:

- 1 ***Tosser***
- 3 ***Habitat Handlers*** (one per sampling area)
- 3 ***Collectors*** (one per sampling area)
- 4 ***Technicians*** (two ***Technicians*** will measure and determine gender of each crab; two ***Technicians*** will measure the size of each rock
- 1 ***Sketch Artist***
- 1 ***Data Keeper***

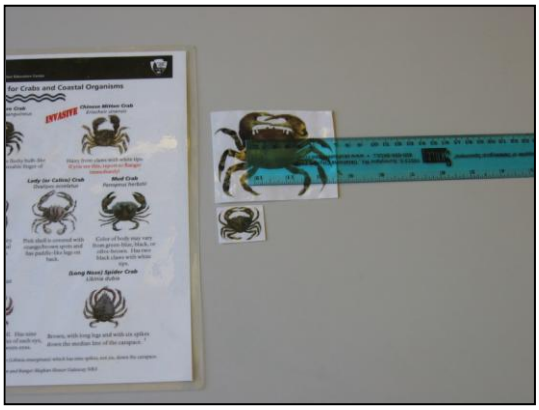
2) The ***Tosser*** tosses the beanbag into the center and places the meter sticks around the rocks. The ***Technician*** puts selection disks on each rock. He/she then designates which rock is sample A, sample B, sample C.



3) The ***Habitat Handler*** and the ***Collector*** flip their rock and begin to catch and sort the organisms. Make sure the ***Habitat Handler*** and the ***Collector*** keep their organisms from each sample area separate from each other.

4) The ***Technician*** flips the crabs over and reports to the ***Data Keeper*** the gender of each crab.

5) The ***Technicians*** measure each crab in centimeters from "shoulder to shoulder." The ***Data Keeper*** places the information on the data sheet.



6) The ***Technicians*** report to the ***Data Keeper*** the numbers of any other organisms or plants found under the rocks.

7) The ***Technician*** measures the width and length of each rock selected in centimeters and reports the measurements to the ***Data Keeper***.

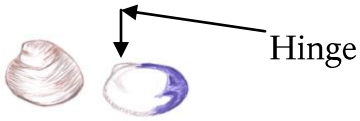
Vocabulary List

Aggregation: A group of organisms living closely together.

Annelid: Any segmented worm belonging to the phylum Annelida.

Arthropod: Any invertebrate which belongs to the phylum Arthropoda. Arthropods have a segmented body, limbs which are jointed, and an exoskeleton. (Example: Asian Shore Crab)

Ballast: Anything carried by a ship to create stability when sailing in salt water. It may be cargo or just a large amount of sea water.



Bivalve: A two-shelled invertebrate. Shells are usually hinged.

Carapace: A hard and protective outer covering found on the back of an animal.

Common Name: The name of an organism in everyday language (not Latin).

Ecosystem: A group of both living and non-living things interacting within their environment.

Exoskeleton: A hard external covering of an organism which provides support and protection, instead of skeleton that is internal.

Footprint: The impression left behind after an object has been moved.

Global Positioning System (GPS): A system used to determine a specific position on the Earth, calculating the latitude and longitude of the location. GPS uses a system of satellites in space and receivers on the Earth.

Gastropod: Any mollusk which belongs to the family Gastropoda. Characteristics of gastropods include a muscular foot, with a single shell no shell at all, and a head with eyes and tentacles.

Genus: The taxonomic level after family. Genus consists of groups of species with similar characteristics.

Invasive (Native) Species: A native species that invades or intrudes an area and takes over. They can be dominant over other natives, may out compete them, and spread quickly.

Invasive (Alien) Species: A species that moves in (by its own actions or human intervention) to a location where it is not naturally found, and spreads quickly; may have a negative effect on its environment.

Invertebrate: An organism that has no backbone.

Latitude:
Angluar distance of a point north or south of the Equator. It is measured in degrees. The *Equator* is 0° Latitude. Horizontal lines on the globe.

Longitude:
Angular distance of a point east or west of the Prime Meridian. *Prime Meridian* is 0° Longitude.
Vertical lines on the globe

Marine: From or relating to the sea, never to fresh water.

Mollusk: Any invertebrate belonging to the phylum Mollusca. Has both a mantle and a developed nervous system. Gastropods, Cephalopods (Squid and Octopus), and Bivalves are all mollusks.

Percent Cover: The amount, percentage-wise, that plant or animal covers a substrate or surface.

