Using Maps to Evaluate Environmental Tradeoffs

These pages contain instructions and materials for an exercise in which you (or your students, if you're an instructor) plan a protection strategy for a coastline threatened by an oil spill--just as responders to a real-life spill must do. You can follow these instructions yourself, or use them to present the exercise to a class.

When a shoreline is threatened by an approaching oil spill, responders must quickly decide which locations along a shoreline to protect from the spill. That is, they must set their protection priorities. To do this, they first identify the places that are most important to protect, then determine which of those locations they can protect, given the resources available to them. Making these decisions sometimes requires difficult tradeoffs.

In this exercise, you present an oil spill scenario in which winds and currents are moving an oil slick towards a section of the shoreline of Delaware Bay. Your students, working in teams, (or you yourself) then use an Environmental Sensitivity Index map to identify the sensitive locations along the threatened coastline that are especially vulnerable to damage from oiling. They'll then set their protection priorities--that is, they'll decide which of those areas they can protect, and how they can do it.

The exercise is appropriate either for middle school and high school students or for adult audiences. You can download all the materials you'll need to plan and lead this exercise from these pages.

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Introduction to ESI Maps

When a shoreline is threatened by an approaching oil spill, responders must quickly decide which locations along a shoreline to protect from the spill. That is, they must set their **protection priorities**. To do this, they first find out:

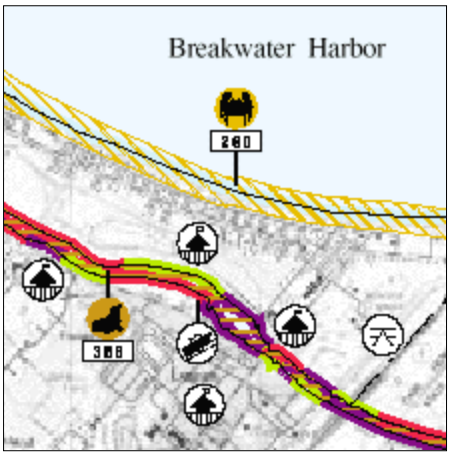
- which areas would be worst affected by the spill. Different kinds of shorelines are more or less sensitive (vulnerable to damage by oiling). Marshes and swamps are especially sensitive, because oil in these areas damages plants and is very difficult to clean up. Areas used by sensitive species, such as seabirds and sea otters--which are easily killed when they are coated with oil--are also especially vulnerable.
- which areas can be protected. Responders usually have only a limited amount of containment equipment, such as floating booms that can be used as barriers to spilled oil. Because there usually isn't enough equipment to protect all areas that could be damaged, responders must decide where to deploy their equipment to be most effective.

A tool commonly used for setting protection priorities, both in the United States and elsewhere, are NOAA's Environmental Sensitivity Index (ESI) maps.

The Front of an ESI Map

A section of the front of an ESI map is shown below. ESI maps show shorelines, wildlife habitats, places important to people, and other locations that are especially sensitive to damage from a spill. People can look at an ESI map of an area threatened by a spill to quickly see the most sensitive locations.

ESI maps show three kinds of things:



Shorelines are color-coded to indicate their sensitivity to oiling (they also are ranked on a scale from 1, least sensitive, to 10, most sensitive). On ESI maps, warm colors like red and orange denote the shorelines that are most sensitive to oiling, such as tide flats, swamps, and marshes (including the marshy stream designated in red on the map segment at right). Cool colors like blue and purple indicate the least sensitive shorelines, such as rocky headlands and sand and gravel beaches (on the map at right, purple line segments denote locations of eroding bluffs). Shades of green denote shorelines of moderate sensitivity (on the map at right, green line segments denote areas of riprap). Large habitat areas, such as tidal flats used by shellfish, and wetlands used by shorebirds or waterfowl, are shown as colored polygons (above, orange hatched polygons denote shellfish habitat, used by horseshoe crabs).

- On our web site, you can learn more about ESI maps and see photos of the different shoreline types shown on ESI maps.

Sensitive biological resources, such as seabird colonies and marine mammal hauling grounds, are depicted by special symbols on the maps. On the map above, a seal symbol marks habitat used by gray and harbor seals.

Important human-use resources, such as water intakes, marinas, and swimming beaches, are also depicted with symbols. In the map section above, four symbols denote historic sites, one denotes a boat ramp, and one denotes a public park.

The Back of an ESI Map

Much of the information on an ESI map is shown in a table on the back of the printed copy of the map (some older maps do not include this table of information). The "back of the map" table lists sensitive plant and animal species that live in the area shown on the map. It shows when each species is present in the area, and what that species is doing during different seasons (for example, a bird species may be nesting, laying eggs, hatching, or fledging young birds). The back of the map is also where you'll find contact information for important human-use locations shown on the map.

- Reading the Back of the Map How to read the table on the back of an ESI map.

Although ESI maps are important tools for spill responders, they may not reflect the current shoreline situation, because biological resources and human uses of shorelines can and do change, sometimes quickly. For up-to-date information, contact your local natural resource management agencies.

Making a Map Kit

If you will be leading students in this exercise, plan to divide your class into teams of 3-4 students each. Prepare a "map kit" for each team, containing one printed copy of each of the documents listed below. (If you are working on your own, you can choose either to print out a map kit for yourself or to work with the documents on your computer.)

- The Example Map shows the area around Lewes, Delaware, just inside the Delaware Bay entrance. (This is Map 8 of our Delaware, New Jersey, Pennsylvania Atlas of ESI maps.) Print in color if possible.
- The "Back of the Map" Table (displayed on the back of this map in the printed atlas) shows the biological species occurring in this area, their concentrations, and the seasons of the year in which they are breeding.
- The Color and Symbol Key shows what the colors and symbols shown in this ESI Atlas represent. Print in color if possible.

You also may wish to include a copy of the Oil Spill Scenario in each team's map kit, as well as the following two documents:

- General Information describing how this and other maps in the Delaware, New Jersey, Pennsylvania Atlas were created, and a summary of the important biological resources in the area covered by maps in this atlas.
- The Index to the Delaware, New Jersey, Pennsylvania ESI Map Atlas, showing the larger region in which this spill has occurred; the area covered by the example map is labeled as section 8.

Printing These Documents

If at all possible, use a color printer to make your copies of the example map and map key.

Each of these PDF files was created as an 11-inch-by-17-inch document. To print these files to fit 8.5-inch-by-11-inch paper, check the "Fit to Page" or "Shrink to Fit" box in the Print Dialog Box.

Ordering the Map

If you'd prefer, you can order from us 11-by-17-inch print copies of this map and the "back of the map" information. Each page costs $1.50 (minimum order $10). Print and complete the order form, requesting the atlas name "Delaware, New Jersey, Pennsylvania" and map number 8.

To learn how to download maps online, or to order a CD/DVD of maps, check our Get ESI Maps page.

Note: This exercise is designed around a map of a section of the shoreline of Delaware Bay, in the state of Delaware. You can modify the basic exercise to use either a map of a shoreline near you or of an area related to other class projects, rather than our example map. Here are tips for creating your own exercise.

Conducting the Exercise

To present this exercise to a class of students, you describe an oil spill scenario in which winds and currents are moving an oil slick towards a section of Delaware Bay shoreline. Your students, working in teams, then use an ESI map of the threatened shoreline to set protection priorities for that area. Below are instructions for leading the exercise. (If you are working on your own, first complete the student tasks described in step 5, then view the Instructor's Notes, below.)

1. Divide the students into small groups of 3-4 people each.
2. Provide each team with a Map Kit, containing the materials they'll need for this exercise.
   - Map Kit for this exercise.
3. Present a brief (10-15 minute) Introduction to ESI Maps.
   - Explanation of ESI Maps for this exercise
4. Present the Oil Spill Scenario to the class.
   - Spill Scenario for this exercise.
5. Assign each team the following tasks. Explain that once the teams have completed these tasks, each team will be asked to present its findings to the class.

