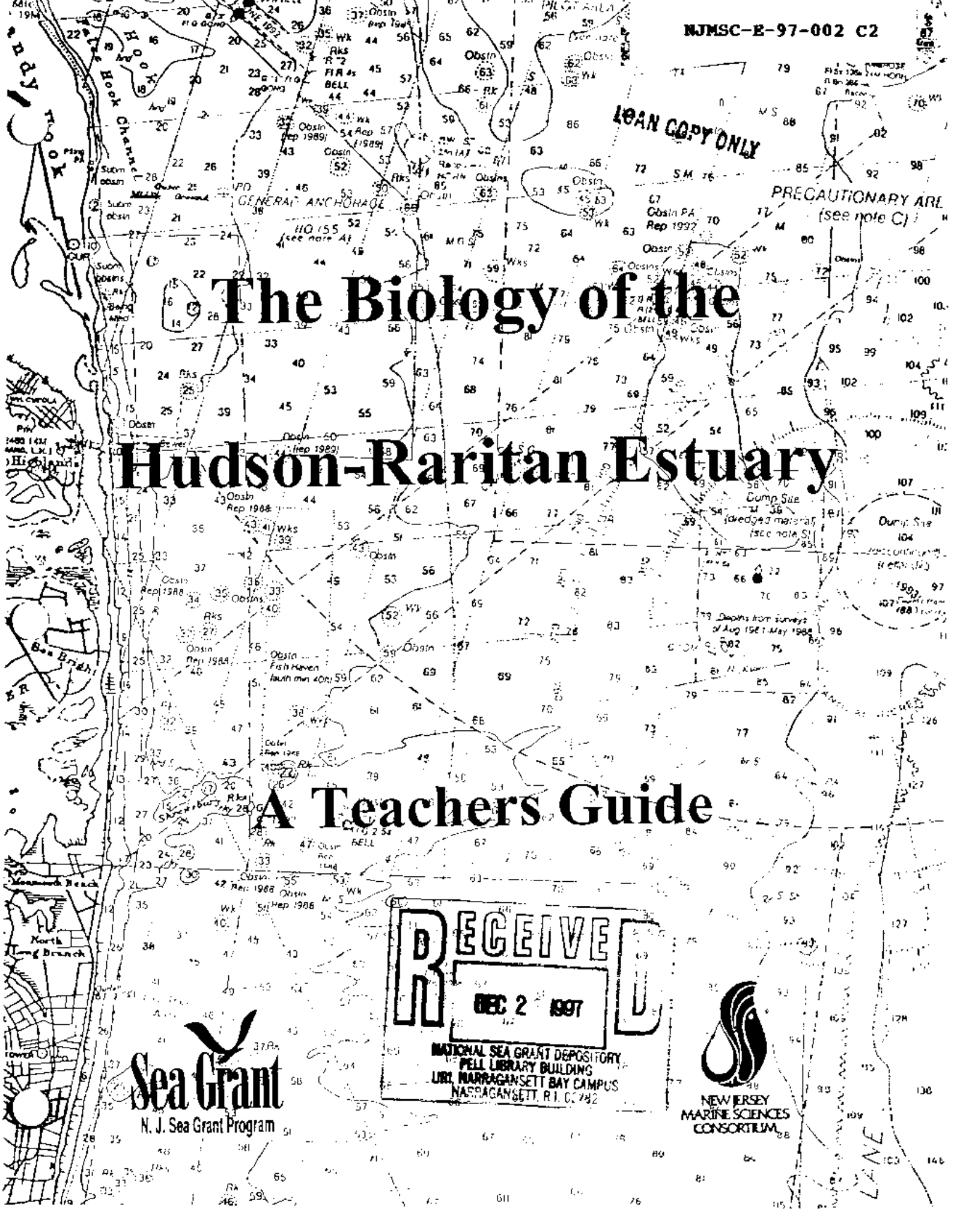
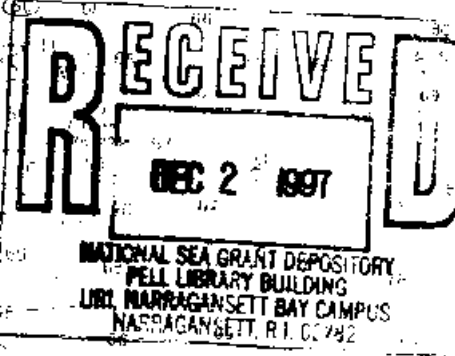


LEAN COPY ONLY

PRECAUTIONARY AREA (see note C)

The Biology of the Hudson-Raritan Estuary

A Teachers Guide



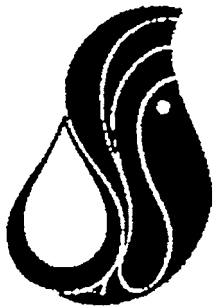
**THE BIOLOGY OF THE HUDSON-RARITAN ESTUARY:
A MARINE EDUCATION PROGRAM**

Produced by the Staff of the
Education Program
at the
New Jersey Marine Sciences Consortium
Building 22, Fort Hancock
Sandy Hook, New Jersey 07732

Funded by the
Geraldine R. Dodge Foundation

and the

New Jersey Sea Grant College Program



**NEW JERSEY
MARINE SCIENCES
CONSORTIUM**



PREFACE AND ACKNOWLEDGEMENTS

The Hudson-Raritan Estuary encompasses the waters of New York Harbor and the tidally influenced portions of all of the rivers and streams that empty into it. The Estuary is an extraordinary resource and a biologically rich ecosystem. However, as the site of extensive human activity, it has experienced significant ecological stress. Presently, the Estuary is threatened by increasing pollution and overuse of its resources.

Although much information has been made available in recent years about human use of the marine resources of the Hudson-Raritan Estuary, it is scattered among technical and semi-technical reports, scientific journals, newsletter and magazine articles and other documents produced by federal and state agencies, private environmental organizations, and academic programs. Educational materials related to the Estuary are typically geared towards users such as commercial and recreational fishers, environmentalists, college students, or the general public.

Educational materials related to the Estuary for teachers and students are lacking. To address this need, the New Jersey Marine Sciences Consortium undertook a project funded by the Geraldine R. Dodge Foundation and the New Jersey Sea Grant College Program to develop an interdisciplinary marine education program on the biology of the Hudson-Raritan Estuary. It is the goal of this project to enable teachers to introduce middle and high school students to the important resources of the Estuary, allowing them to understand why the United States Environmental Protection Agency has designated the Hudson-Raritan Estuary one of national significance.

The guide was conceived as a package of instructional tools. Each chapter is followed by related student activities. These activities are summarized (Activities and Materials Overview) for instructors on a per chapter basis. In addition, the kit includes a glossary, species profiles for the fish, birds and invertebrates of the area and a selection of exemplary materials from other sources.

The production and compilation of the following materials would not have been possible without the ongoing efforts of the staff of the Education Program at the New Jersey Marine Sciences Consortium, including Claire Antonucci Manager of K-12 Education Programs, Linda Cohen Education Specialist, Amanda Maxemchuk-Daly Program Associate, Michael Danko Manager of Marine Operations, Rosemary Higgins Program Associate, Liesl Hotaling Education Specialist, Kerry Lynch Marine Specialist, Thomas Lynch Station Biologist, John A. Tiedemann Director of Education and Special Projects, and Karen Yerkovic Program Associate. The staff of the Education Program also wishes to acknowledge the contributions of Dr. Donald Dorfman, Professor of Biology at Monmouth University.

THE BIOLOGY OF THE HUDSON-RARITAN ESTUARY

CONTENTS

I. INTRODUCTION TO THE HUDSON-RARITAN ESTUARY

II. GEOGRAPHY

Activities:

- Getting Your Bearings
- How High is High? How Deep is Deep?
- Where Does the Water Go?
- Mapping the Ocean Floor

III. OCEANOGRAPHIC FEATURES AND PROPERTIES

Activities:

- Sediments of the Hudson-Raritan Estuary
- Reading a Tide Chart
- Ocean Currents
- Turbidity
- Salinity
- PH
- Oxygen in the Water

IV. PLANTS AND ANIMALS

Activities:

- Nearshore Communities
- Classification
- Phytoplankton
- Form and Function
- Salt Tolerance

V. ECOSYSTEMS DYNAMICS

Activities:

- Food Web
- The Competitive Edge
- Biomagnification
- The Habit of Habitat

VI. WATER QUALITY ISSUES

Activities:

- Variations in Water Quality
- Point and Non-Point Pollution Involvement
- Nutrients - Too Much of a Good Thing
- Oil Spill Clean Up
- Plastic and Fish

VII. MANAGEMENT OF THE ESTUARY

Activities:

- Use and Misuse: The Consequences
- Recycle and Reuse
- The Great Debate

VIII. SPECIES PROFILES

Informative Guides to:

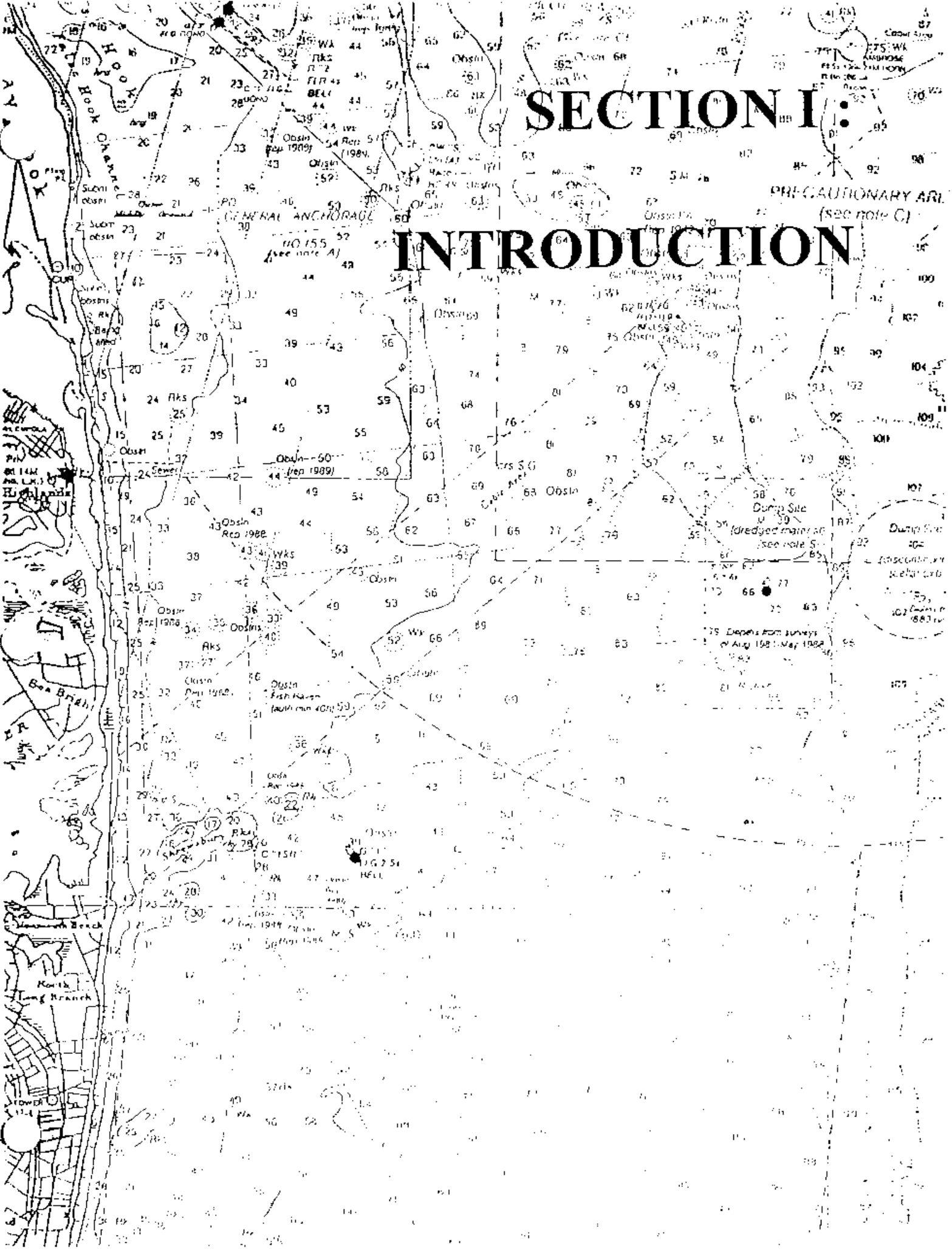
- Fish
- Invertebrates
- Birds

IX. GLOSSARY

SECTION I:

INTRODUCTION

PRECAUTIONARY AREA
(see note C)



AN INTRODUCTION TO THE HUDSON-RARITAN ESTUARY

The Hudson-Raritan Estuary, a system of interconnected waterways, is the most prominent natural feature of northern New Jersey. The watershed of the Hudson-Raritan Estuary includes Upper and Lower New York Harbor, the Hudson River, the East River, Newark Bay, the lower Hackensack River, the lower Passaic River, the Kill Van Kull, the Arthur Kill, Raritan Bay, the Raritan River, Sandy Hook Bay, and the Shrewsbury and Navesink Rivers.

The Hudson-Raritan Estuary is one of the greatest natural harbors in the world and one of the busiest ports in the nation, playing a crucial role in regional economy. During the past 100 years, the Estuary has been subject to serious pollution and other modifications resulting in deleterious changes to the environment and biota.

Wide-scale shoreline development, discharges of industrial wastes and sewage and destruction of tidal marshes have had a serious effect on the aquatic resources of the area. This long history of environmental degradation suggests that there is little left in the Estuary.

Despite this, the area continues to provide important habitat for diverse marine and estuarine species. Among these species are striped bass, bluefish, weakfish, white perch, winter flounder, and summer flounder. Other marine resources of importance include blue claw crabs, lobsters, hard clams, soft clams, and fish such as shad, herring and tomcod. All utilize portions of the Estuary for nursery or feeding grounds.

The land boundaries of the Hudson-Raritan Estuary region are the meeting place of three geologic formations; the rock-based New England Terrain represented by Manhattan, Bronx, Westchester, and Northern New Jersey, the glacial Till/Oak Pinelands represented by Long Island including Brooklyn and Staten Island and the coastal plain/Pine Barrens vegetation represented by southern New Jersey. The shoreline of the area is categorized by two distinct configurations; rocky shores to the north and sand and gravel beaches to the south. The region outside of New York Harbor is classified as a coastal plain.

GEOGRAPHY OF THE HUDSON - RARITAN ESTUARY

USING TOPOGRAPHIC MAPS AND NAUTICAL CHARTS

NAUTICAL CHARTS

A nautical chart can be viewed as a map of the marine environment. They are designed to provide information needed by mariners to make proper piloting decisions. The general shape and nature of the sea floor are important to mariners and a good chart will have a high density of bottom information. They also include information about tides, currents, depth, navigation channels, obstructions and other hazards to navigation, the location and description of local aids to navigation, and other information of interest. Most nautical charts are of the Mercator type, meaning that they are a graphic representation on a flat, two dimensional surface of a navigable portion of the surface of the earth on which latitude and longitude lines are at right angles to one another. Distances are measured on charts either from printed scales or from bordering meridians and are scaled in minutes of latitude or nautical miles.