Polychaete: A class of Annelid worms. The segmented worms are usually found in a marine environment and range in sizes. Each segment has a pair of parapodia (paddle-like projections).

Predator: An animal that preys on another animal, usually for food.

Quadrat: A square plot of land, mostly used when conducting scientific research.

Ratio: Relation in number between two similar things. For humans, the ratio of heads to legs is 1:2.

Scientific Name: The name given to an organism by scientists, always in Latin.

Species: A group of organisms which have the same physical and genetic characteristics capable of producing healthy offspring; the taxonomic level following genus.

Specimen: A part of or an entire organism used to represent a population of that species.

Substrate: A surface on which an organism either lives or attaches itself, like a barnacle.

Taxonomy: The scientific classification of organisms based on physical description, genetic composition, and relation to each other.

Kingdom
Phylum
Class
Order
Family
Genus
Species

Post-Visit Activity: Crunch Those Numbers!

Your field visit is only valuable to National Park Scientists if you collect good data. In your class room, get your field data organized so that you can report it to us via email. Your email should list all the organisms you found in each spot within each quadrate along with the length and width of each rock. Also be sure to list the number size and gender of the crabs you found. Remember we are relying on you as Citizen Scientists to get as accurate and complete information, which scientists will use to determine on how these organisms are impacting our shores.

After emailing the basic information, should be able to start doing some data summary:

- How many total native black clawed mud crabs did you find on the beach?
- How many total Asian shore crabs did you find?
- What is the average size of female and male Asian shore crabs? Which gender predominated?
- What is the average size of female and male black clawed mud crabs? Which gender predominated?
- In each spot, did you ever find Asian shore crabs with other species of crab? Describe what you found.

Call (718) 354–4530, ext. 223, or email NPNH_Ed_Center@nps.gov and ask for past year data and compare your data with past visits to the same beach.

Webquest: Students can do further research on invasive species by accessing this Webquest: **http://mset.rst2.edu/portfolios/m/muller_j/toolsdev/tdevproj/index.htm**

Are Asian shore crabs really so bad? Have your class read these two recent articles in the New York Times and decide for themselves:

http://www.nytimes.com/2008/09/09/science/09inva.html?_r=1&scp=1&sq=Friendly%20invaders&st=cse

http://www.nytimes.com/2008/09/16/science/16lett-PLANTSANDINT_LETTERS.html?scp=1&sq=invasive%20species%20letter&st=cse

Data Sheet – Quadrat 1

Date: 4-12-09 Weather: 60° CLOUDY Time of Day: 11:00AM Time of Low Tide: 10:55AM Location: SEA PLANE RAMP
Lat/Long: 40° 35' 40" / -73° 53' 27" Water Temp: 13° C

Sample 1A

Name of Crab	# of Crabs	Size (cm) & Gender (M/F)	With Eggs? (Y/N)
Asian Shore Crab	3	.5m .4m 2m	N
Chinese Mitten Crab	0	–	–
Green Crab	1	4m	N
Lady Crab	0	–	–
Mud Crab	1	3.5m	N
Rock Crab	1	4m	N
Spider Crab	0	–	–

Sample 1B

Name of Crab	# of Crabs	Size (cm) & Gender (M/F)	With Eggs? (Y/N)
Asian Shore Crab	6	0.5m 0.4m 0.7m 1.5m 1.0F	N
Chinese Mitten Crab	0	–	–
Green Crab	0	–	–
Lady Crab	1	3F	N
Mud Crab	0	–	–
Rock Crab	0	–	–
Spider Crab	0	–	–

Sample 1C

Name of Crab	# of Crabs	Size (cm) & Gender (M/F)	With Eggs? (Y/N)
Asian Shore Crab	8	0.4m 0.6m 0.9m 1.0m 2m 1.5m 0.7m 3.5m	N
Chinese Mitten Crab	0	–	–
Green Crab	0	–	–
Lady Crab	0	–	–
Mud Crab	0	–	–
Rock Crab	0	–	–
Spider Crab	1	5m	N

Sample 1A Cont'd

Name of Plant	% Cover
Sea Lettuce	80 %
Irish Moss	10 %
Bladderwrack	0 %

Name of Shelled Organism	# of Occupied Shells
Blue Mussel	2
Common Periwinkle	0
Gemclam	0
Jackknife	1
N. Quahog	1
Ribbed Mussel	1
Slippersnail	0

Name of Organism	# of Organisms (% Cover for Barnacle)
Amphipod	5
Barnacle	10 %
Long-Clawed Hermit Crab	0
Polychaete Worm	0
Mudsnail	3