   (a) Identify Resources at Risk:
   - Identify the biological resources (animals, plants, or their habitats) that may be at risk from the spilled oil (at sea as well as on shore, if oil reaches shore). List these resources.
   - Prioritize the list of resources at risk according to (a) sensitivity to the oil spilled and (b) the likelihood of being contacted by the spilled oil. In general, species in early life stages (i.e., nesting, laying, hatching, or fledging) or present in large numbers are at the greatest risk. Justify and explain your priorities.

   (b) Establish Protection Priorities:
   - Looking at the shoreline habitats affected by the spill, identify areas that would receive high priority for protection (assuming that protection is possible). In general, the habitats shown in red and orange on ESI maps (and given ESI rankings of 9 or 10) are the most sensitive to spills. Discuss your rationale for choosing these areas over others and the tradeoffs your choices involve. Discuss any potential difficulties you anticipate.

   Instructor's Notes: Here are more details about the resources at risk in the area covered by this map, and examples of possible protection priorities.
6. Ask each team to report their results to the class, then summarize and discuss the teams' results.

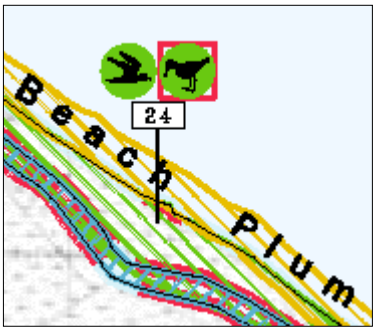
Instructor's Notes

Assessing Resources at Risk

To assess the resources at risk, your students first should check over the map for especially important things, such as

1. endangered or threatened species (endangered species are in danger of becoming extinct; threatened species could easily become endangered if present trends continue).

2. sensitive shorelines (shown on the map in warm colors like red and orange). In this part of Delaware Bay, the most sensitive habitats are streamside marshlands, denoted by red lines on the map.



Students can quickly tell whether any endangered or threatened species are present by checking the map for species symbols surrounded by **red boxes**. A red box indicates an endangered or threatened species. On this map, your students will see a red box around the symbol for the piping plover, as shown in the map segment to the left.

On Map 8, students also can see **red lines** depicting the most sensitive shorelines, such as those on the map segment at left, marking streamside marshland.

Ask your students: If a threatened or endangered species is present, when is it present and what is it doing?

- The Reading the Back of the Map page explains how to read the table from the back of the ESI map to check whether a species is expected to be present at the time of the spill, and to see what it would be doing then.

By reading the back of the map, your students will find that piping plovers are present and busy with reproductive activities in June, the time of the spill.[1]

Your students should discover that, besides the threatened piping plover, endangered whale species, threatened and endangered sea turtles (shown in the "Common in Area" box), endangered/threatened bald eagles, and ospreys (designated as threatened by the state of New Jersey) also are present in this area in June, when the spill would occur. However, generally, we expect these species to be at lower risk from oiling than the plovers:

[1] Local biologists report that the population of plovers on Beach Plum Island beaches has declined recently as human use of this area has increased. In fact, it's hard to be sure, but it's possible that plovers no longer nest on these beaches. During a response to a real oil spill, oil spill experts don't rely only on ESI maps, which may become outdated when conditions change. They also check with local biologists and other experts to make sure they are using current information to set their protection priorities.

- Researchers aren't yet sure how badly affected whales might be by oil spills; they suspect that whales avoid oil slicks.
- Generally, sea turtles are most at risk of being harmed by oil when they are on beaches laying their eggs; in Delaware Bay in June, they probably remain in the open water, where they are at less risk.
- Birds that dive for their food or that habitually rest on the water are at particular risk from oiling, since they are especially likely to contact oil on the water surface. In contrast, bald eagles, which do not dive or rest on the water, are at less risk, unless they feed on dead birds that were oiled in this spill (oil is toxic). To protect eagles and other wildlife, it's a good idea to remove oiled bird carcasses as soon as possible.
- Ospreys are the only diving hawks, and so may be at more risk of being oiled than bald eagles. Both ospreys and eagles nest in the marshlands, and are sensitive to disturbances near their nests. The best ways to protect these species are to protect the marshes from oiling and to ensure that cleanup workers and other people stay well away from identified nests.

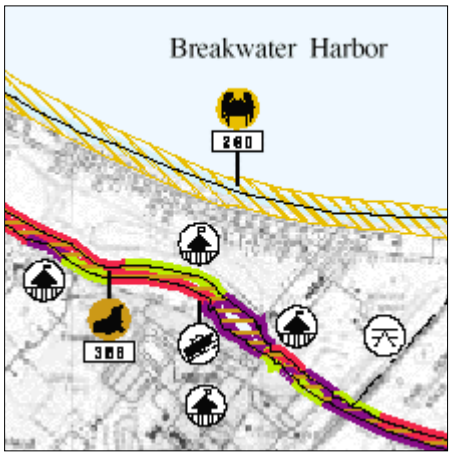
Setting Protection Priorities

To set their protection priorities, your students should consider the biological resources, the human uses, and the types of shoreline habitat affected by the spill.

Shoreline Habitats

Two main kinds of shorelines exist in the area covered by Map 8:

1. The beaches that make up much of the shoreline in this area are classified as shoreline habitat 4 (medium- to coarse-grained sand beaches), which are not ranked as particularly sensitive to oil spills. Few organisms live within the sand of these beaches, and although oil that washes up on the beaches will penetrate into the sand, complicating clean-up, it will not penetrate as far as it would into fine-grained beach sand.



An example of shoreline habitat 4 is the section of the Breakwater Harbor beach shown at left. Shoreline segments classified as shoreline habitat 4 are color-coded with a broad light blue line (the line is hard to see on this example map, because it's overlaid with an orange hatched polygon that indicates shellfish habitat used by horseshoe crabs).

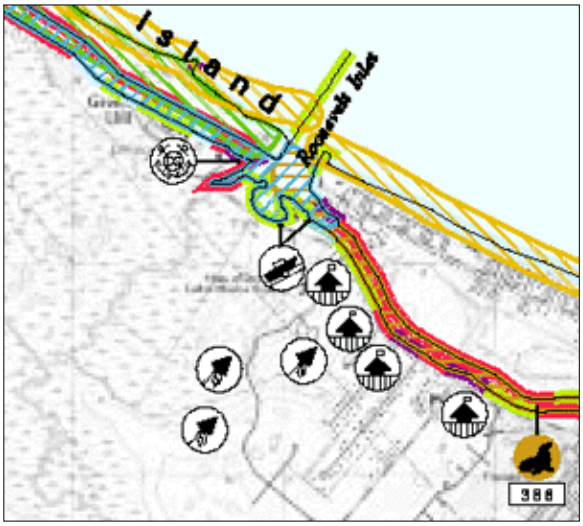
However, although these beaches are ranked as relatively less sensitive to oiling, piping plovers are present in low concentrations along the outer beach of Beach Plum Island. They are important to protect, whenever possible, because they are a threatened species. However, the plovers are present over an length of beach too long to be protected by boom. (Booms can protect things concentrated in small areas, such as seabird colonies.) Possible options to protect the plovers include:

- using other measures to prevent the oil from reaching the beach, such as chemical dispersants[2], skimmers, or in-situ burning, and
- using a deflection boom--a segment of boom placed at an angle to the shoreline--to deflect the oil into the shore before it reaches the plover habitat (this option is difficult to accomplish in real life!).

Responders sometimes use hazing to drive some kinds of birds away from oiled areas. However, hazing would not be a good measure to protect the plovers, because they are very sensitive to disturbance.

Note that vegetated dunes may also be present in areas designated as shoreline habitat 4 (they are found above the high tide line). Vegetated dunes are much more sensitive to oiling and other disturbance than the beaches adjacent to them. They should be protected from oiling and from trampling by responders and cleanup crews.

2. More sensitive habitats that would be threatened by this spill include the salt and brackish water marshes (shoreline habitat 10) inside Roosevelt Inlet. These shorelines are ranked as very sensitive to oiling: marshes are biologically rich; marsh vegetation can be killed or damaged by oiling; and oiled marshes are very difficult to clean up without causing additional harm. The marshes behind Roosevelt Inlet are inhabited in June by sensitive species like bald eagles and ospreys. Also, it is especially important to protect marshes because the U.S. is losing wetlands.