Nautical charts are also extremely useful for studying the features of waterways and the relation of waterways to adjacent land areas. In addition to portraying the physical characteristics of a water body, nautical charts portray land areas in detail including shoreline configuration, topographic landmarks, harbor facilities and prominent natural and manufactured features of interest. Charts are commonly termed large-scale or small-scale. A chart covering a relatively small area is called a large-scale chart. In other words, a certain small expanse on the earth is represented by a relatively large distance on a large-scale chart. A chart requiring less detail and covering a relatively large area, such as an ocean chart, would have the same expanse represented by a comparatively small distance on the chart and, thus, this chart would be termed a small-scale chart.

Charts of the United States waters are prepared and published by the National Oceanic Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA). The scale of a chart is represented by a ratio of a given distance on the chart to the actual distance it represents on Earth. Not unlike topographic maps, a scale of 1:200,000 on a nautical chart indicates that 1 inch on the chart represents 200,000 inches, or about 2.74 nautical miles on earth. One nautical mile equals 6,080.2 ft.

CHART CATEGORIES

Conventional flat nautical charts are published in the following categories:

1. Sailing charts- Utilizing the smallest scale (under 1:600,000), they cover long stretches of coastline and are used for plotting a course in offshore waters between distant ports and for approaching the coast from open ocean waters. The shoreline and topography are generalized

TOPOGRAPHIC MAPS RELATED TO THE HUDSON-RARITAN ESTUARY

NEW JERSEY QUADRANGLE MAPS	
7.5 Minute Series	
MAP TITLE	SCALE
Nyack (NY)	124,000
Paterson	1:24,000
Hackensack	1:24,000
Yonkers (NY)	1:24,000
Orange	1:24,000
Weehawkin	1:24,000
Central Park (NY)	1:24,000
Elizabeth	1:24,000
Jersey City	1:24,000
Perth Amboy	1:24,000
Arthur Kill (NY)	1:24,000
The Narrows (NY)	1:24,000
Coney Island (NY)	1:24,000
New Brunswick	1:24,000
South Amboy	1:24,000
Keyport	1:24,000
Sandy Hook	1:24,000
Long Branch	1:24,000

All of the topographic maps for the Hudson-Raritan Estuary are on the scale of 1:24,000.

and only offshore soundings, principal navigational aids, and landmarks visible at considerable distances are shown.

2. General charts- These charts use scales of 1:150,000 to 1:160,000 and are used for navigation well offshore with vessel position fixed by landmarks, characteristic soundings, and navigational aids such as lights and buoys.

3. Coast charts- Coast charts are large scale charts with scales of 1:50,000 to 1500,000. They are used for nearshore coastwise navigation, entering and leaving bays and harbors of considerable size, and navigating certain inland waterways.

4. Harbor charts- Harbor charts are the most detailed with scales from 1:5,000 to 1:50,000 and may include larger scale inserts. They are intended for navigation and anchorage in harbors or smaller waterways. They contain detailed land features as well as navigational information.

NAUTICAL CHARTS FOR THE HUDSON-RARITAN ESTUARY

CHART NUMBER	CHART TITLE	SCALE
12326	Approaches to New York Fire Island to Sea Girt	1:80,000
12327	New York Harbor	1:40,000
12331	Raritan Bay and southern Arthur Kill	1:15,000
12332	Raritan River - Raritan Bay to New Brunswick	1:20,000
12333	Kill Van Kull and northern Arthur Kill	1:15,000
12334	New York Harbor - Upper Bay and Narrows	1:10,000
12335	Hudson and East Rivers - Governors Island to 67 St	1:10,000
12337	Passaic and Hackensack Rivers	1:20,000
12338	Newtown Creek, East River	1:5,000
12339	East River - Tallman Island to Queensboro Bridge	1: 10,000
12341	Days Point to George Washington Bridge	1: 10,000
12342	Harlem River	1:10,000
12343	Hudson River - New York to Wappinger Creek	1:40,000
12345	Hudson River - George Washington Bridge to Yonkers	1: 10,000
12346	Hudson River - Yonkers to Piermont	1: 10,000
12347	Hudson River - Wappinger Creek to Hudson	1:40,000
12348	Hudson River - Coxsackie to Troy	1:40,000
12350	Jamaica Bay and Rockaway Inlet	1:20,000
12401	New York Lower Bay - southern portion	1:15,000
12402	New York Lower Bay - northern portion	1:15,000

GEOGRAPHIC POINTS OF INTEREST
IN THE HUDSON - RARITAN ESTUARY

COMPONENT WATERBODIES OF THE WATERSHED

Hackensack River

Passaic River

Newark Bay

Arthur Kill

Kill Van Kull

Raritan Bay

Raritan River

Shrewsbury River

Navesink River

Sandy Hook Bay

Hudson River

East River

Harlem River

Hell's Gate

The Narrows

Jamaica Bay

Gravesend Bay

**GEOGRAPHIC POINTS OF INTEREST
IN THE HUDSON - RARITAN ESTUARY**

WATER FEATURE	COORDINATES
Old Orchard Shoal	Lat. 40° 31'.0 N Long. 74° 07'.2 W
Flynns Knoll	Lat. 40° 29'.4 N Long. 74° 01'.4 W
Romer Shoal	Lat. 40° 30'.5 N Long. 74° 00'.0 W
Upper Harbor/Upper Bay	Lat. 40° 35'.5 N Long. 74° 02'.2 W
Lower Harbor/Lower Bay	Lat. 40° 29'.4 N Long. 74° 04'.7 W
Verrazano Narrows	Lat. 40° 36'.4 N Long. 74° 02'.6 W
Robins Reef	Lat. 40 39'.4 N Long. 74 03'.9 W

GEOGRAPHIC POINTS OF INTEREST
IN THE HUDSON - RARITAN ESTUARY

LAND FEATURE	COORDINATES
Sandy Hook	Lat. 40° 27'.0 N Long. 73° 59'.4 W
Rockaway Point	Lat. 40° 33'.5 N Long. 73° 55'.0 W
Staten Island	Lat. 40° 35'.0 N Long. 74° 10'.0 W
Crookes Point	Lat. 40° 31'.73 N Long. 74° 08'.23 W
Ward Point	Lat. 40° 29'.8 N Long. 74° 14'.9 W
Shooters Island	Lat. 40° 38'.6 N Long. 74° 09'.6 W
Governors Island	Lat. 40° 41'.3 N Long. 74° 01'.0 W
Hoffman Island	Lat. 40° 34'.7 N Long. 74° 03'.13 W
Swinburne Island	Lat. 40° 33'.93 N Long. 74° 03'.02 W
Port Newark	Lat. 40° 41'.1 N Long. 74° 07'.9 W

Getting Your Bearings

Words to Know:

Bearings
Latitude
Longitude

Materials:

One magnetic compass to each group of five (5) students. Note: Magnetic compasses can be purchased from boat catalogs, lab supply catalogs, or a Ben Meadow Company catalog. Price range \$7.50-\$20.00.

Activity:

Set up your classroom to represent a portion of the Hudson-Raritan Estuary with three points of interest (e.g. Sandy Hook Lighthouse, Statue of Liberty and South Street Seaport). The relative positions of points of interest can be found on the activity sheet. In this activity students learn how to use a compass and work with navigational bearings, locating the major waterbodies of the Hudson-Raritan Estuary watershed and points of interest along the way.

How High is High? How Deep is Deep?

Words to Know:

Fathom
Latitude
Longitude
Nautical
Navigate
Topography

Materials:

For this activity you will need nautical charts of the Hudson-Raritan Estuary, topographic map of the Hudson-Raritan Estuary, a road map of the area surrounding the Hudson-Raritan Estuary, a map of the continents, corrugated cardboard, tracing paper, construction paper, pencils, scissors, glue, and string.

Activity:

Observe the differences of each map. Have the students think about situations in which each map would be most useful. In this activity students read, interpret and discover the differences between nautical charts and topographic maps, then design a three-dimensional map of an area they choose, using the nautical charts and topographic maps as reference.

Where Does the Water Go?

Words to Know:

Aquifer
Basin
Drainage Basin
Hydrology
Hydrologic Cycle
Watershed

Materials:

For this activity you will need a shallow pan, aluminum foil, the three-dimensional map created for the "How High is High? How Deep is Deep?" activity or a few paper cups, a watering can, topographical maps and nautical charts for the Hudson-Raritan Estuary, and drink mix or other powdery substance.

Activity:

You can use the same groups of students as for the other activities or choose new ones. In this activity students will learn about the hydrologic cycle and be able to define it, construct a model of a watershed, and understand how the watershed affects marine pollution.

Mapping the Ocean Floor

Words to Know:

Contour map
Sonar
Topography

Materials:

For this activity you will need large, watertight Styrofoam coolers, dark plastic garbage bags, waterproof markers, water to fill the coolers, dark food coloring (blue or green), bricks, rocks, sand or gravel, two strings, two metal nuts or washers, two meter sticks, data sheets for each pair of students and a bucket or pan to bail out the coolers.

Activity:

In this activity students use a cooler to build a simulated underwater terrain and take depth readings to accomplish mapping by using the method of lowering weighted ropes into the water to measure the depths. The figures are placed on the corresponding coordinates on the worksheet.

Getting Your Bearings

- Objectives:**
- 1) You will learn how to use a compass and work with navigational bearings.
 - 2) You will locate geographic points of interest along the Hudson-Raritan Estuary.

Background: When people first started traveling on the ocean, they would calculate their approximate location using a magnetic compass to determine direction. If a navigator wanted to travel northwest for 100 miles and then directly west for 200 miles to reach his destination and his ship only went 10 mph, he would travel northwest for 10 hours then turn to travel directly west. Twenty hours later he should reach his destination, making his total trip 30 hours long. This method was not highly accurate. It does not consider changes in speed and location due to wind, ocean currents or tides. Today we use advanced technology that can tell you your exact **longitude** and **latitude** location.

Words to Know:

Bearings
Latitude
Longitude

Materials:

Magnetic compasses with moveable bearings
(Magnetic compasses can be purchased from boat catalogs or lab supply catalogs. Price range \$7.50-\$20.00)
Nautical charts of the Hudson-Raritan Estuary
Topographic maps of the Hudson-Raritan Estuary
A road map of the surrounding area

Activity One:

- 1) Using maps and nautical charts set up your classroom to represent a portion of the Hudson-Raritan Estuary including three points of interest (eg. Sandy Hook Lighthouse, Statue of Liberty and South Street Seaport).
- 2) Set the **bearings** on your compasses. Let the needle on the compass find north, then set the drawn arrow on the plate of the compass over the needle. This establishes magnetic north. Next, set the bearings to 200 degrees. After moving the dial so that 200 degrees is on the line that says "read bearing here", move the compass until the needle and the arrow line up again. Then position yourself to face in the direction of the arrow that says "read bearing here." You are now bearing 200 degrees. Move five even paces bearing 200 degrees. Keep an even pace. Everyone should attempt to standardize their pace.

- 3) Start at one point in the estuary you have set up, and figure out your bearings and distance (paces) as you go from one point to another.

- 4) Divide into small groups. Each group should set up a series of three bearings with distances (paces) which represent actual locations in the Estuary according to their relative position and distance from each other. Each group will then give its directions to another group to follow to test their accuracy. At the end of the activity, a complete set of Hudson-Raritan Estuary courses will be accumulated.

Activity Two:

- 1) Charts included in the text of this section give the location of various points of interest within our Estuary. Use these charts to locate the approximate position of your three points of interest from Activity One.
- 2) As a group, brainstorm to determine the importance of each point of interest listed.

How High is High? How Deep is Deep?

- Objectives:**
- 1) You will read, interpret and recognize nautical charts and topographic maps.
 - 2) You will design a three-dimensional map based on nautical charts and topographic maps.

Background: A **topographic** map depicts the height of the land and land features. Topographic maps express land height in feet above sea level. This is indicated with contour lines. Contour lines are imaginary lines that, in the case of topographic maps, indicate land of the same height above sea level. Topographic maps also indicate the location of railroads, pipelines, points of interest, and other information pertaining to landforms.

A **nautical chart** indicates the shape and depth of the ocean floor. They relate water depth in feet or **fathoms**, with one fathom equaling six feet. Like a topographical map, nautical charts use contour lines. In the case of a nautical chart these lines indicate depths that are the same distance below sea level. Nautical charts also provide mariners with information on lighthouses, submerged structures, channel markers, and points of interest.

Words to Know:

Fathom
Nautical
Navigate
Topography

Materials:

Nautical charts of the Hudson-Raritan Estuary
Topographic maps of the Hudson-Raritan Estuary
A road map of surrounding area
A map of the continents
Corrugated cardboard
Tracing paper, Construction paper
Pencils, Scissors, Glue, String

Activity One:

- 1) Observe the differences of each map. Think about in what situations each map would be most useful.
- 2) Using tracing paper, trace the contour lines of a nautical chart and a topographic map of the same scale for the Hudson-Raritan Estuary. Cut out the traced contours, and retrace onto the corrugated cardboard. Cut the contours out of the cardboard. Place the cut cardboard contours onto a flat surface to recreate the section of the Hudson-Raritan Estuary being represented. The deepest section is flat surface, the first cut pieces set in place should represent the next highest

section, and so forth. The highest land elevation should be placed on last. Let the thickness of each cardboard piece represent 6 feet or one fathom.

- 3) Add colored construction paper to the surfaces of contours to distinguish between shallow water, deep water, sea level and land forms. Label landforms and bodies of water. Glue the contours in place.
- 4) Add at least 10 symbols that indicate land and water features. Use the key of your maps and charts to recreate these symbols.

Activity Two:

- 1) Imagine you are the captain of an oil tanker, **navigating** a full load of crude fuel oil to a refinery in Perth Amboy. Your ship sits 25 feet deep in the water. Using a nautical chart, plot a course to safely navigate from the Atlantic Ocean to Perth Amboy.
- 2) Note the various symbols on the chart. Create an imaginary log of your voyage from the ocean to Perth Amboy. Make a list of dangers encountered and how they were they safely avoided. List the locations of points of interest. Record each observation in your log book as if you were seeing it from the ship.

Discussion:

1. Discuss the difference between nautical charts, topographic maps, road maps, and world maps.
2. Describe the situations each map would be most useful for and why.

Extension:

Each student constructs a 3-dimensional representation of a different part of the Hudson-Raritan Estuary and watershed. All maps are constructed to the same scale. As each map is completed, they are assembled to represent a larger portion of the Estuary and watershed.

Where Does the Water Go?

- Objectives:**
- 1) You will be able to define and understand the hydrologic cycle.
 - 2) You will be able to define and construct a watershed.
 - 3) You will understand how the watershed affects marine pollution.

Background: Approximately 70% of the earth is covered by water and the amount of water in the earth's system changes very little over time. Where does water come from and where does it go? The answer to this question begins with understanding the **hydrologic cycle**, also known as the water cycle. We recycle paper, cans and bottles and the earth's ecosystem recycles water. Water evaporates from the earth's surface, rises into the atmosphere, condenses, and falls to the earth as rain. Once back on the earth's surface, the water may be taken up by plants or animals, sink into the ground, or flow into the nearest body of water (stream, lake, sewer, **aquifer**). Eventually, the water evaporates and condenses, falling to earth as rain in an ongoing cycle called the hydrologic cycle.