Sample 1B Cont'd

Name of Plant	% Cover
Sea Lettuce	75 %
Irish Moss	5 %
Bladderwrack	15 %

Name of Shelled Organism	# of Occupied Shells
Blue Mussel	1
Common Periwinkle	2
Gemclam	0
Jackknife	0
N. Quahog	0
Ribbed Mussel	2
Slippersnail	1

Name of Organism	# of Organisms (% Cover for Barnacle)
Amphipod	4
Barnacle	10 %
Long-Clawed Hermit Crab	1
Polychaete Worm	1
Mudsnail	2

Sample 1C Cont'd

Name of Plant	% Cover
Sea Lettuce	90 %
Irish Moss	5 %
Bladderwrack	10 %

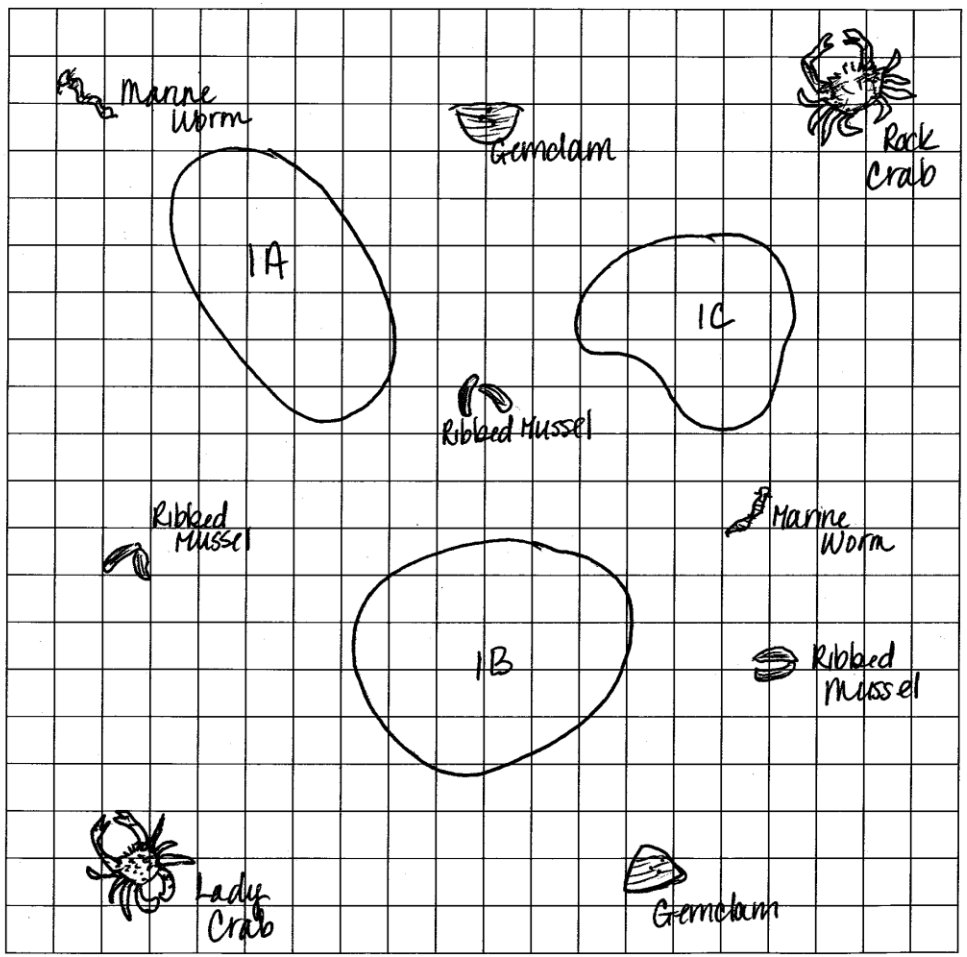
Name of Shelled Organism	# of Occupied Shells
Blue Mussel	1
Common Perwinkle	1
Gemclam	2
Jackknife	0
N. Quahog	0
Ribbed Mussel	1
Slippersnail	0

Name of Organism	# of Organisms (% Cover for Barnacle)
Amphipod	7
Barnacle	15 %
Long-Clawed Hermit Crab	0
Polychaete Worm	1
Mudsnail	1