Spilled oil could infiltrate into these marshlands through Roosevelt Inlet, shown at left.

A good response option would be to place boom across Roosevelt Inlet, to protect the marshlands from a spill. However, strong currents can sometimes make it hard to keep even short boom sections in place.

Other Protection Priorities

Your students might also suggest protective measures for human-use sites in the area of the spill.

[2] It's sometimes possible to prevent damage to some bird populations by applying chemical dispersants to an oil slick before it contacts the coastline. Dispersants act to remove oil from the water surface by dispersing it into the water column. However, chemical dispersants and oil dispersed into the water column can threaten other marine life. For example, chemical dispersants could threaten horseshoe crab larvae that are present in the water column in June. This is one example of how choosing protection strategies can be an exercise in tradeoffs.

Tips for Creating Your Own Exercise

This basic exercise is designed around an example map of a section of the shoreline of Delaware Bay, in the state of Delaware. Here are tips for modifying the basic exercise to use either a map of a shoreline near you or of an area related to other class projects, rather than our example map.

What You'll Need...

- **ESI Map and Index** You can choose a local map or a map related to other coursework. ESI maps are available at a moderate cost from NOAA OR&R. For most areas, we also offer ESI data on CDs. Each CD contains the entire ESI atlas as Portable Document Format (PDF) files, allowing you to print as many copies of the maps as you need. ESI CDs contain data in multiple GIS (Geographic Information System) formats, as well.
    - Try to select a map that shows a variety of biological resources and areas of human use, such as seasonal populations, sensitive populations, commercial harvests, recreational uses, and so on. Areas containing rivers, or narrow inlets that might be boomed, are good choices for an exercise in setting protection priorities.
    - Some of our older ESI maps use a different system to identify the biological resources in the map region, and do not list the biological resources on the back of the map. If you're unsure if the map you wish to order includes this list, you can e-mail our Photos and Orders Specialist or call us at 206.526.6400.
    - Purchase enough copies of your map and other materials, or make enough color copies, to supply groups of 3-4 students each. Be sure to include the list of biological resources on the back of the ESI map, and the key to the map symbols.
- **Scenario** Prepare a scenario of an oil spill, including the product that has been spilled, the season of the year, and an approximate direction that the oil is heading.

More Information

ESI Maps

Learn more about how ESI maps help oil spill responders and planners identify vulnerable coastal locations, establish protection priorities, and identify cleanup strategies.

- ESI Maps An overview of ESI maps.
- ESI Toolkit Links to tools, resources, and information for ESI maps and data.
- Training Exercise A training module for ESI users. The manual and associated training materials help spill responders and planners learn to use ESI data in multiple formats.

Spill Response

You can learn more about how to identify and prioritize sensitive sites and how to develop a protection strategy from the two reports below.

- Mechanical Protection Guidelines (PDF, 1.0M) A 1994 manual describing how to identify and prioritize sensitive sites, and how to deploy booms, barriers, and other mechanical protection devices during a spill response.
- An Introduction to Coastal Habitats and Biological Resources for Spill Response A 1992 training manual covering physical, geological, and biological considerations relevant to oil spill response and cleanup.

Question?

- ESI Specialist Contact our ESI Specialist for more information.

Appendices

Example Map

"Back of the Map" Table

Reading the Back of the Map

General Information

Color and Symbol Key

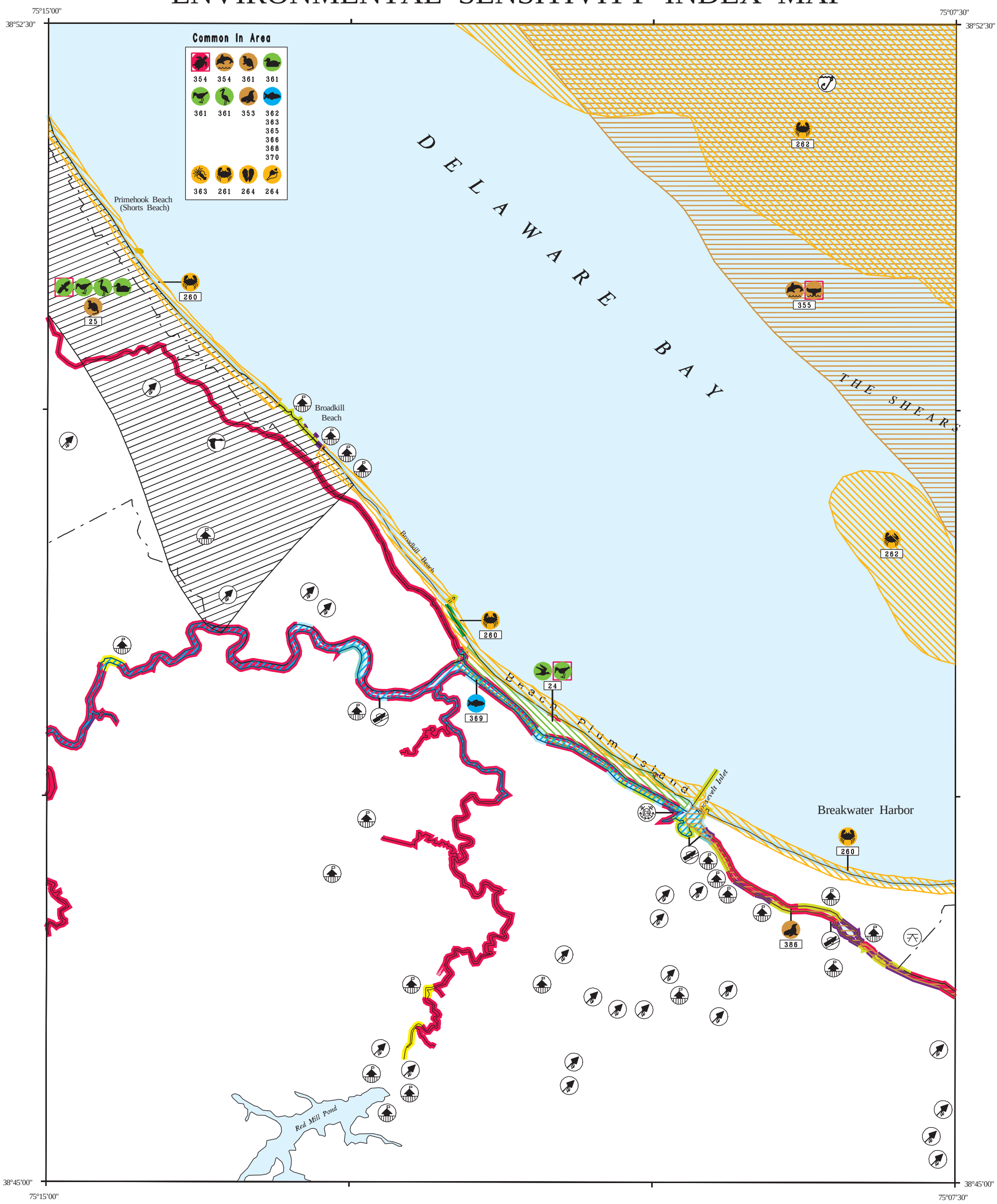
Oil Spill Scenario

Index of ESI Maps

Oil Types

- Alaska North Slope Crude Blends (PDF; 611K)
- No. 6 Fuel Oil (Bunker C) Spills (PDF; 611K)
- Small Diesel Spills (500-5000 gallons) (PDF; 544K)
- Tarballs (PDF; 384K)

ENVIRONMENTAL SENSITIVITY INDEX MAP



Prepared for:

HAZARDOUS MATERIALS RESPONSE
and ASSESSMENT DIVISION
National Oceanic and Atmospheric Administration
Seattle, Washington
and
The States of DELAWARE,
NEW JERSEY, and PENNSYLVANIA