Just as gravity causes rain drops to fall to earth, gravity causes water to flow downhill. A water droplet that falls on land will move downward into and through the soil or along the ground until it reaches a stream, river, estuary or the ocean. The waterbody is a **basin**. The section of land which drains into a given body of water is that basin's watershed. The size of a **watershed** is related to the size of the drainage basin. A stream has a smaller watershed than an estuary. The watersheds of larger drainage basins like estuaries are made up of many smaller watersheds, and these smaller watersheds feed the streams and rivers that empty into the estuary. Water that flows over the land into a drainage basin is called runoff. During its downhill trip over the land into streams, rivers, estuaries, and eventually the oceans, water droplet pick up pollutants. Thus, human activities on land affect surrounding bodies of water.

Words to Know:

Aquifer
Basin
Drainage Basin
Hydrology
Hydrologic Cycle
Watershed

Materials:

A shallow pan
Aluminum foil
A three-dimensional map created for the "How High is High? How Deep is Deep?" activity and blocks **or** a few paper cups and blocks
A watering can
Topographic maps and nautical charts for the Hudson-Raritan Estuary
Drink mix or other powdery substance
Food coloring

Activity:

1) If you divided into groups for the activity "How

High is High? How Deep is Deep?" and constructed three-dimensional maps of the Hudson-Raritan Estuary, divide into those same groups to use the map your group constructed. Otherwise, divide into groups as directed. If you did not build the 3-D map you will be using paper cups and blocks for this activity.

2) Tear off a piece of aluminum foil the size of the pan being used. Place it over your 3-D model and mold the foil to conform to the contours of your map. Place this in the shallow pan and support it with the blocks so it does not fall over. If you did not construct a model, place paper cups and blocks in a shallow pan to represent the high and low points of a portion of the Hudson-Raritan Estuary. Place the foil over the blocks and use your hands to create valleys in a shape that represents the form of the portion of the Hudson-Raritan Estuary you chose to represent. When you are finished, you will have a model of a watershed.

3) Make it rain over your model with the watering can. Observe where the water goes. Sprinkle some

drink mix, a drop of food coloring or a powdery substance over the model to represent pollutants. Make it rain again, and observe what happens.

4) Place all models next to each other to represent a larger portion of the Hudson-Raritan Estuary. If possible, place all the models in the same pan or take them outside and staple them together so that one continuous model is formed. Sprinkle different colors of drink mix over the different parts of the model and make it rain again.

Discussion:

Discuss the direction in which the water runs when it rains on your model. Consider the following questions:

1. How do gravity and topography influence where water goes;
2. Discuss the role of the hydrologic cycle in the pollution of streams, rivers, and estuaries;
3. What happens to pollutants on land when it rains;
4. How is the size of a watershed related to the size of a drainage basin;
5. Which is larger, the watershed for the Raritan River or the watershed for the Raritan Bay, and
6. Is the Raritan River watershed part of the Hudson River watershed?

Extension:

Create a diagram indicating which watersheds of the Hudson-Raritan Estuary are part of other watersheds. Start with the largest watershed and work your way backwards to show which smaller watersheds are part of each larger watershed and how they are all connected.

Mapping the Ocean Floor

- Objectives:
- 1) You will be able to develop a better understanding of how scientists once mapped the bottom structure of underwater habitats.
 - 2) You will understand that it is possible to describe something you cannot see through the collection and correlation of accurate data.
 - 3) You will simulate how water body contours were mapped.

Background: Despite the fact that it is underwater, the ocean floor can be mapped by scientists. This activity demonstrates the old fashioned method of measuring depth by the use of a weighted, marked line. People lowered these lines into rivers, lakes and coastal waters to test depths. Presently depth sounders and sonar accomplish the same task more accurately and efficiently. Sonar sends impulses of sound downward and measurements of depth are determined by the length of time it takes the sound impulse to travel to the water body bottom and bounce back again.

Words to Know:

Contour Map
Sonar
Topography

Materials:

Large watertight Styrofoam coolers
Dark plastic garbage bag
Waterproof marker
Water (to fill the cooler)
Dark food coloring (blue or green)
Bricks, rocks, sand or gravel
Two strings
Two metal nuts or washers
Two meter sticks
Data sheets for each pair of students
Bucket or pan to bail out coolers

Activity:

- 1) Write north, south, east and west on the sides of the coolers so maps will have the same orientation.
- 2) Using the magic marker, draw lines one centimeter apart around the top of the cooler. Label with a,b,c's going north and south and 1,2,3's east to west across the coolers.
- 3) Modify and copy the attached data sheet to correspond to the size of your coolers.
- 4) Line the cooler with a dark plastic garbage bag and place a variety of objects (rocks, bricks, sand or gravel) inside the cooler to simulate a varied underwater terrain.

5) Once prepared, place the cooler on a table and fill with water and add food coloring.

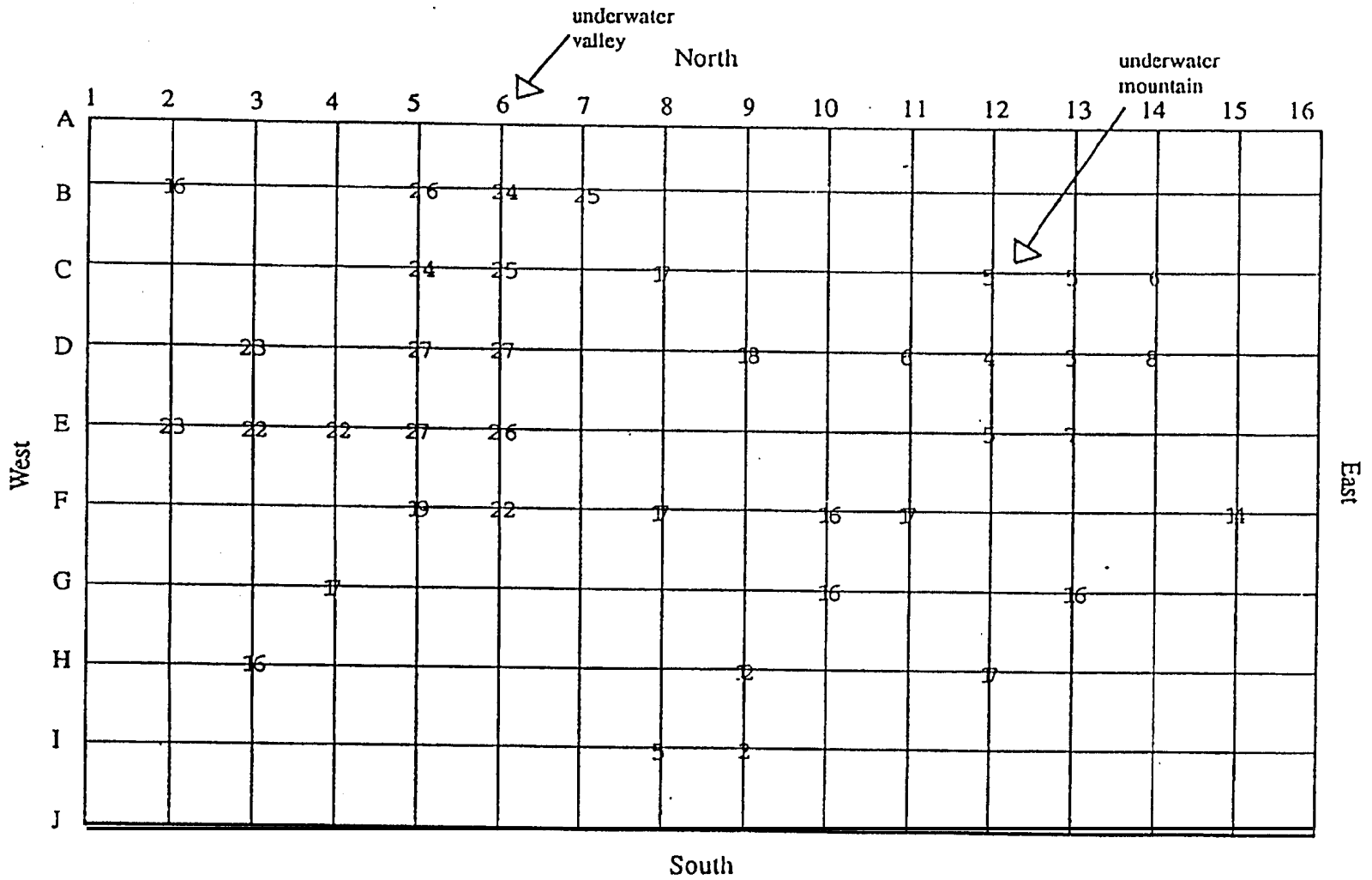
6) Using a length of string weighted with a washer at one end, take depth readings at predetermined coordinates by lowering the weighted string into the cooler until it touches the bottom surface. Coordinates are determined by laying the meter sticks across the marked cooler, perpendicular to one another.

7) After the string hits bottom, it is then measured and the resulting figure is placed at the corresponding coordinate on the work sheet. Take at least 15 measurements, entering the data on the work sheet as it is gathered.

Discussion:

1. Make predictions about your cooler bottom topography based on your 15 readings.
2. Create your own nautical chart by connecting the points of common depth.
3. After everyone's predictions have been made, empty the coolers. Compare the cooler's bottom to your own predictions.
4. How might you have made more accurate predictions? a more accurate **contour map**?

Write depth (in cm) next to the position where lines cross.



GEOGRAPHY OF THE HUDSON - RARITAN ESTUARY

USING TOPOGRAPHIC MAPS AND NAUTICAL CHARTS

TOPOGRAPHIC MAPS

Just as a globe is a model of the earth, maps are models of the places they represent. A topographic map is a line and symbol representation of natural and manufactured features on the Earth's surface plotted to a definite scale.

Map scale defines the relationship between distance on a map and the corresponding distance on the Earth. Scale is generally stated as a ratio in which the numerator (first number) represents map distance and the denominator (second number) represents a horizontal ground distance. Scale is graphically depicted on topographic maps by bar scales marked in feet and miles or in meters and kilometers. For example, a scale of 1:24,000 would mean that one inch on the map would represent 24,000 inches on earth (or 2,000 ft.).

Large-scale maps cover small geographic areas and are useful when detailed information on a particular location is needed. An example of a scale for a large-scale map would be 1:24,000. Small-scale maps cover very large areas and are useful for comprehensive views of a particular region. Examples of map scales on small-scale maps include 1:250,000, 1:500,000, or 1:1,000,000.

The National Mapping Program of the United States Department of Interior Geological Survey produces the standard topographic map series. Each map in the U.S. Geological Survey series conforms to established specifications for size, scale, content, and symbolization. The unit of survey for standard topographic maps is the quadrangle. Each quadrangle is defined by parallels of latitude and meridians of longitude. Quadrangles are named after a city, town, or prominent natural feature within the area mapped. Standard edition topographic maps produced for New Jersey are published at a scale of 1:24,000 (1 inch = 24,000 inches or 2,000 feet) in a 7.5 x 7.5 minute format. This means that these quadrangles cover 7.5 minutes of latitude and longitude. Other quadrangles covering 15 minutes of latitude and longitude are published at a scale of 1:62,500 (1 inch = 62,500 inches or 1 mile). In addition, a few special maps are published at other scales.

Topographic maps give as complete a picture of the terrain as can be legibly produced in mapped form. Topographic maps show the location and shape of mountains, valleys, and plains, the networks of streams and rivers, and the principal manufactured features of the area depicted. A distinguishing characteristic of a topographic map is the portrayal of the shape and elevation of the terrain by contours. Contours are imaginary lines which follow the land surface or the ocean bottom at a constant elevation above or below sea level. The contour interval is the elevation difference between adjacent contour lines. The contour interval is chosen on the basis of the map scale and the local relief. Contour intervals differ with the scale of the map and the relief of the area mapped. For example, a small contour interval is

used for flat areas whereas larger intervals are used for mountainous terrain.

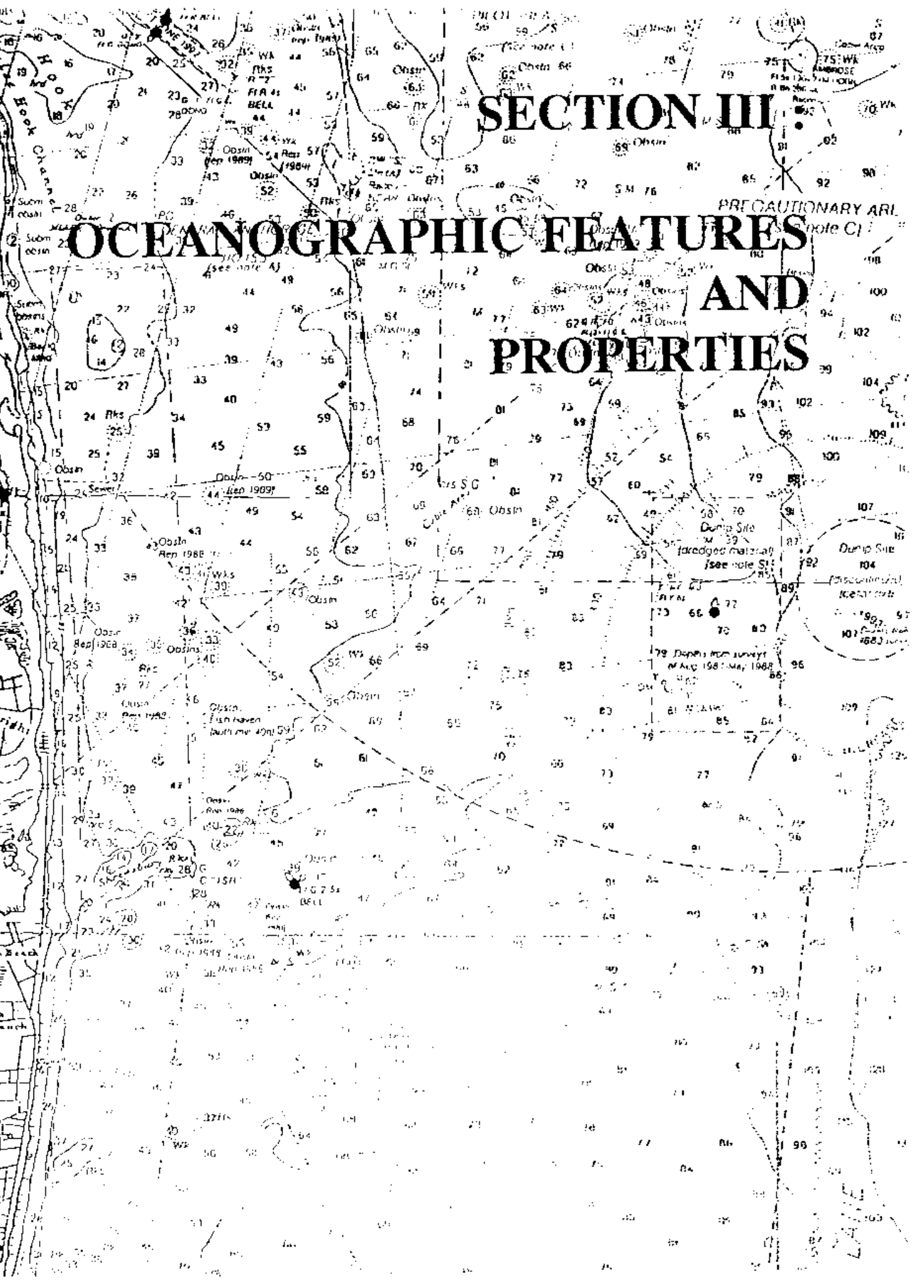
The physical and cultural characteristics of an area depicted on a particular topographic map are determined by engineering surveys and field inspections. These features are recorded on topographic maps in a convenient, readable format using standardized symbols. Color helps distinguish categories of features. Manufactured features are printed in black, water features are printed in blue, road classifications, urban areas, and U.S. land lines are red, woodlands and other vegetated areas are shown in green, and contour lines are printed in brown.