Model

Quadrat 1

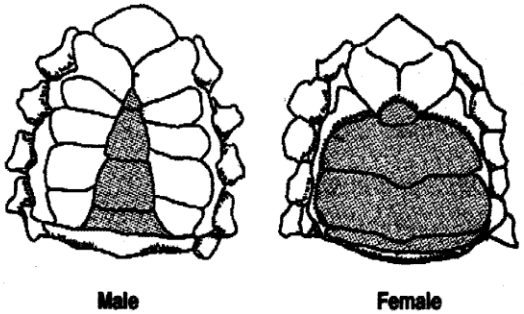
Model



Sample 1A: Length 16in.
Width 6in.
Area 96in.^{2}

Sample 1B: Length 12in.
Width 9in.
Area 108in.^{2}

Sample 1C: Length 14in.
Width 7in.
Area 98in.^{2}



Crab Gender Key
(only for crabs measuring greater than 1 cm)

Challenge: If you discover organisms in your quadrat that are NOT UNDER ROCKS, write the names of the organisms, and mark their positions relative to the rocks on your grid.

Reference Guide

National Park Service
U.S. Department of the Interior

National Parks of New York Harbor Education Center

Reference Guide for Crabs and Coastal Organisms

INVASIVE

Asian Shore Crab
Hemigrapsus sanguineus

Striped legs. Males have fleshy bulb-like structure at base of moveable finger of claw.

INVASIVE

Chinese Mitten Crab
Eriocheir sinensis

Hairy front claws with white tips.
If you see this, report to Ranger immediately!

INVASIVE

Green Crab
Carcinus maenas

Black/green body with hairy back legs. Has five marginal teeth on each side of eyes.

Lady (or Calico) Crab
Ovalipes occelatus

Pink shell is covered with orange/brown spots and has paddle-like legs on back.

Mud Crab
Panopeus herbstii

Color of body may vary from green-blue, black, or olive-brown. Has two black claws with white tips.

Rock Crab
Cancer irroratus

Red/purple fan-shaped shell. Has nine smooth edged teeth to the sides of each eye, and three small teeth between eyes.

(Long Nose) Spider Crab
Libinia dubia

Brown, with long legs and with six spikes down the median line of the carapace. [1]

[1] Similar to the Portly Spider Crab (*Libinia emarginata*) which has nine spikes, not six, down the carapace.

Illustrations by: AGillustration.com and Ranger Meghan Heuser Gateway NRA

Amethyst Gemclam
Gemma gemma

Shell may be glossy smooth or have concentric rings. Very small, only about 1/8" long.

Amphipod
Gammarus sp.

Mostly white; <2" with two antennae. Legs vary in size. Body is laterally compressed (flattened side to side).

Atlantic Jackknife ("Razor Clam")
Ensis directus

Long, smooth hard shell; one rounded end.[2]

Atlantic Ribbed Mussel
Geukensia demissa

Beige/black ribbed shell with radial markings.

Blue Mussel
Mytilus edulis

Black/Blue and smooth shell with radial markings.

Common Periwinkle
Littorina littorea

Sharply pointed, with dark spiral bands. Can grow to 1 ½" long.

Eastern Mud Whelk ("Mudsnail")
Nassarius obsoleta

Black spiral shell, white tip (apex). Oval opening (aperture).

Long-clawed Hermit Crab
Pagurus longicarpus

Long narrow claws. One claw larger than other. Exoskeleton covers half the body.

Polychaete Worm

Species have hair-like structures (setae) that branch out from a segmented body.[3]

Northern Quahog
Mercenaria mercenaria

Hard, heavy shell with rings on the exterior. Inside usually has a bright purple edge.

Northern Rock Barnacle
Semibalanus balanoides

Round, with opening on top. Forms dense aggregations attached to living/non-living things.

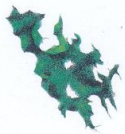
Bladderwrack
Fucus vesiculosus

Yellow/deep green; bulbs at the ends.

Irish Moss
Chondrus crispus

Purplish/red; near rocks; 7-10" tall.

Sea Lettuce
Ulva rigida



Green/dark green; resembles lettuce; floats in water.

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[2] There is an actual species called a "Razor Clam", but the term Razor Clam designates clams in the family, *Solenidae*.
[3] There are many different species of polychate worms, and body forms differ among them.