N
W E
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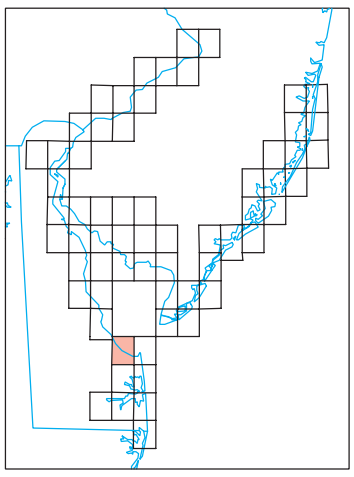
1 .5 0 1 KILOMETER

1 .5 0 1 MILE

Not For Navigation
Published: August 1996



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DELAWARE, NEW JERSEY, and PENNSYLVANIA ESIMAP 8

BIOLOGICAL RESOURCES:

BIRD:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Laying	Hatching	Fledging
24	Gulls				MED			X	X	X	X	X	X					-	-	-	-
	Piping plover	DE	S/F	T/T	LOW		X	X	X	X	X	X	X	X				APR-AUG	MAY-JUN	MAY-JUL	JUN-AUG
	Terns				LOW			X	X	X	X	X	X					-	-	-	-
25	American wigeon				800	X	X	X							X	X	X	-	-	-	-
	Bald eagle	DE	S/F	E/T	LOW	X	X	X	X	X	X	X	X	X	X	X	X	NOV-JUL	JAN-MAR	FEB-APR	MAY-JUL
	Black duck				400-4000	X	X	X	X	X	X	X	X	X	X	X	X	MAR-AUG	MAR-JUL	APR-AUG	APR-AUG
	Blue-winged teal				200-500				X	X	X	X	X	X	X			-	-	-	-
	Canada goose				150-200				X	X	X	X	X					APR-JUN	APR-MAY	JUN-JUN	JUN-JUL
	Canada goose				5000	X	X	X						X	X	X	X	-	-	-	-
	Gadwall				50-1200	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAY-JUN	JUN-JUL	JUL-JUL
	Green-winged teal				40000	X	X	X							X	X	X	-	-	-	-
	Mallard				300-3000	X	X	X	X	X	X	X	X	X	X	X	X	MAR-AUG	MAR-JUL	APR-AUG	APR-AUG
	Northern pintail				21000	X	X	X	X					X	X	X	X	-	-	-	-
	Northern shoveler				600-1500	X	X	X								X	X	-	-	-	-
	Osprey	NJ	S	T	MED			X	X	X	X	X	X	X				MAR-JUL	APR-JUN	JUN-JUL	JUN-JUL
	Ring-necked duck				2000									X	X	X		-	-	-	-
	Shorebirds				HIGH			X	X	X								-	-	-	-
	Shorebirds				MED						X	X	X	X				-	-	-	-
	Snow goose				90000	X	X	X						X	X	X	X	-	-	-	-
	Wading birds				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Wood duck				700-2000			X	X	X	X	X	X	X	X	X		-	-	-	-
361	American wigeon				800	X	X	X							X	X	X	-	-	-	-
	Black duck				400-4000	X	X	X	X	X	X	X	X	X	X	X	X	MAR-AUG	MAR-JUL	APR-AUG	APR-AUG
	Blue-winged teal				200-500				X	X	X	X	X	X	X			-	-	-	-
	Canada goose				150-200				X	X	X	X	X					APR-JUN	APR-MAY	JUN-JUN	JUN-JUL
	Canada goose				5000	X	X	X						X	X	X	X	-	-	-	-
	Gadwall				50-1200	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAY-JUN	JUN-JUL	JUL-JUL
	Green-winged teal				40000	X	X	X							X	X	X	-	-	-	-
	Mallard				300-3000	X	X	X	X	X	X	X	X	X	X	X	X	MAR-AUG	MAR-JUL	APR-AUG	APR-AUG
	Northern pintail				21000	X	X	X	X					X	X	X	X	-	-	-	-
	Northern shoveler				600-1500	X	X	X								X	X	-	-	-	-
	Ring-necked duck				2000									X	X	X		-	-	-	-
	Shorebirds				MED				X	X		X	X	X	X			-	-	-	-
	Snow goose				90000	X	X	X						X	X	X	X	-	-	-	-
	Wading birds				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Wood duck				700-2000			X	X	X	X	X	X	X	X	X		-	-	-	-

FISH:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Outmig.	Larvae/Juv
362	American shad				MED			X	X	X	X	X	X	X	X	X		APR-MAY	-	MAY-NOV
	Atlantic croaker				MED	X			X	X	X	X	X	X	X	X	X	-	-	MAY-JAN
	Atlantic menhaden				MED				X	X	X	X	X	X				-	-	MAY-OCT
	Atlantic sturgeon				LOW	X	X	X	X	X						X	X	-	-	-
	Bay anchovy				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	MAY-SEP	-	MAY-JAN
	Black drum				LOW				X	X	X	X	X	X	X	X		-	-	JUN-NOV
	Black seabass				LOW				X	X	X	X	X	X	X	X		-	-	APR-OCT
	Bluefish				MED					X	X	X	X	X	X			-	-	MAY-OCT
	Seatrout (weakfish)				HIGH				X	X	X	X	X	X	X	X		-	-	-
	Spot				MED					X	X	X	X	X	X	X	X	-	-	MAY-NOV
	Striped bass				MED	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Summer flounder				MED				X	X	X	X	X	X	X	X		-	-	APR-NOV
363	Porgy (scup)				LOW				X	X	X	X	X	X	X	X	X	-	-	-
	Winter flounder				LOW	X	X	X	X	X	X	X	X	X	X	X	X	NOV-MAR	-	MAY-OCT
365	Black drum				HIGH				X	X	X							APR-JUN	-	-
366	Tautog				HIGH				X	X	X	X	X	X	X			APR-JUN	-	MAY-OCT
368	Seatrout (weakfish)				HIGH					X	X							MAY-JUN	-	-
369	White perch				MED	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	-	-
370	White perch				MED	X	X	X								X	X	-	-	-

M_MAMMAL:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Mating	Calving	Pupping	Molting
353	Gray seal				RARE	X	X	X	X								X	-	-	-	-
	Harbor seal				COMMON	X	X	X	X								X	-	-	-	-
	Harp seal				RARE	X	X	X	X								X	-	-	-	-
	Hooded seal				RARE	X	X	X	X								X	-	-	-	-
354	Atlantic white-sided dolphin				RARE					X	X	X	X	X	X	X		-	-	-	-
	Bottlenose dolphin				COMMON					X	X	X	X	X	X	X		-	-	-	-
	Common dolphin				RARE					X	X	X	X	X	X	X		-	-	-	-
	Harbor porpoise				OCCASIONAL			X	X	X								-	-	-	-
	Rough-toothed dolphin				RARE					X	X	X	X	X	X	X		-	-	-	-
	Stenellid dolphin				RARE					X	X	X	X	X	X	X		-	-	-	-
355	Dwarf sperm whale				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Fin whale	DE	S/F	E/E	OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Humpback whale	DE	S/F	E/E	COMMON	X	X	X	X	X	X	X	X	X	X	X		-	-	-	-
	Long-finned pilot whale				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Minke whale				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Northern right whale	DE	S/F	E/E	OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Pygmy sperm whale				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Risso's dolphin				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Sei whale	DE	S/F	E/E	OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Shortfin pilot whale				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Sperm whale	NJ	S/F	E/E	OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
386	Gray seal				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
	Harbor seal				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-

REPTILE:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Hatching	Internesting
354	Green sea turtle	DE	S/F	T/T	RARE						X	X	X	X	X	X		-	-	-
	Kemp's ridley sea turtle	DE	S/F	E/E	OCCASIONAL						X	X	X	X	X	X		-	-	-
	Loggerhead sea turtle	DE	S/F	T/T	COMMON						X	X	X	X	X	X		-	-	-