Topographic maps have many uses. They are an essential part of terrestrial ecological studies, geologic research and water quantity and quality studies. They may also be used in flood control, soil conservation, and reforestation projects. Topographic maps are extremely useful for studying marine environments. They depict details about shorelines including the extent of wetlands or shoreline development and the approximate mean high water line. They also provide the types and locations of prominent coastal features like seawalls, breakwaters, jetties, piers, or wharves. In addition, topographic maps reflect local bathymetry including water depth depicted by depth curves based on soundings and other bathymetric features like areas exposed at low tide, the locations of channels, sunken rocks, rocks awash and exposed wrecks.

SECTION III

OCEANOGRAPHIC FEATURES AND PROPERTIES

PRECAUTIONARY AREA (see note C)



OCEANOGRAPHIC FEATURES AND PROPERTIES

OCEANOGRAPHIC FEATURES

The Hudson-Raritan Estuary connects with the ocean at the Sandy Hook-Rockaway Point transect and Hell's Gate. Water elevation varies at these ocean boundaries and within the Estuary itself. Factors influencing these variations include both predictable astronomical tides and wind driven meteorological tides.

The major freshwater input to the system originates in the Hudson River Basin, which discharges through Upper New York Bay, at the Verazzano Narrows into Lower Bay and continues onto the New Jersey coast and the Atlantic Ocean. A portion of the discharge through the Narrows moves southwesterly along Staten Island into the easterly area of Raritan Bay. Exact conditions at any time and location are dependent on the key factors of freshwater inflow and the tidal motion, which affect the degree of mixing.

There is a net outflow of lower salinity surface waters and an inflow of higher salinity waters along the bottom of the Estuary due to tides. Both tidal dispersion and circulation contribute to the differences of salinity in any given area of the Estuary. This two-layer circulation pattern provides the Estuary with a far greater flushing rate than would be the case if circulation were in a seaward direction due to freshwater discharges only.

Salinity differences in the Hudson-Raritan Estuary are typical of a partially mixed estuary. Throughout most of the year, the Hudson-Raritan can be classified as a partially mixed, moderately stratified estuary.

Circulation in the Hudson-Raritan Estuary can be understood by separating it into two parts; tidal circulation driven by the astronomical tides at the ocean boundaries and a residual or net circulation which is the average circulation over one or more complete tidal cycles. The reversing tidal currents serve to move water over distances of about 5 to 10 kilometers on either a flood or ebb portion of a tidal cycle. The net displacement over a complete tidal cycle is the major factor that determines exchange and renewal of the Estuary. This average or residual circulation is as variable as are tides, winds, and freshwater discharges. The key point is that the residual currents by themselves fail, in general, to predict the transport pattern through the Estuary.

Residual tidal circulation, combined with the residual or net circulation driven by other mechanisms, affects the transport of contaminants through the Estuary, and exchanges the estuarine waters with adjacent coastal ocean waters. These forces also flush and renew the waters of the Estuary. The net or residual circulation is of primary concern, from the viewpoint of water quality. If the Lower Hudson River, Raritan Bay, Upper Bay, and Lower Bay were dependent only on freshwater inflow for their renewal, then residence time for these waters would be about three to six months during low flow conditions in the Hudson. The actual residence time is more nearly one to two weeks, which is testimony to the vigor of the residual circulation arising from the interplay of the tidal, wind, and freshwater discharge processes of the Estuary.

Circulation which arises from regional wind blowing over the adjacent continental shelf water is called meteorological tides. Meteorological tides can cause substantial exchange of estuarine and ocean waters, especially when storm surges occur. These surges can inundate low-lying land. Variable local winds over the Estuary also produce changes in circulation patterns within the Estuary. This is most evident in Raritan Bay, which is broad and relatively shallow.

The last major force in estuarine circulation is freshwater discharge. The difference in density between the freshwater entering at the upstream limits of the Estuary and seawater at its downstream limit drives vertical and horizontal residual circulations which increase net transport and exchange of water through the Estuary.

PROPERTIES OF LOCAL WATERS

Currents and tidal action move water within the Estuary, causing water quality conditions in one area to influence conditions in other areas. Tributary and adjacent water bodies also affect conditions in the Estuary. These include the Middle Hudson, Hackensack, Raritan, Passaic, Rahway, and South Rivers, Western Long Island Sound and adjacent ocean waters of the New York Bight.

With each rainfall, pollutants such as fertilizers, pesticides, pet wastes, oil, and grease are washed from lawns and streets into storm drains that flow into streams, rivers, the Estuary and eventually the ocean. Known as nonpoint source pollution, this process degrades coastal water quality and can result in negative impacts to aquatic life and habitat quality within the system.

When materials such as sand, dirt and other fine particles become suspended in water, clarity is reduced making the water turbid. The clarity or transparency of marine and estuarine waters is of prime importance. Since photosynthesis is confined to the sun-lit upper layers of marine ecosystems, light penetration is of great importance for primary productivity. In the marine environment, absorption and scattering of light causes rapid loss. This loss of light is further accelerated by turbidity or particles suspended in water.

Materials contributing to turbidity are varied. In the summer, turbidity may be due to plankton. Plankton grows and multiplies rapidly in warm, sunlit, nutrient rich water, giving the water a cloudy appearance. During periods of heavy runoff, silt-laden surface water flows into the Bay. Wind-generated waves, boat wakes and waves breaking on shore also stir up sediments contributing to turbidity.

In addition to turbidity, other measurable properties of water include temperature, salinity, dissolved oxygen, and pH. These four basic properties influence the biological, physical and chemical processes that occur in the Estuary.

Water temperature exerts a strong control over the distribution and activities of marine organisms. For example, some species of phytoplankton will grow more rapidly under certain temperature conditions.

pH is a measure of how acidic or basic (alkaline) a solution is. Pure water has a neutral pH of 7.0. When pH is less than 7.0, water is said to be acidic. When the pH is greater than 7.0, water is basic or alkaline. A pH of 6.5 to 9.0 is generally accepted as the range necessary to support survival of marine organisms. The pH of sea-water normally ranges from 7.5 to 8.4. Fluctuations in pH can occur in association with photosynthesis and bacterial activity. In bright light, photosynthesis can raise the oxygen content appreciably and the resulting withdrawal of carbon dioxide from the water raises pH. Diminished oxygen, increased carbon dioxide, and reduced pH may result from the rapid bacterial decomposition of detritus. Events in a watershed that may affect pH include increased leaching of soils or mineral outcrops during heavy precipitation, human activities including accidental spills and agricultural runoff of pesticides, fertilizers, soil leachate and sewer overflow. Seawater is resistant to fluctuations in pH due to the carbonate

dissolved in the water, which acts as an acid buffer in marine systems.

Dissolved oxygen at the proper level is one of the most critical factors for maintaining aquatic life. It is essential for all plants and animals inhabiting the water of the Estuary. When oxygen levels in the water fall below 3-5 parts per million (ppm), fish and many marine organisms cannot survive. Oxygen levels are influenced by chemicals present in the water and biological activity. The amount of dissolved oxygen available in a water body is also directly related to temperature. Dissolved oxygen depends on the balance between the respiration demands of organisms present in the water, bacterial decomposition, and the addition of oxygen from the atmosphere and the photosynthetic activity of plants. Oxygen depletion is a significant event that can occur as a result of nutrient pollution and excessive phytoplankton production (i.e., algal blooms) and may result in mass killings of fish and shellfish in coastal waters if the reduced level of dissolved oxygen is prolonged.

Salinity is a key factor affecting the physical make-up of coastal waters. It refers to the concentration of dissolved salts in the water, usually expressed in parts of salts per one- thousand parts of water or parts per thousand (ppt or ‰). Freshwater contains few salts (drinking water usually has a salinity of less than 0.5 ppt), while seawater averages 35 ppt. In estuaries, salinity changes with the tides and freshwater input. Since seawater enters bays through the inlets, salinity is highest at that point and decreases as one moves away from the inlet. Salinity decreases in the spring when rainfall and groundwater cause increases in freshwater inflows. In the fall, when freshwater inflows are reduced, salinities increase as more salt water penetrates further into the Estuary.

Salinity generally increases with depth since the presence of salts increases water density and lighter, less saline water tends to remain at the surface. The relationship between depth and salinity is not constant. If a bay is shallow, winds and tidal action can cause mixing and salinity would become the same throughout that water column. Perhaps the most important aspect of a bay's salinity regime is its effect on the distribution of the various biological populations living in the bay. Different species have different salinity tolerance ranges. Those that are euryhaline can tolerate a wide range of salinities and may be found throughout the Estuary. Species that are stenohaline can only live in a very narrow salinity range and are confined to a relatively small area of the Estuary.

Sediments of the Hudson-Raritan Estuary

Words to Know:

Siltation

Coring

Hypothesis

Materials:

For this activity you will need 4 glass cylinders, 4 large jars with lids, stop watch, prepared sediments, an aluminum roasting pan, over flow basin, and clear plastic tubing.

Activity One:

The students collect a wide range of sediments ranging in size from fine sand to pebbles. After collecting, they make predictions as to which type of particle will sink fastest when dropped in water. Using a stop watch, they record the time it takes for particles to fall and settle to the bottom. Using the large jars for the second part of the activity, the students create a mixture of particles in each jar. Once filled with water, the jars are inverted and observations are made as to what happens.

Activity Two:

Students learn about the sampling technique, coring, by actually forcing a tube through sedimentary layers. Making predictions beforehand the students learn if the hypothesis they made was right.

Reading A Tide Chart

Words to Know:

Navigation

Semi-diurnal tides

Neap tide

Spring tide

Materials:

In this activity you will need a tide chart (supplied), flashlight, index cards labeled: full moon, quarter moon, new moon, spring tide, neap tide; two students to represent the earth and the sun; one student per labeled index cards.

Activity:

Using the tide chart, the students answer questions about the tides in the first part of this activity. For the second part, using the labeled index cards, the students demonstrate the phases of the moon that give us the different tides.

Ocean Currents

Words to Know:

Upwelling

Downwelling

Materials:

For this activity you will need a 2-liter soda bottle (cut off at the shoulder to make a wide-mouth container), one large ice cube colored dark blue, hot water colored red, tap water, plastic-foam cup, blue and red colored pencils, and unlined paper.

Activity:

The students fill a 2-liter bottle half full with tap water. A blue ice cube is floated in it and using unlined paper the students sketch their observations. Using a plastic foam cup containing hot water with red food coloring in it, the cup is poured slowly down the side of the 2-liter bottle. The changes are added to the drawing. For an extension, this experiment is repeated using very salty water and observations are made and differences noted.

Turbidity

Words to Know:

Benthic

Runoff

Materials:

For this activity you will need a water sampling kit, Secchi disk, three or four hydrometer jars (optional), water (optional), soil, sand, clay, rocks (all optional), clock with second hand (optional).

Activity:

In this activity students will measure the turbidity of the water using a secchi disk. This is done by lowering the disk with a calibrated line, into the water until it disappears, reading the measurement, and recording the depth. This leads to a discussion on why turbidity is important.

Salinity

Words to Know:

Hydrometer

Meniscus

Refractometer

Specific gravity

Materials:

For this activity you will need water, salt, hydrometer, hydrometer jar, salinity conversion table, two pans, two eggs, thermometer, eye dropper (optional) and refractometer (optional).

Activity:

In this activity students place two pans on a table, one with fresh water and one filled with very salty water, putting an egg in each pan they observe what happens. Using the hydrometer jar filled with salty water the students obtain a temperature and a hydrometer reading. This process is repeated using fresh water. A comparison is made. After that a variety of objects are experimented with to see what sinks and floats.

pH

Words to Know:

SAV
buffer
reagent

Materials:

For this activity you will need a water sample freshly drawn, LaMotte pH colorimetric test kit, chemical waste receptacle, and hand-held pH meter (optional).

Activity:

In this activity students take a freshly drawn water sample to measure pH. This leads to a discussion on acid rain and how it can cause problems for the Estuary and surrounding region. The method and test kit used in this activity are the same ones that are used by field scientists.

Oxygen in the Water

Words to Know:

Colorimetric
Diffusion
Phytoplankton
Photosynthesis

Materials:

For this activity you will need a LaMotte Winkler-Titration test kit, LaMotte Oxygen in the Water test kit, bucket, thermometer, water sample, and a chemical waste receptacle.

Activity:

Students in this activity measure dissolved oxygen in the water by two methods using two different test kits. It is important to obtain fresh samples. These tests can be done in the field, making sure the students are familiar with all test equipment beforehand.

Sediments of the Hudson-Raritan Estuary

- Objectives:**
- 1) You will be able to investigate and analyze the natural patterns of sedimentation in the Hudson-Raritan Estuary.
 - 2) You will learn about coring, a sampling method that is used to study sediment.
 - 3) You will observe how heavier particles sink faster than finer particles in an estuary.

Background: Sediments collect as particles, settling slowly to the bottom, varying in composition depending on location. The sediments of the Hudson-Raritan Estuary are the product of materials, principally minerals and rocks derived from various upland sources, delivered by rivers and streams. Particles of sediment are also carried into the Estuary from the ocean's tidal currents. The sediments found in the Hudson-Raritan Estuary can be made up of very fine particles consisting of silt and clay. Since fine particles remain suspended in the water column longer than larger, denser particles, the particles are carried up into the tidal creeks, collecting as marsh mud or finely grained shorelines. Other factors that influence where sediments are deposited are waves, tides, weather conditions, wind and artificial structures such as jetties, groins and bulkheads.

Words to Know:

Siltation
Coring
Hypothesis

Materials:

Clear Cylinders
Large Jars with lids
Stop Watch
Prepared Sediments
Aluminum Roasting Pan
Over Flow Basin
Clear Plastic Tube
Watering can

Activity One:

- 1) Collect a variety of sediments ranging in size from pebbles to fine sand. Arrange the particles in separate piles and predict which particles will sink the fastest when dropped in water. Using a stop watch and a clear container of water, record the time it takes for each different type of particle to fall to the bottom of the container.
- 2) Based on your findings predict what will occur when a mixture of particles are placed in a container of clear water. Using large jars with lids, create a "sediment mix" in each jar. Fill jar slowly with water. When the sediments have settled invert the jars and observe the action.

Discussion:

1. Discuss the relationship of **siltation** rates from your activity and what effects it might have on the Hudson-Raritan Estuary.
2. How do sedimentation rates affect the composition of various locations within the estuary?
3. What factors (human and natural) influence the layering of sediments?

Activity Two:

In order to study and analyze bottom sediments scientists utilize a process known as coring. By forcing a pipe through sedimentary layers, a sample core can be extracted, representing sediments in the order in which they were deposited.