New York State Core Curriculum

STANDARD	GRADE
Science, Unit 4, Interdependence *Global Warming and human impact* LE 7.2d, PS2.2r, ICT 1.4, 2.1-3, 4.1, 5.1-2, 6.1-2, IPS 1.3 *Populations & definition of species* LE 1.1h, 7.1a *Ecosystems* LE 7.1a, 7.2a-b, ICT 1.2 *Factors affecting population growth* LE 7.1b *Relationships among organisms* LE 3.2a, 7.1c-d, 7.2c *Effects, environnemental changes* LE 7.2a-d, 7.1e, ICT 5.2	**6**
Living Environment Standard 4 Using science to study the living environment & physical setting	**High School**
Mathematics, Science & Technology *Measurement* 3.5 *Uncertainty* 3.6 *Patterns & Functions* 3.7 *Impacts of Technology* 5.6	**High School**
English Language Arts Standards 1 & 3	**High School**

For Further Research

Literacy-Based Learning: Books Students Can Read

- Rogers, Sally. *Earthsong*. Dutton Children's Books. 1998. Based on Sally Roger's popular song "Over in the endangered meadow." This rhyming picture book introduces children to different endangered species.

- Stone, Lynn M. *Endangered Animals: A New True Book*. Children's Press. August 1990. Discusses various endangered animal species in the world, why and how they became endangered, and what can be done to save them.

Books for Teachers and Students

- Baker, Jeannie. *The Story of Rosy Dock*. Greenwidow Books, 1995. Rosy Dock is a non-native plant in Australia. It was introduced from North Africa or Western Asia and has spread across Western, Central, and South Australia.

- Blakemore, Sally, Sarah Lovett & Mary Sundstrom. *Endangered Species*. Avalon Travel Publishing, 1996. Resource teaches about unusual endangered creatures such as the California Condor and the Giant Armadillo.

- Galan, Mark. *There's Still Time: The Success of the Endangered Species Act*. National Geographic Society, 1997. The author looks at several plants and animals that are now on the road to recovery thanks to the 1973 Endangered Species Act.

- Taylor, Dave David. *Endangered Ocean Animals*. Crabtree Publishing, May 1995. Problems such as ocean pollution, oil spills, and hunting have caused marine mammals, birds, and fish to become endangered.

Web Sites

- **Executive Order 13112: Invasive Species, February 3, 1999**
  http://invasivespeciesinfo.gov/laws/execorder.shtml
  Defines invasive and native species; describes duties of National Invasive Species Council

- **Alien Species Prevention Enforcement Act of 1992**
  http://www.fws.gov/laws/lawsdigest/aliensp.html
  US Dept of Agriculture, Dept of Interior, Postal Service and State of Hawaii partner to protect Hawaii from introduction of invasive species entering via mail

- **USDA National Invasive Species Information Center**
  http://www.invasivespeciesinfo.gov/
  Lists and articles regarding invasive species in United States

- **USFW Invasive Species Information**
  http://www.fws.gov/invasives/faq.html
  Answers to frequently asked questions regarding invasive species

- **Plants Invading Natural Areas in the United States**
  http://www.invasive.org/weedus/index.html
  Lists and images of exotic plants with information about taxonomy, native range, and where they are reported to be invasive.

- **Invasive Species of New York**
  http://invasivespecies.nbii.gov/states/newyork.html
  Lists, maps and information on invasive plant and animal species found in New York State

- **Invasive Species Maps**
  http://pest.ceris.purdue.edu/index.php
  Lists of invasive species with regional maps showing where they are found

- **Invasive Species Control**
  http://invasivespecies.nbii.gov/control.html#biological
  Ways to control invasive plant and animal species

- **Coastal and Marine Invasive Species**
  http://nsgl.gso.uri.edu/flsgp/flsgpg05001.pdf
  A primer on invasive species in coastal and marine waters

- **Ecological and Evolutionary Consequences of Coastal Invasions**
  http://marine.rutgers.edu/dmcs/ms309/Lec25/Grosholz02-TrEE-17-1-22.pdf
  Article discussing the extensive spread of non-indigenous species in coastal areas and marine waters

- **Descriptions of Introduced Species**
  http://massbay.mit.edu/exoticspecies/invaders/factsheet.html
  Exploration of ways that non-native aquatic species are introduced into new geographic range, and the impact that can have on ecology and economy

- **Sea Grants National Aquatic Nuisance Species Clearinghouse**
  http://www.aquaticinvaders.org/
  Lists and information about aquatic invasive species

- **Coastal Hitchhikers Guide to Exotic Species**
  http://massbay.mit.edu/exoticspecies/hitchhikers/index.html
  Download information, view images or report your sighting of exotic species