SHELLFISH:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Larvae/Juv	Mating
260	Horseshoe crab				LOW				X	X	X							APR-JUN	JUN-JUN	APR-JUN
261	Blue crab									X	X	X	X	X	X	X	X	JUL-AUG	SEP-OCT	-
262	Blue crab					X	X	X	X	X	X	X	X	X	X	X	X	JUL-AUG	SEP-OCT	MAY-JUN
264	Channeled whelk				LOW	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Knobbed whelk				LOW	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Northern quahog (hard clam)				LOW	X	X	X	X	X	X	X	X	X	X	X	X	JUN-SEP	JUN-SEP	-
363	Squid				MED				X	X	X	X	X	X	X	X		APR-JUL	AUG-OCT	-

T_MAMMAL:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D
25	Muskrat				HIGH	X	X	X	X	X	X	X	X	X	X	X	X
	Northern raccoon				HIGH	X	X	X	X	X	X	X	X	X	X	X	X
	River otter				LOW	X	X	X	X	X	X	X	X	X	X	X	X
361	Muskrat				HIGH	X	X	X	X	X	X	X	X	X	X	X	X
	Northern raccoon				HIGH	X	X	X	X	X	X	X	X	X	X	X	X
	River otter				LOW	X	X	X	X	X	X	X	X	X	X	X	X

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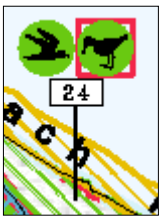
Reading the Back of the Map



On the front of any ESI map, you'll see symbols representing locations where sensitive species of birds and animals are present, during some or all seasons of the year. Information about the species or species subgroup represented by each symbol is shown on the back of most ESI maps (some older maps do not include this information). Here's an example:

At right is a section of Map 8, the example map for this exercise. It shows two symbols representing subgroups of bird species present on Beach Plum Island:

- the lefthand symbol represents **gulls and terns**.
- the righthand symbol represents **shorebirds**.

The number **"24"** appears just below the two symbols. You'll use that number to find information about the two species subgroups on the back of the map. Also, a red box around the shorebird symbol warns you that this symbol represents a **threatened or endangered species** (endangered species are in danger of becoming extinct; threatened species could easily become endangered if present trends continue).

Below are the top few rows of the table on the back of Map 8. To find the information for the two symbols above, check in the left-most column for "24." It's easy to find at the top of the table, where it's associated with two species subgroups, gulls and terns, and one species, the piping plover *(Charadrius melodus)*.

DELAWARE, NEW JERSEY, and PENNSYLVANIA ESIMAP 8

BIOLOGICAL RESOURCES:

BIRD:

RAR#	Species	ST	S/F	T/E	Concen	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Laying	Hatching	Fledging
24	Gulls				MED			X	X	X	X	X	X					-	-	-	-
	Piping plover	DE	S/F	T/T	LOW			X	X	X	X	X	X	X				APR-AUG	MAY-JUN	MAY-JUL	JUN-AUG
	Terns				LOW			X	X	X	X	X	X					-	-	-	-
25	American wigeon				SOD	X	X	X							X	X	X	-	-	-	-
	Bald eagle	DE	S/F	E/T	LOW	X	X	X	X	X	X	X	X	X	X	X	X	NOV-JUL	JAN-MAR	FEB-APR	MAY-JUL
	Black duck				400-4000	X	X	X	X	X	X	X	X	X	X	X	X	MAR-AUG	MAR-JUL	APR-AUG	APR-AUG
	Blue-winged teal				200-500				X	X	X	X	X	X				-	-	-	-
	Canada goose				150-200				X	X	X	X	X					APR-JUN	APR-MAY	JUN-JUN	JUN-JUL

The second row in the table shows information about the piping plover. The first three cells to the right of the species name give information about its status:

ST	S/F	T/E
DE	S/F	T/T

- "DE" in the "ST" column shows that the State of Delaware ("DE") has designated this species as threatened or endangered.
- "S/F" in the "S/F" column tells you that both the state ("S") and Federal ("F") governments have designated this species as threatened or endangered.
- "T/T" in the "T/E" column tells you that both the state of Delaware and the Federal government have designated this species as threatened ("T"), as opposed to endangered ("E"). (On Map 8, a symbol for bald eagles *(Haliaeetus leucocephalus)* is also shown boxed in red. Information about this species is shown three rows below the piping plover row. "E/T" in the "T/E" column for bald eagles tells you that the state of Delaware has designated this species as endangered, while the Federal government has designated it as threatened.)

Other cells in the piping plover row of the table tell you when the plovers are present, what they are doing, and about how many there are:

- "LOW" in the "Concen" (Concentration) column tells you that the plovers are present in this area at low concentrations.
- The next 12 columns represent the months in the year, starting with "J" for January. An "X" in any of these columns shows that the species is present during the corresponding month of the year (a blank means that it is absent during that month). The piping plover is present from February through September.
- The remaining columns show the times of the year when species are nesting, laying eggs, hatching, and fledging. Piping plovers, for example, nest from April through August in this area.

In this exercise, your students will set protection priorities for an oil spill that happens in June. By checking the piping plover line of the table, you can quickly see that this threatened species

- is present during this month (there's a "X" in the column for the month of June).
- is nesting, laying, hatching, and fledging during this month.

Because piping plovers are present and busy with reproductive activities during this month, June is a particularly bad time for their habitat to be oiled.

ENVIRONMENTAL SENSITIVITY INDEX: DELAWARE, NEW JERSEY, AND PENNSYLVANIA

INTRODUCTION

Environmental Sensitivity Index (ESI) maps have been developed for the shorelines of Delaware, New Jersey, and Pennsylvania, encompassing the outer coast from the Maryland-Delaware border north to Toms River, in Barnegat Bay, New Jersey and the Delaware Bay and River system to Trenton, New Jersey. The ESI maps include information for three main components: shoreline habitats; sensitive biological resources; and human-use resources. Background information, as well as the methods of data collection and presentation, are summarized in the following sections.

SHORELINE HABITAT MAPPING

The intertidal habitats of Delaware, New Jersey, and Pennsylvania were mapped during overflights conducted from 10-17 April 1995. The aerial surveys were conducted using helicopter, flying at elevations of 300-500 feet and slow air speed. An experienced coastal geologist updated the intertidal habitats originally mapped in 1985 on plots of 1:24,000 U.S. Geological Survey (USGS) topographic maps which had the original shoreline classification plotted on them. Where appropriate, multiple habitats were delineated for each shoreline segment.

Prediction of the behavior and persistence of oil on intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The vulnerability of a particular intertidal habitat is an integration of the following factors:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

All of these factors are used to determine the relative sensitivity of intertidal habitats. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate, shoreline type, product type, fate and effect, and sediment transport patterns. The intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline.

These concepts have been used in the development of the ESI, which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity have the highest ranking. The list below includes the shoreline habitats delineated for the shorelines of Delaware, New Jersey, and Pennsylvania, presented in order of increasing sensitivity to spilled oil.

1) Exposed Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
2A) Eroding Bluffs
2B) Wave-cut Clay Platforms
3) Fine-grained Sand Beaches
4) Medium- to Coarse-grained Sand Beaches
5) Mixed Sand and Gravel Beaches
6A) Gravel Beaches
6B) Riprap Structures
7) Exposed Tidal Flats
8A) Vegetated, Steeply Sloping Riverine Bluffs
8B) Sheltered Seawalls and Other Solid Structures Made of Concrete, Wood, or Metal
9) Sheltered Tidal Flats
10) Salt and Brackish-water Marshes

Each of the shoreline habitats are described on pages 7-12, in terms of their physical description, predicted oil behavior, and response considerations.

SENSITIVE BIOLOGICAL RESOURCES

The biological information presented on the maps was compiled with the assistance of federal, state, and regional biologists and resource managers from the U.S. Fish and Wildlife Service, Delaware Department of Natural Resources and Environmental Control (DNREC), New Jersey Department of Environmental Protection and Energy (DEPE), and Pennsylvania Department of Environmental Resources (DER). Information collected and depicted on the maps denotes the key biological resources that are most likely at risk in the event of an oil spill. Seven major categories of biological resources were considered during production of the maps: marine mammals, terrestrial mammals, birds, reptiles, fish, shellfish, and habitats.