- 1) Using a large aluminum roasting pan set up on an angle, build an estuarine sediment deposit by placing at least three different types of sedimentary materials in separate piles at the top of the pan. Using a source of water that you can regulate, slowly water each pile, one at a time, moving them down to the bottom of the pan. Be sure the pan is placed in a larger basin to allow for waste water overflow. Continue moving sediment until the sample is complete.
- 2) Predict how you think the layers have settled.
- 3) To test your **hypothesis**, take samples using this simple coring method. Using a clear plastic

tube, carefully insert the tube into the drained sediment. This method should yield a core. Observe the layers within the tube. Did you make a correct prediction?

Reading a Tide Chart

- Objectives:**
- 1) You will learn how to read and interpret tide charts.
 - 2) You will use information contained in tide charts to plan and predict marine-related events.

Background: Tide charts are used to determine at what time of day the two high or low tides will occur in a specific location on a daily basis. A tide chart posts the projected time for daily high and low tides, based on the effects of the phases of the moon, the position of the sun and observed local changes. Tidal predictions assume average weather conditions, so actual tides may deviate during extreme weather situations. Tides are an important phenomenon. They affect **navigation**, replenish sea life, and assist in keeping coastal areas like the Hudson-Raritan Estuary clean. The ability to read tide charts becomes important if you plan to work or recreate in coastal areas. To find a tide chart look in the local newspaper or check with a local marina.

Words to Know:

Navigation
Semi-diurnal tides
Neap tide
Spring tide

Materials:

Tide Chart
Flash Light
Index cards labeled: full moon, quarter moon, new moon, **spring tide**, **neap tide**.
Two students: 1-Earth, 1-Sun
One student: 1-moon chosen by the labeled cards.

Activity One:

- 1) Using the given tide chart, look at one month of your choice, use the information to answer the following questions.
 - a) What is the relationship in time between the two daily high tides?
 - b) What is the relationship in time between the two daily low tides?
 - c) Compute the average time lapse between high and low tide?
- 2) There are two high tides and two low tides each day in the Hudson-Raritan Estuary. These are known as semi-diurnal tides. The rule of thumb for high tides is that they occur 12 hours and 25 minutes apart. This is because the moon passes the same spot on the Earth every 24 hours and 50

minutes. If the morning high tide arrives at 8 a.m. it will occur at **8:50** a.m. tomorrow morning. The same is true of low tides.

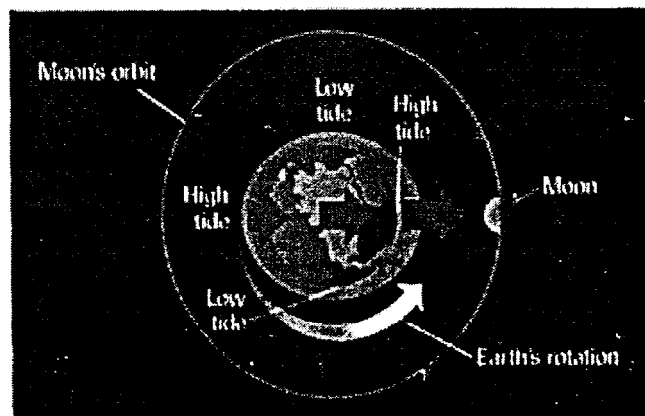
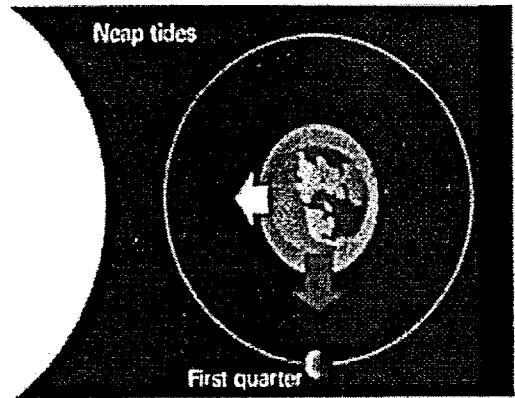
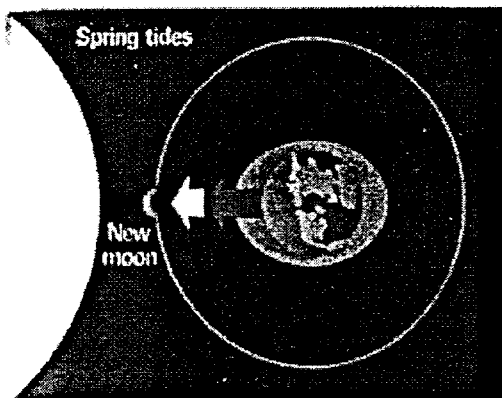
Using a tide table look at the morning tides and answer the following questions.

- a) What date will the morning high tide appear just after sunrise?
- b) When is the next high tide?
- c) Calculate the difference between the high tides.
- d) What is the time difference between the morning high tide and the next low tide on the date you chose.

Activity Two:

The moon's gravity pulls on Earth's near side more than it pulls on Earth's far side, because gravity depends on distance. These forces tend to create two bulges in Earth's oceans. One bulge is on the near side of the Earth, the other is on the far side. As Earth rotates, a coastline approaching a bulge has a high tide. Between the bulges, coastlines have low tides. The sun's gravity also contributes to the tides. Twice each month, at new moon and full moon, the sun and moon combine their gravity to produce very high tides and very low tides. At the first quarter and the third quarter phases, the sun and moon are not working together, and there is a smaller difference from low to high tide. These smaller-than-average changes are called neap tides. Neap tides occur at the first quarter and third

quarter phases. Spring tides occur at new moon and full moon. We can only see that part of the moon which is facing the sun. If the sun is shining on the half moon that we see, we call it a full moon. If the moon is between the earth and the sun making it difficult to see, we call it a new moon. The following activity will demonstrate the phases of the moon. Acting as the earth, one student will be assigned a position in the center of the classroom. Holding a light source, another student will be positioned to act as the sun. The balance of the class will then, one by one, draw prepared cards. The cards will say full moon, quarter moon, new moon, neap or spring tide. Acting as the moon, each student will see if he or she can assume the proper position as assigned by the card, for example, if the student has drawn the full moon card, the student would position themselves facing the earth on the side opposite the sun.



Ocean Currents

- Objectives:
- 1) You will investigate how temperature differences in waterbodies causes currents.
 - 2) You will have a better understanding of density as it relates to water.
 - 3) You will better understand the impact of human actions on the marine environment.

Background: Currents are like giant rivers of water flowing through a given waterbody. Some flow on the surface, while others move huge amounts of water deep in the ocean. Currents are fueled by winds, heat, water density and the gravitational pull of the sun and the moon. Winds are caused by the accumulation of energy generated by the sun. As winds push across water, friction creates waves. Winds that push up against waves are the driving force behind surface currents. Currents formed by temperature start in the ocean's colder regions, (i.e. earth's polar areas) and move slowly across the sea floor towards land. When they run into a land mass or converge with another current they rise to the surface. When the cold water is forced to the surface it sinks down since it is heavier. The water or current then moves sluggishly towards warmer water at the equator. Gradually, these once chilly waters work their way back to the surface, replacing new, cold surface water that sinks. This **upwelling** and **downwelling** carries all sorts of interesting life with it including plankton and other marine creatures. Like cold water, salt water is denser than fresh, so it sinks when it encounters fresh waters causing currents. This is the case in the bays of the Hudson-Raritan Estuary. Fresh water from rivers converge with salty, colder ocean water. The ocean water sinks, causing vertical currents that continuously mix the water. Currents keep the Estuary's waters mixed constantly, carrying and supporting a myriad of marine organisms.

Words to Know:

Upwelling
Downwelling

Materials:

2-liter soda bottle (cut off at the shoulder to make a wide-mouth container)
One large ice cube colored dark blue
Hot Water (colored red)
Tap Water
Plastic-foam Cup
Blue- and Red pencils
Unlined Paper

Activity:

- 1) Fill a 2-liter bottle about half full with tap water. Float a blue ice cube in it. Use unlined paper to sketch your observations.
- 2) Obtain a plastic foam cup containing hot water with red food coloring in it. Be careful not to spill the hot water. Slowly pour the hot water down the side of the 2-liter bottle.
- 3) Allow the 2-liter bottle to sit as you continue to

observe. Add any changes you observed to your drawing.

Discussion:

1. Keeping in mind the poles and the equator, how does this experiment explain the flow of some ocean currents?
2. Write a simple explanation of how the temperature of water is one cause of ocean currents.

Extension:

1. Repeat this experiment with a blue ice cube made with very salty water. Drop into a 2-liter bottle half full of fresh tap water. Sketch your observations.
2. Add moderately salty water to this mixture. You may want to tint this water red before slowly pouring it down the side of the 2-liter bottle. Once again, observe and sketch your observations.

Turbidity

- Objectives:**
- 1) You will be able to measure the turbidity of the water.
 - 2) You will be able to identify possible environmental complications caused by excess turbidity.

Background: Turbidity or cloudiness in the water is caused by suspended solid matter which scatters light passing through the water. There are many possible sources of turbidity. Most people think primarily of sediment from disturbed or eroded soil and **runoff** as sources of turbidity. Microscopic plankton also contribute to high turbidity when their numbers are increased due to excess nutrients. Apparent water color, microscopic examination and streamwalk observations can help determine the sources of turbidity. In addition to blocking out the light needed by submerged aquatic vegetation (SAV) and burying eggs and **benthic** creatures, suspended sediment can carry nutrients and pesticides throughout the water system. Suspended particles near the water surface also absorb additional heat from sunlight, raising surface water temperature.

Words to Know:

Benthic
Runoff

Materials:

Water sampling kit
Secchi disk
3 or 4 hydrometer jars (optional)
Water (optional)
Soil, Sand, Clay, Rocks (optional)
Clock with second hand (optional)

Activity:

- 1) Attach a secchi disk to a calibrated line. Lower the disk into the water until it just disappears. Record the depth of water from the surface to the disk. If the secchi disk reaches the bottom before disappearing, the secchi depth is greater than the water depth and cannot be accurately measured. When this occurs, a notation must be added to the secchi depth reading in your data.
- 2) Slowly raise the disk until it reappears. Record this depth.

Discussion:

1. Very clear water, typically found in the open ocean, supports only sparse plant and animal life. With that in mind, what might low levels of turbidity indicate?

2. What environmental complications might be indicated by a high turbidity environment?

Extension:

- 1) Fill 3 or 4 hydrometer jars with water. To each jar, add a different type of sediment, for example, sand, rocks, clay or soil.
- 2) Mix the jars well and time how long it takes for the sediment to settle down below a predetermined point in the hydrometer jar.
- 3) Discuss the effects different types of sediment might have in the estuarine waters.

Salinity

- Objectives:**
- 1) You will be able to determine the salinity of a water sample by using a hydrometer.
 - 2) You will understand how salinity affects when an object will or will not float in water.

Background: Salinity is the total of all salts dissolved in water. Salt water is more dense (heavier per unit of volume) than fresh water. Salinity is usually expressed in “parts per thousand” (ppt). In an estuary, the flow of fresh water from streams and rivers mix with salty ocean water, producing salinity ranging from 0 to 35 ppt. The salt content of water can cause currents and affect the distribution of animal and plant species according to the amount of salinity they can tolerate. Salinity may be calculated by measuring the specific gravity of a sample of water using a **hydrometer**, correcting for the effect of temperature and converting the readings to salinity by means of a salinity conversion table.

Words to Know:

Hydrometer
Meniscus
Refractometer
Specific gravity

Materials:

Water
Salt
Hydrometer jar
Hydrometer
Salinity conversion table
2 pans
2 eggs
Thermometer
Eye dropper (optional)
Refractometer (optional)

Activity:

- 1) Place two pans on a table, one filled with fresh water and the other filled with very salty water. Place an egg in each pan. Note what happens.
- 2) Fill the hydrometer jar with salt water and obtain a temperature reading. Remove the thermometer and place the hydrometer in the hydrometer jar.
- 3) Wait until the hydrometer stops bobbing. Be sure that your eye is even with the water level in hydrometer jar, not the **meniscus**, because viewing down or up at an angle can give an inaccurate reading. Read and record the specific gravity. Use the conversion tables that came with your

hydrometer to determine the salinity of your sample.

- 4) Repeat this procedure with fresh water.

Discussion:

1. Why did the eggs behave the way they did when placed in the pans of water?
2. How might the different seasons effect the salinity of the oceans and the estuaries?

Extension:

- 1) After obtaining a salinity measurement from the hydrometer, use a refractometer to create a comparison between the two readings. Discuss how the readings may be similar or different.
- 2) Attempt to float or sink a variety of objects in salt water after making predictions of what will sink or float.

pH

- Objectives:**
- 1) You will be able to test the pH level of a water sample.
 - 2) You will understand the dramatic effect the pH level can have on a waterbody.

Background: The pH test is one of the most common analysis in water testing. An indication of the sample's acidity, pH is actually a measurement of the activity of hydrogen ions in the sample. pH measurements run on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acids. Solutions with a pH of 7.0 to 14.0 are considered basic. In a lake or pond, the water's pH is effected by its age and the chemicals discharged by communities and industries. Most lakes are basic when they are first formed and become more acidic with time due to the build-up of organic materials. As the organic substances decay, carbon dioxide forms and combines with water to produce a weak acid called carbonic acid. Large amounts of carbonic acid lower the water's pH. A range of pH of 6.5 to 8.2 is optimal for most organisms. Most fish can tolerate pH values of 5.0 to 9.0. Rapidly growing algae or **SAV** remove carbon dioxide from the water during photosynthesis. This can result in a significant increase in pH levels. The pH of salt water is not as vulnerable as the pH of fresh water to acid wastes. This is because the different salts in sea water tend to **buffer** the water. Normal pH values in sea water are about 8.1 at the surface and decrease to about 7.7 in deep water. Shellfish and algae are generally more sensitive than fish to large changes in pH, so they need the sea's relatively stable pH environment to survive.

Words to Know:

SAV
Buffer
Reagent

- 4) Insert both tubes into the color comparator. Facing a source of natural light, match the sample color to a color standard.
- 5) The color corresponds with a number and that number will be the pH value of the sample.

Materials:

Water sample (freshly drawn)
LaMotte pH Colorimetric test
Chemical waste receptacle
Hand-held pH meter (optional)

Discussion:

1. Using a hand-held pH meter, compare the results with the wide range colorimetric pH test.
2. Use the topic of pH to discuss acid rain and the problems it causes in the Estuary and the surrounding region.

Activity:

- 1) The pH measurement must be made in the field or from a freshly drawn sample. The pH of a bottled sample will quickly change due to biological and chemical activity in the sample container.
- 2) Using the LaMotte pH colorimetric test, rinse and fill two sample tubes with water to the mark. Cap one tube and use it as the blank.
- 3) To the second tube, add ten drops of the **reagent**. Cap the tube and invert gently several times to mix the solution.

Oxygen in the Water

- Objectives:**
- 1) You will be able to use a test kit to measure dissolved oxygen in a water sample.
 - 2) You will be able to determine if the dissolved oxygen level is reflective of a healthy system.
 - 3) You will understand that it is possible to describe a process that you cannot see by taking measurements of dissolved oxygen in a water sample.
 - 4) You will develop an understanding of how oxygen enters and exits the water.

Background: A large percentage of all the oxygen we breathe is manufactured by green plants. A total of three-fourths of the earth's oxygen supply is produced by **phytoplankton**. Oxygen is a necessary component of life to virtually every living creature on this planet. Commonly, we think of oxygen as being the air that surrounds us, but then how would aquatic creatures get the oxygen they need to survive? Oxygen gets into the water by **diffusion** from the surrounding air, by tumbling over falls and rapids, and as a bi-product of **photosynthesis**. The oxygen in water is dissolved oxygen. The two test kit procedures described below will yield results of varying degrees of accuracy. The LaMotte Oxygen in the Water Test Kit is a **colorimetric** test kit which allows for only a broad generalization of the level of dissolved oxygen in a water sample. The LaMotte Winkler-Titration Test Kit offers much more accurate results, in the range of 0.2 ppm (parts per million).

Words to Know:

Colorimetric
Diffusion
Phytoplankton
Photosynthesis

Materials:

LaMotte Winkler-Titration Test Kit
LaMotte Oxygen in the Water Test Kit
Bucket
Thermometer
Water sample
Chemical waste receptacle

Activity:

1) Obtain a water sample, ideally one that has just been pulled from the source under investigation. Follow the procedures as outlined below for the dissolved oxygen test kit selected:

LaMotte Winkler-Titration Test

1. Rinse sample bottle 3 times
2. Obtain an air-tight sample by submerging the sample bottle fully under the water and slowly allowing the water to fill the bottle. Cap the bottle underwater.

3. When you are ready to do the test, uncap the sample bottle, making sure that the plastic cone from the cap stays in the cap (this displaces the proper amount of water to allow room for the chemicals that are about to be added to the sample. Please keep the plastic cone in the cap at all times).
4. Add **8 drops of Manganous Sulfate Solution** (pinkish solution) and **8 drops of Alkaline Potassium Iodide Azide Solution** (same size bottle, clear solution).
5. Cap the sample bottle and mix by inverting several times. A precipitate will form.
6. Place bottle in an undisturbed area and allow precipitate to settle below the shoulder of the bottle (approximately 5 minutes).
7. Add **8 drops of sulfuric acid** (clear solution with red cap).
8. Cap and gently shake until precipitate is completely dissolved.
9. Fill titration tube (glass bottle with the cap with the hole in top) to the 20 ml mark.
10. Fill the direct reading titrator (syringe) with **Sodium Thiosulfate**. When filling the direct reading titrator, the upper part of the black rubber stopper should be even with the zero mark. Make sure that there are no air bubbles in the column.

11. Insert the direct reading titrator into the center hole of the titration tube cap.

12. Add 1 drop of Sodium Thiosulfate and gently swirl the tube. Continue one drop at a time until the yellow-brown color is reduced to a very faint yellow. The term “very faint” is subjective. It is helpful to bring a piece of white paper with you to hold the sample up against to determine the “faintness” of the color.

13. Remove the titration tube cap, being careful not to disturb the plunger.

14. Add **8 drops of Starch Indicator Solution** and gently swirl.

15. Replace the titration tube cap.

16. Continue adding **1 drop of Sodium Thiosulfate** and swirling until the blue solution turns clear.

17. Read the test result where the plunger tip meets the scale. Record dissolved oxygen in parts per million (ppm) .

LaMotte Oxygen in the Water Test Kit

1. Collect the water sample as described above.

2. Fill the vial to overflowing with the water sample and cap underwater.

3. Add *two Dissolved Oxygen Tablets* and cap. The water will overflow the vial. Make sure that there aren't any air bubbles in the sample.

4. Gently invert until the tablets have dissolved.

5. Wait 5 minutes for full color development.

6. Facing a source of natural light, hold the vial flat against the white section of the ColoRuler. Match the sample color to a color standard.

7. Record the oxygen level as zero, low or high.

Discussion:

1. How could overfertilization of water plants deplete the dissolved oxygen levels?

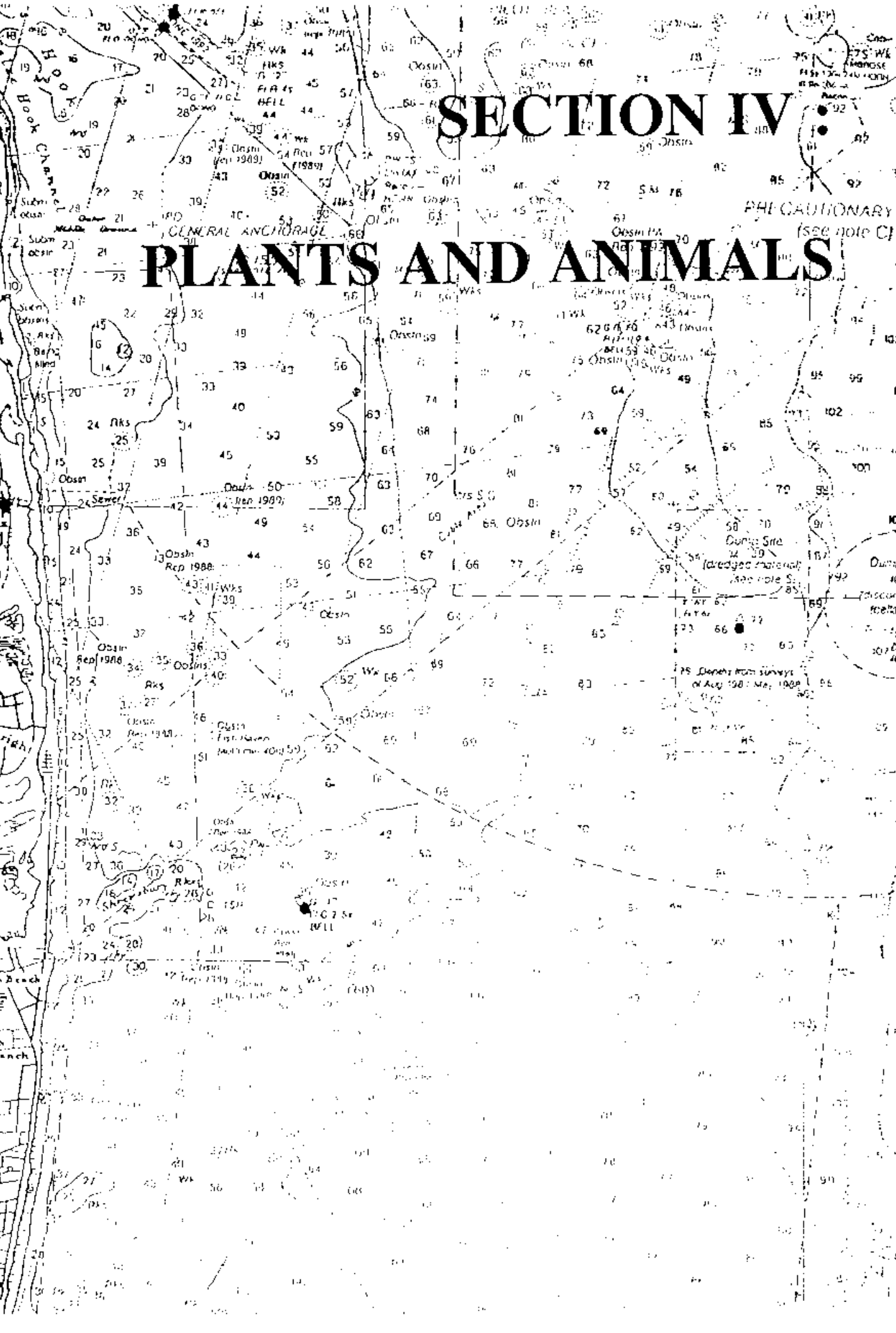
2. Overall, how would an algal bloom effect the environment? What would happen to the other life in the water?

Extension:

1) Obtain a dissolved oxygen meter, or readings from a meter and use the test kits to measure for accuracy.

SECTION IV

PLANTS AND ANIMALS



PLANTS AND ANIMALS

PLANTS

PHYTOPLANKTON

Phytoplankton make up 99% of all plant life in marine ecosystems. Phytoplankton are small, mostly microscopic plants that can range in size from a thousandth of a millimeter to two or more millimeters. They are most abundant near coastlines where nutrient levels are the highest. Both phytoplankton and zooplankton may float or drift at the mercy of the currents because they are often unable, too weak or too small to swim.

Phytoplankton are at the bottom of the food chain. They are consumed in large quantities by zooplankton and larval and juvenile marine organisms. Like most plants, phytoplankton produce their own food through photosynthesis. They use nutrients in the water and sunlight to accomplish this. They are generally not found at depths where sunlight cannot penetrate.

DINOFLAGELLATES

Two of the more abundant and important types of phytoplankton are diatoms and dinoflagellates. Diatoms are single celled phytoplankton that make up more than half of all planktonic life. They live inside a shelter that they build with silica, the same material sand consists of. A diatom's shelter consists of two halves, one larger than the other so that the smaller one can fit inside. Diatoms can be quite beautiful and have many projections to keep them afloat.

PLANT GROWTH

Growth rates of phytoplankton can be expressed in terms of "primary production." Primary production is the amount of plant growth, or photosynthesis, for a given unit of surface area or volume, over a specified time period. Rates of primary production depend on several factors, the most important being availability of light and nutrients, which limit the production of phytoplankton.

Primary production forms the base of the food web leading up to fish, shellfish, birds and ultimately, humans. High rates of primary production by some plant species enhance seafood production. However, over-abundant primary production almost always results in reduction of the aesthetic values of ocean water, taking the form of algal blooms, such as red, brown and green tides.

The high nutrient levels in the Hudson-Raritan Estuary support high rates of growth of phytoplankton. Plankton fluctuates on a cycle and depends on deep, nutrient rich waters mixed with less nutritious surface waters. The first rapid growth period of plankton begins in the spring after winter storms have mixed the waters. Phytoplankton begins to bloom,

supporting zooplankton populations. These populations will provide food for fish. Plankton production during the summer is typically low, but in fall mixing of nutrient-rich bottom water with surface water occurs and the process experienced last spring is repeated. Spawning of many larger species of marine animals often coincides with these plankton growth periods.

ANIMALS

ZOOPLANKTON

Zooplankton has representatives in almost every phylum in the animal kingdom. Species in the Hudson-Raritan Estuary represent most major taxonomic groups common to estuaries along the eastern seaboard. Larvae, fingerlings and invertebrates represent a large portion of the zooplankton population. They begin their life as zooplankton but eventually settle to the bottom and take on a benthic existence. This is common to many types of crabs, bottom fishes and mollusks.

Copepods, one of the classes of the phylum Arthropoda, are dominant zooplankton in the Hudson-Raritan Estuary. They often make up 70-90 percent of a zooplankton sample, especially in the spring. Copepods consume many diatoms and support large populations of herring and sardines.

BENTHIC INVERTEBRATES

Benthic fauna are usually defined as those invertebrates that dwell in or on the seabed or on submerged structures (pilings, rocks, boat bottoms, etc.). The benthos of the Hudson-Raritan Estuary are generally regarded as an extremely important component of this estuarine ecosystem. Benthic organisms are often indicative of the relative "health" or condition of an estuary. They also provide much of the food for commercially and recreationally important fish species such as flounder, blackfish, striped bass, and bluefish. Commercially, clams and lobsters are the most important benthic species living in the estuary.

Benthic organisms are categorized by their positions in the water column. Mussels, barnacles and some species of shrimp, crabs and lobsters usually reside on the surface of the sediment or on hard surfaces and are termed epibenthic. Organisms such as clams, worms and many crustaceans reside in the sediment, either in tubes or burrows and are called infauna.

FISH

The rich waters of the Hudson-Raritan Estuary support a diversity of fish species. Many species spend only part of the year in the Estuary while migrating through offshore waters or between the ocean and Estuary. Other species are year-round residents. Seasonal occurrence and distribution of fish in the Hudson-Raritan Estuary is related to life history patterns. A

variety of studies related to the distribution and abundance of fishes in portions of the Hudson-Raritan Estuary have been conducted. These studies have identified over 145 species representing more than 50 families of resident and migratory finfish.

The Hudson-Raritan Estuary is a major spawning and/or nursery ground for many species of fish and shellfish. Studies have found close to two dozen species of fish in egg and larval stages in upper New York Bay alone. Other studies have shown that the lower bay region serves as an important area for species in young-of-the-year and/or juvenile life stages.

Year-round residents, i.e., fish that spawn and remain within the Estuary for their entire life cycle include the silverside minnow, killifish or mummichogs, white perch, and bay anchovies. The area is particularly important for diadromous species which migrate through the Estuary to different spawning places such as striped bass, white perch, shad, alewife, American eel and shortnose sturgeon. Anadromous species such as shad, alewife, blueback herring, Atlantic sturgeon, tomcod, and smelt make spring spawning runs from the ocean into fresh and brackish waters. Catadromous species such as eels arrive as juveniles, mature in freshwater after several years then return to the ocean to spawn.

In recent years, the Hudson-Raritan Estuary, particularly the Hudson River and New York Harbor region, has been identified as a significant habitat for striped bass. Studies of both the Hudson and East Rivers have documented the usage of the Estuary by adult and juvenile striped bass. Generally, the juveniles use the pier and interpier areas of Manhattan and the northern parts of the Arthur Kill, Newark Bay, and other areas as overwintering grounds while adults utilize channel areas. Currently, the Hudson-Raritan Estuary stock of striped bass is extremely important since the historically dominant stocks from the Chesapeake are experiencing low abundance.

BIRDS

Although the shoreline of the Hudson-Raritan Estuary is intensely developed, the area supports a diverse and abundant bird population. With approximately 125 species of resident or migratory birds recorded in the region, the area is home to a diverse population of resident, migrating, wintering and breeding birds. The Estuary is able to support this diversity because it offers many habitats. These habitats range from open water to marsh and woodlands. The birds that use these varied habitats can range from large birds of prey to waterfowl or passerines. In addition, plants and invertebrates living in shore and marsh areas provide plentiful food sources.

The Hudson-Raritan Estuary is a prominent feature of the Atlantic flyway during spring and fall migrations supplying abundant feeding and resting areas for many avian species. It is during spring and fall when food is most abundant that migrating waterfowl, snow geese and brant frequent the Estuary as they utilize the flyway to travel between northern breeding grounds to southern wintering areas. Fall migrations are generally heaviest because they include offspring from the summer breeding season. Other species overwinter within the

confines of the Estuary. Shooters Island, located north of Staten Island at the confluence of the Arthur Kill and Kill Van Kull in Newark Bay, is an uninhabited island providing an undisturbed environment for colonial nesting birds, primarily herons.

Birds have evolved in such a way as to make them specialists and each bird occupies its own niche. Body parts have evolved to perform specific functions. Waterfowl, for example have short legs and webbed feet, and spend most of their time in the water. Wading birds, such as herons and egrets, have long necks, legs and beaks that enable them to stalk prey in the shallow water habitats they frequent. Birds of prey, such as osprey, use sharp beaks and powerful legs to grasp prey once it is sighted with their keen eyesight.

Wading birds such as herons and egrets do not swim but wade through the water. They stalk their prey along the shallow edges of marshes, mud flats and creeks. These birds have short tails, long legs, long necks and specialized bills. The bills of egrets and herons are used to quickly seize prey such as small fishes, frogs and aquatic insects.

Gulls and terns are long winged birds with short legs and webbed feet. They have hooked bills and are good swimmers. They are probably the most common and visible of all birds in the area. The herring gull and the common tern are two of the most abundant birds in the area. Gulls are opportunistic feeders and will feed on almost any food source. Terns are smaller and more graceful. Unlike the gull they have sharp pointed bills. Terns are more selective feeders, preferring small live minnows, squids and shrimp.