Spatial distribution of the species on the maps is represented by polygons, lines, and points, as appropriate. Associated with each of these representations is an icon depicting the types of plants or animals that are present. Species have been divided into groups and subgroups, based on their behavior and taxonomic classification. The icons reflect this grouping scheme. The groups are color coded, and the subgroups are represented by different icons as follows:

on

The polygon, line, or point color and pattern are the same for all the animals in one group (i.e., birds). When there is more than one group of animals in one polygon, the polygon is then assigned the multigroup color and pattern. Also associated with each biological polygon, line, or point feature on the map is a number (located under the icon). This number references a table on the reverse side of the map with a complete list of species found in the polygon as well as seasonality and life-history information on each species.

There are some species that are found throughout the nearshore zone on the map. While it is important to note the presence of these species, showing these distributions as polygons would cover large areas, making the maps very difficult to read. Thus, species found in over 25 percent of the water area are identified in a box stating that they are "COMMON IN AREA". This approach informs the user of the presence of these species, while maintaining readability of the map.

For many biological resources, information and expert knowledge may not be available for all geographic locations. For this reason, absence of a resource on a map does not necessarily mean it is not present. Under the descriptions of the various biological resource groups, the geographical limits of available knowledge, or the survey boundaries of particular studies, are given when known.

MARINE MAMMALS

Three subgroups of marine mammals, seals, dolphins, and whales, are depicted for Delaware Bay and surrounding areas.

Harbor seals are sighted frequently throughout the area, while gray, harp, and hooded seals are sighted occasionally.

The bottlenose dolphin and harbor porpoise are common throughout the Bay and coastal area. Occasionally, the Atlantic white-sided dolphin, common dolphin, Risso's dolphin, rough-toothed dolphin, and stenellid dolphin are seen in the area. The humpback whale is also a frequent denizen of the Delaware Bay area. These animals have been seen in the Bay during their migrations. Other species of whales are included that are infrequent visitors, so that the full range of mammals that may be present in the Bay is included.

Marine mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first columngives the species name. The second and third columns denote whether the species has either state (S) and / or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

TERRESTRIAL MAMMALS

Terrestrial mammals included in the Delaware, New Jersey, and Pennsylvania atlas are river otter, raccoon, mink, and muskrat. These animals are found primarily in the wetlands along Delaware Bay. The river otters concentrate in the streams that feed into the Bay.

Terrestrial mammal distributions are shown by a brown hatch polygon. However, if species in addition to mammals are included in the polygon, a black hatch (multigroup) polygon is used. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No terrestrial mammals included on the maps have such designations. The next column provides an estimate of the concentration of species at this site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

BIRDS

Birds are divided into several species subgroups based on behavior and taxonomy. The species table lists all the birds included on the maps, sorted by subgroup. These species were included either because of their likelihood of impact by an oil spill or special protection status as threatened or endangered. Of particular importance are the spring migratory shorebird concentrations in Delaware Bay. With 800,000 to 1,500,000 shorebirds present in the spring, Delaware Bay is one of the most significant migratory areas for shorebirds in the Western Hemisphere. Shorebirds are attracted by the spawning horseshoe crab. Delaware Bay area is a significant overwintering place for waterfowl. Pea Patch Island is also a major nesting site for various species of wading birds.

Bird distribution is shown on the maps as green hatch polygons. These areas depict known migratory, overwintering, nesting, or other concentration areas. Green dots on the maps represent the location of nesting colonies. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name, followed by the state (S) and/or federal (F) species designation for endangered (E) or threatened (T) status. The species will be identified as threatened or endangered for all occurrences of the species, even if it is only listed as such in one state. The next column provides an estimate of the concentration of each species at the site. For birds, the highest count of individuals recorded at each site is given. Where counts were not available, "Unknown" is listed in the concentration column. Even though concentration may be listed as "Unknown", it should be recognized that the number of individuals or the importance of the site was still significant enough to be included. The species seasonality is shown in the next twelve columns representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. The last column denotes the nesting season for each species, if nesting occurs at the site. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon or point that it references.

REPTILES

The only reptiles included in the Delaware, New Jersey, and Pennsylvania atlas are sea turtles and northern diamondback terrapins. There are no known sea turtle nesting beaches present in the area. The in-water areas represent known foraging, developmental, migratory, or other habitat areas where sea turtles are likely to occur in substantial numbers. Northern diamondback terrapins are a species of special concern and are known to nest in the Delaware and New Jersey area. The maps show known concentration areas rather than nesting sites.

Turtle distributions are shown as polygons with a red hatch pattern. If species in addition to turtles are included in a polygon, a black hatch (multigroup) pattern is used. A red icon with a turtle silhouette is used to indicate the presence of turtles. The number under the icon references a table on the reverse side of the map. In the tables, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of the species at a site. Concentration is indicated as "RARE", "OCCASIONAL", or "COMMON". Concentration estimates are subjective based on local expert opinion on relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at that location in a particular month, an "X" is placed in the month column. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

FISH

The fish species included in the Delaware, New Jersey, and Pennsylvania atlas are those of commercial or recreational importance. The species table lists all of the species of fish included on the maps, grouped by anadromous and all other species. There are many more species of fish than those shown on the maps. In addition, most areas depicted reflect only the more significant concentrations. These areas are identified because of higher concentrations, important spawning areas, important juvenile areas, or high use recreational and/or commercial fishing for the named species.

The distributions of fish are shown as polygons with a blue hatch pattern. If species in addition to fish are included in the polygon, a black hatch (multigroup) pattern is used. A blue icon with a fish silhouette is used to indicate the presence of fish. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for outmigration, spawning, and the presence of juveniles. For many species there is a temporal shift in seasonality along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

SHELLFISH

Shellfish included in the Delaware, New Jersey, and Pennsylvania atlas include bivalves (clams and oysters), cephalopods (squid), crabs, gastropods (whelk), and lobsters. The species table lists all the shellfish shown on the maps, sorted by subgroup. Commercially or recreationally important species are included. For clams, only moderate to high concentration areas are depicted. For oysters, the seed beds, lease beds, and general concentration areas have not been differentiated; all of these features are shown as oyster beds. Whelk concentration areas are shown in the lower portion of Delaware Bay, which is an important whelk fishing area.

Horseshoe crab concentration areas are shown for Delaware Bay. This is an important species because tremendous numbers (as many as 1.2 million in a single day) mate every year on the sand beaches of the lower bay. This activity attracts numerous shorebirds during their spring migration.

The distributions of shellfish are shown as polygons with an orange hatch pattern. If species in addition to shellfish are included in the polygon, a black hatch (multigroup) pattern is used. Orange icons are associated with the polygons, and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. In this table, the first column gives the species name. The second and third columns denote whether the species has either state (S) and/or federal (F) designations as endangered (E) or threatened (T). No shellfish included on the maps have such designations. The next column provides an estimate of the concentration of species at the site. Concentration is indicated as "HIGH", "MED", or "LOW". These estimates are subjective based on local expert opinion on the relative concentrations in the area. The species seasonality is shown in the next twelve columns, representing the months of the year. If the species is present at a location in a particular month, an "X" is placed in the month column. The last three columns indicate dates for spawning, mating, and the presence of juveniles. Spawning refers to the release of gametes to the water column during reproductive periods, or the mass release of larvae. Mating applies to shellfish which form temporary reproductive pairs for fertilization of gametes (e.g., blue crabs), with later release of more developed larval young. For many species there is a temporal shift in seasonality and reproduction along with spatial changes in location. Temporal information included in the tables is specific to the one polygon that it references.

HABITATS

Habitats included in the Delaware, New Jersey, and Pennsylvania atlas include seagrasses and terrestrial plants. Seagrasses in Delaware and New Jersey consist of eelgrass. For most oil spills, the many small animals associated with seagrass habitats are often at greater risk than the vegetation. The seagrasses are limited to the northern sections of Barnegat Bay and the eastern edge of the Indian River and Rehoboth Bays.