Shorebirds like plovers, sandpipers and oyster catchers, inhabit the beach-littoral and marsh zones. These shorebirds have long legs and pointed beaks. They live near areas that are only exposed during low tide, feeding mainly on sand and mud dwelling invertebrates.

Raptors are birds of prey and feed at the top of the food chain. They include ospreys, hawks and owls. They feed mainly on fish and small rodents. They are large birds with strongly hooked bills and powerful feet with hooked claws.

Waterfowl spend most of their time on the water as their name would imply. They consist of ducks, geese and swans. Waterfowl have webbed feet and are very good swimmers. They are also strong and swift fliers that enable them to undertake extensive migrations each spring and fall. Migrations begin in the early afternoon and continue through the night. Waterfowl follow specific paths in their migrations and these paths have become known as flyways. Most waterfowl are gregarious, staying together as a flock, which is advantageous for feeding and safety when migrating.

Passerines are the largest order of birds containing some 59 families. They are made up of sparrows, warblers, ravens and other similar perching type birds. They can range in size from 4-26 inches. Passerines are the most adaptive and intelligent of all birds. They all have three toes pointed forward and one backward. This enables them to perch easily on anything from a branch to a grass stem.

Wintering grounds are very important to all birds, and each species has specific requirements for an area to qualify as wintering grounds. Populations will often move to satisfy these needs. Plenty of food is a major requirement of all birds. To endure colder temperatures birds need more energy. In order to produce more energy, they need to eat more. Open water is important to waterfowl because this is where they feed. Should an area become iced over they will have to move on in search of open water. Waterfowl prefer the Hudson-Raritan Estuary because the constant currents ensure there will always be some open water available to them.

The Hudson-Raritan Estuary is also a breeding ground. Saltmarshes, beach-littoral zones and uplands with woody vegetation are the most widely used areas in the Estuary. Breeding areas must be able to support a growing population of birds by providing plenty of food and protection. Because birds use the same breeding grounds year after year, the health of the Estuary can be measured on how successful breeding is.

Nearshore Communities

Words to Know:

Benthic	Niche
Benthos	Pelagic
Diversity	Phytoplankton
Detritus	Plankton
Dominant	Nekton
Ecosystems	Vertebrate
Habitat	Zooplankton
Invertebrate	

Materials:

For this activity you will need a seine net, two pairs of chest waders, a bucket filled with estuary water, data sheets, pencils, plankton net with jar, wash bottle, microscopes, an eight inch piece of 4.5 inch diameter PVC tubing, meter stick, sample jars, a sieve with mesh, a well sealed opaque jug containing a 10% solution of formalin, dissecting microscope, field guide books on fish, invertebrates, birds and plants of the area, and keys for the organisms of the area.

Activity:

There are four activities all related to nearshore communities. The first activity is to collect live samples by seining. Using a seining net, chest waders and a bucket filled with estuary water, the students identify the animals found, recording species names and quantities, using field guide books as necessary. After they have been counted, the catch should be released back into the environment. Activity Two tells how to use a plankton net to get a plankton sample and examine the findings under a microscope. Activity Three is taking a sample of the benthos or bottom sediment using a PVC pipe and getting a core sample. A sieve and wash bottle are used to sift out the sample, the sample is placed into a formalin solution to be looked at under the microscope in the classroom. Activity Four is taking a walk through or around the area being studied. The students identify the plants, birds, and terrestrial animals observed, recording identities and relative abundance.

Classification and Identification

Words to Know:

Classification	Key
Couplet	Nomenclature
Binomial Nomenclature	Systematics
Dichotomous	Taxonomy-Taxonomic Key
Hierarchical	

Materials:

For this activity you will need a bag for each student containing ordinary household items (eg. straw, rubber band, screw, washer, eraser), an additional household item for each student that is not placed in the bag (eg. button), a bag containing shells from the Hudson-Raritan Estuary (eg. clam, oyster, scallop, mussel, moon snail, slipper snail, oyster drill), poster board, drawing paper, glue, colored

pencils or markers, four or five different kinds of local marine or estuarine fish (these may be obtained by the students through a seining activity or from a local fish market. The fish may be frozen and reused for this activity or for fish printing. You will also need field guides for the shells of the area, and a copy of the Illustrated Guide to the Hudson River Fishes.

Activity:

Divide the students into groups of four or five each. Each group gets one bag and one additional item. Removing the items from the bag, the items get divided into two groups based on one thing that makes the two groups different (eg. shells that have a hinge and shells that do not have a hinge or hard objects vs. soft objects). The students keep dividing the groups into two groups until each object has its own group. The field guide for shells may be used if shells are used, to help with the classification. For the second part of this activity the students mix up the objects, start over again, and at each step draw a picture of the objects in each group and write a phrase that describes a physical characteristic that makes all the objects similar. When the picture is done, starting at the top and working your way down, lines are drawn from the smaller groups to the larger one they came from, and in this way, students create a diagrammatic key of their own.

Phytoplankton

Words to know:

Autotroph	Pigment
Biomass	Primary Productivity
Carotenoids	Producers
Chlorophyll	Production
Consumers	Respiration
Fucoxanthin	
Photosynthesis	

Materials:

For this activity you will need a sample of green algae, brown algae and red algae collected from a beach along the Hudson-Raritan Estuary kept in a cool dark place during transport and then frozen, fresh spinach, acetone, white vinegar (mixed with acetone in a ratio of 92 parts vinegar to 8 parts acetone), chromatography paper, capillary tubes, test tubes with cork lids, vials, cheesecloth, mortar and pestle, fine sand, funnel, knife, pencil, tacks, a fresh water sample from the Hudson-Raritan Estuary, a 130 micron mesh screen, 4 glass bottles (2 clear and 2 completely opaque), and a LaMotte or Hach dissolved oxygen kit. You will need to use the algae as soon as possible after collecting. If frozen it must be defrosted and blotted dry.

Activity:

In this activity the students get to observe the color pigments found in different algae. In part two of this activity, the students perform a dissolved oxygen test to calculate respiration, net production, and gross primary production using the equations that are given. Respiration and net production reflect the amount of energy (food) used and made by the phytoplankton and zooplankton together. The gross primary production reflects the energy (food) produced by the phytoplankton alone. Repeating this activity at different times of the year gives you a record of differences in community respiration, net community production, and gross primary production over a period of time and different seasons.

Form and Function

Words to Know:

Adaptation	Morphology
Anatomical adaptation	Physiological adaptation
Anatomy	
Behavioral adaptation	
Benthic	

Materials:

For this activity you will need library access, paper, pencil, several whole fish of different shapes from the Hudson-Raritan Estuary, either obtained through seining or from the local fish market (the fish should be fresh and frozen immediately after being caught), newspaper, paint or ink, brushes, colored pencils or markers, newsprint, cloth or another medium to which paint can be applied.

Activity:

For this activity the student will define and discuss three types of adaptations, then try to describe an example of each type, for an organism from the Hudson-Raritan Estuary. Next the student reads the nine sentences on the activity sheet and decides if the sentences describe an anatomical, physiological, or behavioral adaptation. For Activity Two, the student chooses a benthic organism, then goes to the library to research the lifestyle of the organism. The student creates a personal ad or classified ad, making a clear description of the organism without naming it, and reads it to a classmate to see if that student can guess which organism it is. Once the classmate has guessed correctly, see if together, they can explain the morphology or anatomy of that organism that makes it most suitable for the position or description. In Activity Three, fish are placed on newspaper and examined for their external anatomy. The different fins of the fish are observed to see how shape or size might change the way the fish moves. Next the fish gets painted with a very thin coat of paint to make a print of the fish. Paper or cloth can be used for this. After the print dries, the different parts of the fish can be labeled or the name of the fish can be added to the print.

Salt Tolerance

Words to Know:

Adaptation	Osmoconformer
Brackish	Osmoregulator
Dehydrate	Osmosis
Euryhaline	Salinity
Homeostasis	Stenohaline
Molecules	

Materials:

For this activity you will need potatoes, carrots or celery, two glasses, measuring cup, Elodea (available at pet shops or from Frey Scientific 1-800-225-FREY), sea salt (available at pet shops), chlorine remover (available at pet shops), metric balance, glass jars, salt marsh cordgrass ***Spartina alterniflora***, collected by permit along the Hudson-Raritan Estuary, four 1-gallon plastic buckets, four 1.5gal. (or 2-gal.) plastic buckets.

Activity:

In this activity students get to do an experiment using vegetables, salt water and making observations as to what happens to the vegetables overnight and why. In Activity Two the students perform the experiment adding salt to water in different amounts to four jars containing Elodea, observing and recording changes over a four day period. The second part of Activity Two is optional because it involves getting a collectors permit to dig up salt marsh cord grass. It should be stressed not to dig up more than you need for the experiment as this is unnecessary destruction of precious salt marsh habitat. In this experiment four buckets of salt marsh cord grass are given salt water of different salinities for a process of five consecutive days. Observations are made and changes are recorded daily.

Classification and Identification

- Objectives:**
- 1) You will learn to classify objects and organisms based on physical attributes.
 - 2) You will identify objects and organisms.
 - 3) You will create a diagrammatic key.
 - 4) You will use a taxonomic key.

Background: Systematics is used to classify plants and animals into organized groups. This is usually done based on physical characteristics, presuming that organisms that look similar are similar. Once organisms are classified and each organism is in a group by itself, organisms can be identified through the use of **taxonomic keys**. These keys are usually **dichotomous**, dividing organisms into groups of two at each step of the **key**.

It should be noted that organisms are given Latin names usually describing their form or function. These Latin names are universal in use. This creates a universal understanding of which organism is being referred to. Each plant and animal has two names - a genus name and species name. The genus name is capitalized and comes first, the species name is lower case and comes second, and each name is either italicized or underlined (eg Genus ***species*** or Genus species). There is only one organism for each species, but there can be many species for each genus (eg ***Etropus crossotus***, ***Etropus microstomus***, and ***Etropus rimosus*** are three different kinds of flounder from the same genus.) There are different levels of classification, and at each taxonomic level, organism groups are described in more specific detail until the species level is reached. This creates a **hierarchical** system of **nomenclature** and grouping of organisms. Kingdom is the broadest category and species is the narrowest.

Words to Know:

Classification
Binomial Nomenclature
Dichotomous
Hierarchical
Key
Nomenclature
Taxonomy-Taxonomic Key

estuarine fish (these may be obtained by the students through a seining activity or from a local fish market-fish may be frozen and reused for this activity or for fish printing)
Laminated key to univalves and bivalves (included)
Illustrated Guide to the Hudson River Fishes, (included)

Materials:

A bag for each student containing ordinary household items (eg. straw, rubber band, screw, washer, eraser); an additional household item for each student that is not placed in the bag (eg. button)

A bag containing shells from the Hudson-Raritan Estuary (eg. clam, oyster, scallop, mussel, moon snail, slipper snail, oyster drill)

Poster board
Drawing paper
Glue, Colored pencils or Markers
Four or five different kinds of local marine or

Activity:

1) Divide into groups of four or five. Each group should take one bag and one additional item provided. Keep the single item separate from the items in the bag. Remove the items from the bag and divide them into two groups based on one thing that makes the two groups different (eg. shells that have a hinge and shells that don't have a hinge **or** hard and soft objects). Take each of these two groups and divide them into two more groups based on something that makes them different. Continue to divide each group into two groups until each object has its own group. You

may use a field guide for shells if shells are used for this activity to help with the classification.

2) Mix up your objects and start over again, dividing your objects into smaller and smaller groups. This time, at each step, draw a picture of the object in each group, and write a phrase that describes a physical characteristic that makes all the objects in that group similar (eg. hinged shells, shells with no hinge or hard objects, soft objects). Paste your picture and your description on a piece of poster board, starting at the top and working your way down. Draw lines going from the smaller groups to the larger group they came from. You have just created a diagrammatic key.

3) Take your additional object and classify it using the diagrammatic key you have created. Which group would it fall into at each step? Draw this onto your diagrammatic key at each step. Then divide the last group it fell into in half so that each object is in its own group, thereby incorporating it into the diagrammatic key.

4) As a group, move from table to table, working together to identify the fish in front of you using the Illustrated Guide to Hudson River Fishes. This is a dichotomous key and usually offers you two choices, known as a couplet, at each step. Start with the first step. Choose the description at each numbered step that best characterizes the fish you are trying to identify. As you make a choice at each step, you will be directed to another couplet until you have identified the fish.

Extension:

Identify other organisms of the Hudson-Raritan Estuary such as plants, birds, and invertebrates using keys to the local flora and fauna. Once you have determined the genus and species names as well as the common names of the organisms you are identifying, determine the Latin names of the larger groups that the organisms belong to (i.e. Family name, Order name, Class name, Phylum name, Kingdom name).

Discussion:

1. Discuss as a class what physical characteristics you used to group the shells or objects you were provided with. While there is a correct and an incorrect way to classify shells because there is already a method of classification that is accepted in Systematics there is no correct or incorrect way to classify objects or organisms that have not been classified. Therefore, every student's system of classifying objects is correct.

Sampling Nearshore Communities

- Objectives:**
- 1) You will learn how to sample organisms of nearshore communities.
 - 2) You will learn to identify organisms of nearshore communities in the Hudson-Raritan Estuary.
 - 3) You will create a database by recording the numbers and types of organisms sampled from the community.

Background: Once you have developed skills for identifying organisms, you can begin to study where and how organisms live within the Hudson-Raritan Estuary. Estuaries are highly complex ecosystems that contain numerous habitats. There are habitats with different salinities, different sediments, and different water depths. There are habitats that are vegetated, habitats with soft-sediment bottoms, and habitats with hard, solid structures. Organisms in a habitat depend on and are strongly influenced by their surroundings. Each habitat has a community that may be slightly or drastically different from the community of the next habitat. Estuaries are also highly susceptible to seasonal changes in climate because they are shallow-water environments. These seasonal changes cause changes in the populations of organisms that make up communities. Lastly, organisms in a community are influenced by physical and chemical disturbances in their habitats. Some organisms are more tolerant of pollution and disturbance than others. Therefore, the presence or absence of certain organisms in a community can be an indication of an area's environmental health. It is for this reason that many people like to study and monitor the communities of nearshore habitats. These habitats are the most impacted of all marine habitats because they are so close to land and are utilized by humans. In order to understand how humans affect nearshore communities, we must first understand how naturally-existing habitat differences and seasonal changes influence them.

Words to Know:

Benthic
Benthos
Detritus
Diversity
Dominant
Ecosystem
Habitat
Invertebrate
Nekton
Niche
Pelagic
Phytoplankton
Plankton
Vertebrate
Zooplankton

Pencils

Data sheets or blank paper

Plankton net with a jar

Wash bottle or spray bottle

Microscopes

An 8-inch long piece of 4.5-inch diameter PVC tubing (marine or brackish habitats)

Meter stick

Sample jars or other containers

A sieve with a 1.0-mm mesh

Well-sealed, opaque jug containing a 10% solution of formalin

Dissecting microscope

Field guide books for the fish, invertebrates, birds and plants of the area

Keys for identifying organisms of the area

Activity One:

1) This activity is performed in the field, ideally at a bayfront shoreline where you have obtained permission to seine. First, half fill a bucket with local water. This will provide a temporary

Materials:

Seine net
Chest waders (2 pair)
Bucket to be filled with water from the Estuary

habitat for observing your catch. Two people then put chest waders on and hold the seine net stretched between them. The weights should be at the bottom of the net and the floats should be at the top of the net. Turn the net so that it is parallel with the ground, and walk into the water to the desired depth or location. Turn the net perpendicular to the ground so that the weights are on the bottom again. Walk through the water with the net stretched between you and your partner, keeping the floats above water and the weights on the bottom, pointing the bottom of the seine net slightly into the direction of your movement. As you approach the shore, scoop up the bottom of the net to form a hammock. Walk the net up on the beach or bank, and place it on the ground. Using wet hands, remove all organisms from the net and place in the bucket that has been filled with estuary water.