Habitats are shown as polygons with a purple hatch pattern. If species in addition to plants are present in the polygons, a black hatch (multigroup) pattern is used. Purple icons are associated with the polygons and the silhouette of the subgroup is shown. The number under the icon references a table on the reverse side of the map. The concentration column provides an estimate of the plant abundance at the site. Concentration for seagrasses and terrestrial plants are unknown, since the source information only indicated presence or absence. The last twelve columns provide information on seasonality. All 12 months are marked with an "X" since the plants are present all year. However, it should be recognized that during winter months, above-ground vegetation may be reduced or not present.

HUMAN-USE FEATURES

The human-use features depicted on the maps are those that either could be impacted by an oil spill or could provide access for response operations. All the features are represented by icons indicating the type of human-use resource.

ACCESS POINT

Locations where it is possible to gain vehicle access to the shoreline.

AIRPORT

Location of airfields or airports, whether manned or unmanned. The locations were obtained from USGS 1:24,000 topographic maps.

ARCHAEOLOGICAL SITE

Location of known archaeological sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

BOAT RAMP

Location of boat ramps. These data were obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

COAST GUARD

Location of Coast Guard facilities. This information was obtained from visual observation during overflights and from USGS 1:24,000 topographic maps.

FERRY

Location of ferry docks. This information was obtained from USGS 1:24,000 topographic maps.

HISTORICAL SITE

Location of historical sites in close proximity to the shoreline. This information was provided by the Delaware Office of Historic Preservation, the New Jersey Office of Historic Preservation, and the Pennsylvania Bureau for Historic Preservation.

MARINA

Location of marinas. This information was obtained from visual observation during overflights, the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

PARK

Location of state parks. The boundaries were obtained from the U.S. Fish and Wildlife Service, the New Jersey Department of Environmental Protection and Energy, and from USGS 1:24,000 topographic maps.

RECREATIONAL FISHING OR BOATING

General areas where there is heavy recreational fishing or boating. These areas were provided by the Delaware Department of Natural Resources and Environmental Control.

RESERVE, PRESERVE, OR REFUGE

All boundaries for the reserves, preserves, refuges, or any other managed and regulated wildlife areas were provided by the U.S. Fish and Wildlife Service and the New Jersey Department of Environmental Protection and Energy. These managed lands include an icon and the name of the property.

WATER INTAKES

Location of surface water intakes whether for cooling water, industrial use, or potable water. All public and private surface water intakes are shown. Information was provided by the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection and Energy, and the Pennsylvania Department of Environmental Resources.

For water intakes, the name of the resource, the manager/ owner, an emergency contact person, and a telephone number are provided. The information is listed on the reverse side of the maps, when available.

GEOGRAPHIC INFORMATION SYSTEM DATA

The entire atlas product is stored in digital form in a Geographic Information System (GIS). The information is stored as maps and associated databases. The format for the data varies depending on the type of information or features for which the data are being stored. The three major formats are shoreline habitat classification, biological resources, and human-use features.

Under separate cover are a complete data dictionary, metadata, and descriptive information for the digital data sets and maps that were used to create this atlas. Below is a brief synopsis of the information contained in the digital version. Please refer to the metadata file for full explanations of the data and its structure.

SHORELINE HABITAT CLASSIFICATION

The shoreline habitat classification is stored as lines with the data identifying the type of habitat associated with the line. In many cases, a shoreline may have two classifications. These multiple classifications are represented on the maps by double lines and in the database by ESI#1/ESI#2, where ESI#1 is the landward-most classification and ESI#2 is the seaward-most classification.

SENSITIVE BIOLOGICAL RESOURCES

Biological resources are shown on the map as lines, points, or polygons. Associated with each map feature is a unique identification number which is linked to a series of databases that further identify the resources. The first data set consists of a list of the species and the concentration of each species. This dataset is then linked to a dataset that describes the life history of each species (temporal presence and reproductive times at month resolution) for the specified map feature. Other databases linked to the first data set are the species identification database, which includes common and scientific names for all species and their threatened or endangered status, and the sources database, which provides source metadata at the feature level.

HUMAN-USE FEATURES

Human-use features are represented on the maps as an icon describing the feature. In the digital file, the feature location is represented by a point or by polygons. If the feature is either an aquaculture facility or water intake, a data file that contains the fields for the name of the owner/manager, telephone number at which the person can be contacted, identification of the type of feature, and a brief description of the feature is associated with the feature. For all of the other human-use features, only the name, when available, is entered into the database.

REFERENCES

Listed below are the major hardcopy reference materials used during this project. In some instances, reference materials were not directly used as source materials, but were instead used or interpreted by scientists or resource managers who provided expert knowledge or personal communication concerning resources depicted in the atlas.

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At Research Planning, Inc. (RPI), Joanne Halls and Mark White were the project managers. Shoreline mapping was conducted by Todd M. Montello. Biological and human-use resources data were collected and compiled by Jeffrey Dahlin. Mark White, Lee Diveley, Kara Hastings, and James Olsen entered the data and produced the final maps, under the supervision of Joanne Halls. Systems administration was coordinated by Bill Holton. Graphics were provided by Joe Holmes and Becky Cox, and Dot Zaino prepared the text.

DELAWARE, NEW JERSEY, AND PENNSYLVANIA

SHORELINE HABITAT RANKINGS

- 1 - EXPOSED SEAWALLS AND OTHER SOLID STRUCTURES MADE OF CONCRETE, WOOD, OR METAL
- 2A,2B - ERODING BLUFFS; WAVE-CUT CLAY PLATFORMS
- 3 - FINE-GRAINED SAND BEACHES
- 4 - MEDIUM- TO COARSE-GRAINED SAND BEACHES
- 5 - MIXED SAND AND GRAVEL BEACHES
- 6A - GRAVEL BEACHES
- 6B - RIPRAP STRUCTURES
- 7 - EXPOSED TIDAL FLATS
- 8A - VEGETATED, STEEPLY SLOPING RIVERINE BLUFFS
- 8B - SHELTERED SEAWALLS AND OTHER SOLID STRUCTURES MADE OF CONCRETE, WOOD, OR METAL
- 9 - SHELTERED TIDAL FLATS
- 10 - SALT AND BRACKISH WATER MARSHES

HUMAN-USE FEATURES

- ACCESS POINT
- AIRPORT
- ARCHAEOLOGICAL SITE
- BOAT RAMP
- COAST GUARD
- FERRY
- HISTORICAL SITE
- MARINA
- PARK
- RECREATIONAL FISHING
- WATER INTAKE
- WILDLIFE REFUGE
- H123 ID NUMBER
- PARK/REFUGE BOUNDARY
- STATE BOUNDARY

SENSITIVE BIOLOGICAL RESOURCES

BIRDS

- DIVING BIRDS
- GULLS & TERNS
- RAPTORS
- SHOREBIRDS
- WADING BIRDS
- WATERFOWL
- NESTING SITES

FISH

- FISH

MARINE MAMMALS

- DOLPHINS
- SEALS
- WHALES

TERRESTRIAL MAMMALS

- SMALL MAMMALS

REPTILES

- TURTLES

SHELLFISH

- BIVALVES
- CEPHALOPODS
- CRABS
- GASTROPODS
- LOBSTERS

HABITATS

- SUBMERGED AQUATIC VEGETATION
- TERRESTRIAL VEGETATION

MULTI-GROUP

- THREATENED/ENDANGERED
- 123 ID NUMBER

Oil Spill Scenario

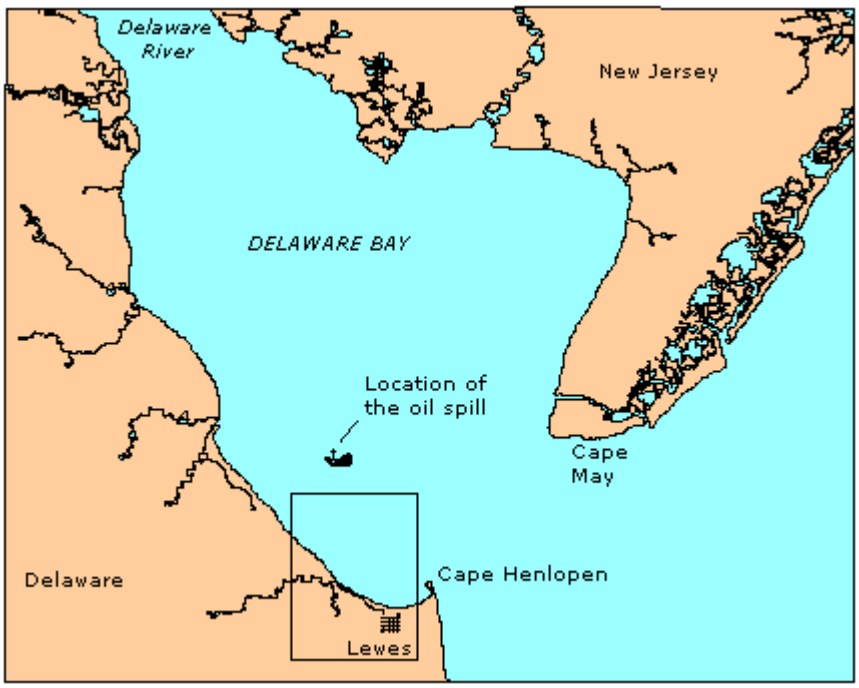
At about 5:30 am on June 10, while approaching Big Stone Anchorage in Delaware Bay, the tanker T/V *Sally Ann* collides with a freighter, the M/V *James*, and spills oil from a damaged cargo tank. The master of the *Sally Ann* radios the U.S. Coast Guard to report that his vessel has leaked about 200,000 gallons (6,350 barrels; 780 cubic meters) of medium crude oil into Delaware Bay. The location of the collision and oil spill is marked on the map below.

The Captain of the Port closes Delaware Bay to all vessel traffic and designates a safety zone around both vessels, now at anchor in Big Stone Anchorage. Weather and sea conditions in the area are as follows: wave heights are at 1 to 2 feet (0.3 to 0.6 meters), winds are from the northeast at about 10 knots (5 meters per second), air temperature is about 59 degrees F (15 degrees C), skies are overcast, and visibility is unrestricted.

Oceanographers at NOAA's Emergency Response Division use computer models to predict that winds and currents will move the spilled oil in a southerly direction. They predict that within the next 20-24 hours, the oil will come ashore just west of Cape Henlopen, in the area covered by Map 8 of NOAA's Delaware, New Jersey, Pennsylvania Atlas of ESI maps (the example map used in this exercise). This area is shown enclosed in a rectangle on the map below.

A team of oil spill responders convenes at Lewes, Delaware, led by the Incident Command (a group of representatives from local, state, and Federal governments and the company responsible for the accident).

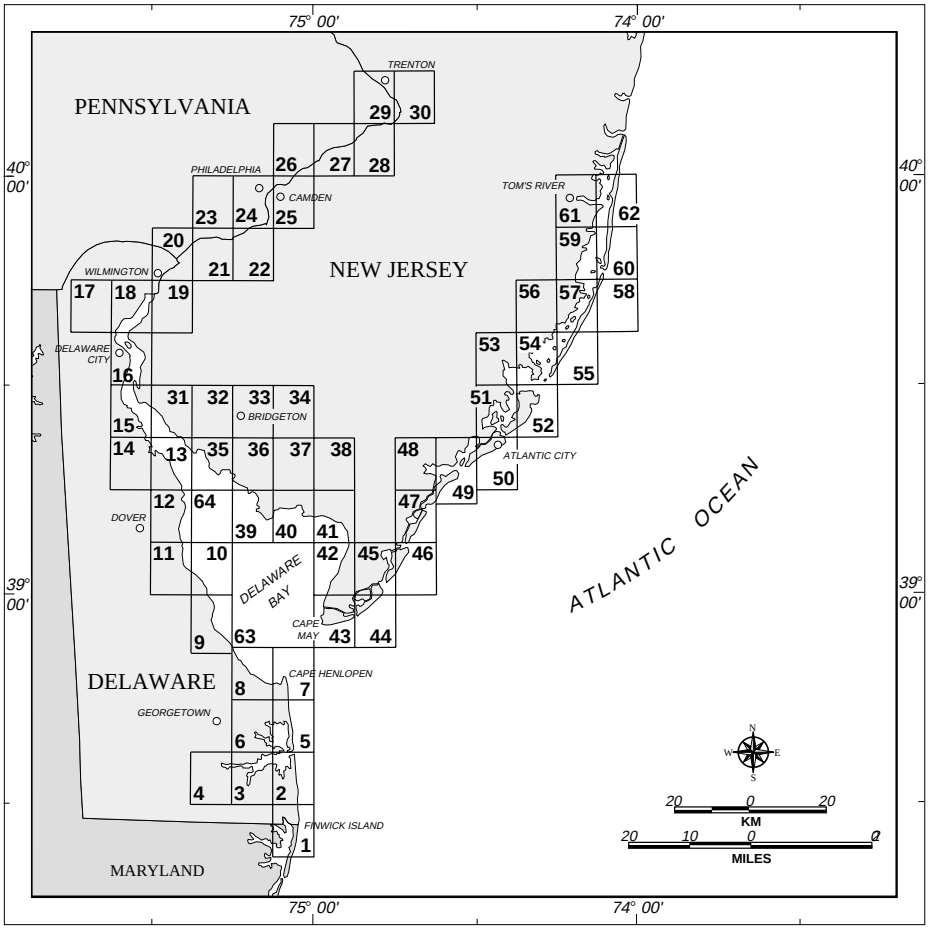
The response team has access to a stockpile of floating boom, which they can use to protect sensitive sites. In order to position booms as effectively as possible, the Incident Command requests your help setting protection priorities for the coastline predicted to be oiled.



Sensitivity of Coastal Environments and Wildlife to Spilled Oil

DELAWARE, NEW JERSEY, PENNSYLVANIA

ATLAS



HAZARDOUS MATERIALS RESPONSE and ASSESSMENT DIVISION

National Oceanic and Atmospheric Administration

Seattle, Washington

and

THE STATES OF DELAWARE,

NEW JERSEY AND PENNSYLVANIA

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Oil Types

We think of oil as being a single substance, but there actually are many different kinds of oil. Kinds of oil differ from each other in their viscosity, volatility, and toxicity. Viscosity refers to an oil's resistance to flow. Volatility refers to how quickly the oil evaporates into the air. Toxicity refers to how toxic, or poisonous, the oil is to either people or other organisms.

When spilled, the various types of oil can affect the environment differently. They also differ in how hard they are to clean up. Spill responders group oil into four basic types. Here is a list of those four types, along with a general summary of how each type can affect shorelines.

Type 1: Very Light Oils (Jet Fuels, Gasoline)

- Highly volatile (should evaporate within 1-2 days).
- High concentrations of toxic (soluble) compounds.
- Localized, severe impacts to water column and intertidal resources.
- No cleanup possible.

Type 2: Light Oils (Diesel, No. 2 Fuel Oil, Light Crudes)

- Moderately volatile; will leave residue (up to one-third of spill amount) after a few days.
- Moderate concentrations of toxic (soluble) compounds.
- Will "oil" intertidal resources with long-term contamination potential.
- Cleanup can be very effective.

Type 3: Medium Oils (Most Crude Oils)

- About one-third will evaporate within 24 hours.
- Oil contamination of intertidal areas can be severe and long-term.
- Oil impacts to waterfowl and fur-bearing mammals can be severe.
- Cleanup most effective if conducted quickly.

Type 4: Heavy Oils (Heavy Crude Oils, No. 6 Fuel Oil, Bunker C)

- Heavy oils with little or no evaporation or dissolution.
- Heavy contamination of intertidal areas likely.
- Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion).
- Long-term contamination of sediments possible.
- Weathers very slowly.
- Shoreline cleanup difficult under all conditions.

More technical information about the characteristics of different oils is available on these fact sheets.

- Alaska North Slope Crude Blends (PDF; 611K)
- No. 6 Fuel Oil (Bunker C) Spills (PDF; 611K)
- Small Diesel Spills (500-5000 gallons) (PDF; 544K)
- Tarballs (PDF; 384K)