2) Using field guides and keys, identify the organisms collected and count them. Record how many of each organism is found on a piece of paper or a pre-prepared data sheet. Release the organisms back to their environment as gently and as soon as possible.

Activity Two:

1) Attach a jar to the end of a **plankton** net. Tie the rope attached to the net to a stationary structure and place the net in the water so that the current flows through the net. The jar at the end should fill with water. If there is no current, the net can be towed through the water either by hand or by boat. The net will collect more plankton when this procedure is conducted for longer periods of time.

2) When sampling is completed, gently wash down the sides of the net with a wash or squirt bottle so anything that has accumulated on the net goes into the sample jar. Remove the jar from the end of the net and cover for transport.

3) Place a drop of the sample under a microscope. Note how much detritus is in the sample, and try to identify the organisms, making note of which organisms are most abundant,

Activity Three:

1) To sample the **benthos**, take the PVC pipe and push it down into the substrate until it is flush with the bottom. Push your hand down along the outside of the pipe and reach underneath to cover the bottom opening. Pull the sample up and place in the 1.0-mm sieve. Wash water from the sample site over the sample until all smaller particles pass through the sieve. Wash the sample into a jar and preserve with the formalin solution. If a hard substrate is being sampled, mark off a small, designated, predetermined area and identify and count the organisms occupying the marked space.

2) In the classroom or laboratory, rinse the samples thoroughly in a well-ventilated area until they no longer smell of formalin. Remove all animals from the sample and identify them with the aid of a dissecting microscope. Record the numbers and types of organisms found.

Activity Four:

1) Walk through the area being studied, identifying as many plants, birds, and terrestrial animals as you see.

2) Record the organisms observed and their numbers or relative abundances.

Discussion:

Discuss your data in terms of diversity.

1. Did you find a lot of different organisms or species?
2. Which organisms dominated in each of the samples from each of the four activities?
3. Did phytoplankton, zooplankton, or detritus dominate the plankton sample?
3a. Does this relate to what time of year it is?
4. What role does each of the organisms play in the community (what is its niche or what does it do)?

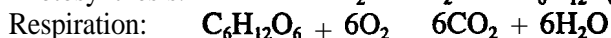
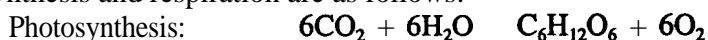
Extension:

Collect the same types of samples at different locations, times of the year, or tidal stages. Discuss how the community changes.

Phytoplankton

- Objectives:**
- 1) You will learn the colors of marine algae.
 - 2) You will learn what phytoplankton needs to make food and grow.
 - 3) You will learn that phytoplankton makes oxygen, but also uses oxygen to make its own biomass.

Background: With the exception of a very few kinds of bacterial organisms, plants are the only organisms that are **autotrophs** or **producers** of their own food energy. The process by which food is used is called **respiration**. Without plants, life on earth would not exist. They are the only organisms that make oxygen, while most other organisms only use oxygen. The general reactions that describe photosynthesis and respiration are as follows:



The process by which plants make their own food is called **photosynthesis**. Plants put together nutrients and water to form plant material using light energy. The main pigment which helps plants to do this is **chlorophyll**, although other pigments may be involved as well. Pigments are molecules that have color because they absorb a certain wavelength of light. Plants appear to be the color of the pigment that dominates. While rooted plants like sea and marsh grasses are partially responsible for the **primary productivity** of estuaries and other marine environments, the majority of primary production comes from phytoplankton. The amount of primary production occurring at any time is influenced by several environmental factors including temperature, the availability of nutrients, and how much light is available.

Words to Know:

Autotroph
Biomass
Carotenoids
Chlorophyll
Consumers
Fucoxanthin
Photosynthesis
Pigment
Primary Productivity
Producers
Production
Respiration

Acetone

White vinegar (mixed with the acetone in a ratio of 92 parts vinegar to 8 parts acetone)

Chromatography paper

Capillary tubes

Test tubes with cork lids

Vials

Cheesecloth

Mortar and pestle with fine sand

Funnel, Knife, Pencil, Tacks

A fresh water sample from the Hudson-Raritan Estuary

A 130 micron mesh screen

4 glass bottles (2 clear and 2 completely opaque)

A LaMotte or Hach dissolved oxygen kit

Materials:

A sample each of green algae (division Chlorophyta), brown algae (division Phaeophyta), and red algae (Rhodophyta) collected from a beach along the Hudson-Raritan Estuary, kept in a cool dark place during transport and frozen
Fresh spinach

Activity One:

- 1) Use the algae as soon as possible after collecting. Defrost the algae, if frozen, and blot it dry.
- 2) Chop the spinach and each of the algae as fine as possible with a knife. Place about 2 tablespoons of chopped spinach in the mortar.

Add up to 5 ml of acetone and thoroughly grind with the pestle to make a very concentrated solution. This should be done in a well-ventilated place. More acetone may be added as needed.

3) Once the acetone has become colored, pour the solution through a funnel lined with several layers of cheesecloth into a vial. If this solution is not used immediately, the vial must be wrapped in foil to prevent light exposure.

4) Place 6-7 mm of the white vinegar-acetone mix in the bottom of a test tube. Center a pencil dot 2 cm from the bottom of a chromatography paper strip, handling the paper by the edges only. Dip a capillary tube in the spinach-acetone mix, and touch it briefly to the pencil dot. Blow until the acetone evaporates. Repeat until the dot is very dark in color. Tack the other end of the paper to the cork lid. Place the cork in the test tube so that the end of the paper is in the vinegar-acetone mixture. Make sure the dot is not in the fluid and the paper is not touching the sides of the test tube. Do not move the setup for 5-10 minutes, or not until the fluid has traveled to the top of the paper. Remove the strip and observe the pigments.

5) Repeat steps 2-4 for each algae. The following pigments will probably be observed:

chlorophyll a: blue-green

chlorophyll b: green (in green algae only)

chlorophyll c: green (in brown algae only)

chlorophyll d: green (in red algae only)

xanthophyll: yellow to brown

carotene: yellow-orange

Discussion:

1. Discuss which pigments are found in which plants observed.
2. Discuss which pigments were most concentrated in each of the samples and how this reflects on the color of the specimen.

Activity Two:

1) Immediately filter the Hudson-Raritan Estuary water sample through a 130 micron mesh to remove the larger zooplankton. Take a subsample and measure the dissolved oxygen with LaMotte

or Hach kit. Measure the dissolved oxygen of a second subsample. Average the two dissolved oxygen measurements. This will be your $DO_{initial}$.

2) Fill the four bottles to the top with the remaining water sample and cap the bottles so that no air bubbles are trapped inside. Place all four bottles under continuous light for about 24 hours.

3) After 24 hours, measure the dissolved oxygen in each of the bottles and average the measurements for the two dark bottles (DB DO_{final}) and for the two light bottles (LB DO_{final}).

4) Calculate respiration, net production, and gross primary production using the equations that follow. Respiration and net production reflect the amount of energy (food) used and made by the phytoplankton and zooplankton together and are denoted as R_c and NCP respectively. Gross primary production reflects the energy (food) produced by the phytoplankton alone and is denoted as GPP.

$$R_c = DO_{initial} - DB \ DO_{final}$$

$$NCP = LB \ DO_{final} - DO_{initial}$$

$$GPP = NCP + R_c$$

Extension:

Repeat the activity at different times of the year. Discuss the differences in community respiration, net community production, and gross primary production. Speculate on why there may be differences in these values at different times of the year.

Form and Function

Objective: 1) You will learn how an organism's anatomy and morphology can reveal how it lives and functions.

Background: Most organisms are adapted to a specific way of life. Adaptations may be behavioral, anatomical, or physiological. Many adaptations can be understood through observation and understanding how the animal lives. For example, we know that fish live in water having ways to move through the water to keep themselves afloat. We also know that seastars love to eat bivalves, and they have developed a way to open tightly closed shells to eat the animal inside. The following is a series of activities that involves observing and discussing the morphology and anatomy of various organisms, focusing on how this relates to the animal's lifestyle.

Words to Know:

Adaptation
Benthic
Morphology

Materials:

Library access
Paper, Pencil
Several whole fish of different shapes from the Hudson-Raritan Estuary, either obtained through seining or from the local fish market (the fish should be fresh and frozen immediately after being caught)
Newspaper
Paint or Ink, Brushes, Colored Pencils or Markers
Newsprint, Cloth, or another medium to which paint can be applied

Activity One:

- 1) Define and discuss the three types of adaptations. Try to describe an example of each type for organisms from the Hudson-Raritan Estuary.
- 2) Read the following sentences and decide whether the sentence describes an anatomical, physiological or behavioral adaptation.
 - a) Sea gulls that live near people feed on garbage at garbage dumps.
 - b) An osprey has clawed feet coated with small spines or spicules so it can grasp slippery fish.
 - c) A clapper rail hides in marsh grasses for protection.

- d) A pipefish turns from gray to a muddy brown as it swims to the bottom of the Estuary.
- e) A mallard duck has webbed feet to help it swim.
- f) Hermit crabs hide in their shells for protection.
- g) The male egret grows a large yellow plume during mating season.
- h) The razor clam has a muscular, hatchet-like foot that anchors it into the sand.
- i) The squid emits a black ink to blind a predator that is pursuing it.
- j) Marsh snails climb to the top of the salt marsh cordgrass during high tide to avoid drowning.

Activity Two:

- 1) Choose a benthic organism that lives in the Hudson-Raritan Estuary. Go to the library and research the lifestyle of the organism you chose. Write a classified ad or personal ad for which your organism would be suited.
- 2) Read your ad out loud and let other students guess what organism it was written for. Once they guess correctly, the students explain what is it about their morphology or anatomy makes them most suitable for the position or description.

Example 1: Classified Ad

Looking for an experienced driller for clam mining operation. Must work neatly. (Oyster Drill - An oyster drill has a special organ called a radula which is like a tongue with teeth. This snail will drill perfectly round little holes in a clam shell to get to the meat inside.)

Example 2: Personal Ad

Feisty freckled male seeks a crabby lady with attitude. If you like surf and sand and a good fight, you're the one for me. (Lady crab- This pale grayish crab has clusters of purple specks all over it. It is usually found in shallow water with sandy habitats. It is an ill-tempered crab that needs to be handled with care.)

Activity Three:

- 1) Thaw fish specimens under cold water 1/2 hour before using them. Dry the fish well and place them on newspaper.
- 2) Look at the different fish. Use the Fish Anatomy and Fish Morphology worksheets to identify the different fins of the fish and how they help the fish move. If an aquarium is available, watch fish to see how the different fins help the fish move. Look at the **morphology** chart to identify the different fish shapes and how fish with different shapes move.
- 3) Take a paint brush and brush a very thin layer of paint over a fish (the less paint used, the better). Place a piece of paper or cloth over the painted fish and gently press it down around the edges of the fish, taking care not to squash the fish. Lift the paper or cloth to reveal the fish print. When the print has dried, label the different parts of the fish's external anatomy on the print, write the name of the fish, and write the shape of the fish with a description of how the fish moves.

Salt Tolerance

- Objectives:**
- 1) You will learn how different plants adapt to various amounts of salt water.
 - 2) You will conduct experiments under controlled situations, making observations and recording information over time.

Background: An estuary is a place where saltwater and freshwater meet and mix. After a heavy snow or rainfall, there is more freshwater flowing into the estuary and salinity is lower. At other times, saltwater from the ocean intrudes further into the estuary making salinity higher. Estuaries are very complex and, for many animals, very stressful ecosystems because of the large fluctuations in salinity. The organisms that live in estuaries are usually adapted to stressful conditions. For example, if you poured seawater on a regular houseplant, it would die. Unlike house or garden plants, salt marsh plants have made **adaptations** to separate salt from freshwater so they can use the freshwater for hydration.

Salinity is most often measured in parts per thousand (ppt). The major ions in seawater are chloride (55%) and sodium (30.6%) (which together make table salt), sulfate (7.7%), magnesium (3.7%), calcium (1.2%), and potassium (1.1%). There are also ions inside cells, giving them a measurable salinity. Organisms will either let the ion concentrations, or salinity, in their cells conform to the ion concentrations, or salinity, of their surroundings or they will try to maintain the ions in their cells at a constant concentration. The process by which an internal balance is maintained while external conditions change is called **homeostasis**. Ions don't usually pass across cell membranes, so water does instead. If the salinity of an organism's surroundings drops due to an influx of freshwater, water will flow into the organism's cells to drop the concentration of ions to the same level causing the cells to swell, or the organism's cells will work to pump the water that flows across the membranes out of the cells to keep the ionic concentrations where they were. If the salinity of the organism's environment drops too low, the organism's cells may explode because too much water flows in. The reverse happens if environmental salinity gets too high, causing the organism's cells to shrink and **dehydrate**.

Words to Know:

Adaptation	Scientific,
Brackish	1-800-225-FREY)
Dehydrate	Sea salt (available at pet shops)
Euryhaline	Chlorine remover (available at pet shops)
Homeostasis	Metric balance
Molecules	Glass jars
Osmoconformer	<i>Spartina alterniflora</i> (salt marsh cordgrass;
Osmoregulator	collected from along the Hudson-Raritan Estuary)
Osmosis	(opt.)
Salinity	Four 1-gal. plastic buckets (opt.)
Stenohaline	Four 1.5- or 2-gal. plastic buckets (opt.)
	Four 6-gal. buckets (opt.)

Materials:

A Potato, Carrots, or Celery
 At least two glasses
 Salt, Measuring cup
 Elodea (available at pet shops or from Frey

Activity One:

Fill two glasses with tap water. Add about 1/4 cup of salt to one glass of water and stir until the salt dissolves. Place potato sticks, carrot sticks,

or celery sticks in each of the two glasses and allow them to sit overnight. Observe what happens to the vegetables, and discuss why it happens.

Activity Two:

1) Place tap water in a large clean pail or basin and treat it with chlorine remover. Place 1 liter (**L**) of the treated water in each of 4 jars. Add 30 grams (g) of sea salt to one jar and stir until the salt dissolves. This makes 30 ppt salt water. Add 15 g of sea salt to another jar and 7.5 g to a third jar, also stirring until the salt is dissolved.

2) Place a piece of **Elodea** in each jar. Observe and record changes over a four day period.

The remainder of this activity is optional but better illustrates the concept of salt tolerance.

3) Punch four holes in the bottom of each 1-gal bucket for drainage.

4) Go to a salt marsh for which you have a collectors permit and dig up enough cordgrass and substrate to fill each bucket. Do not dig up more than you need, as this is unnecessary destruction of precious salt marsh habitat. Place the plants in the bucket so that they stand upright.

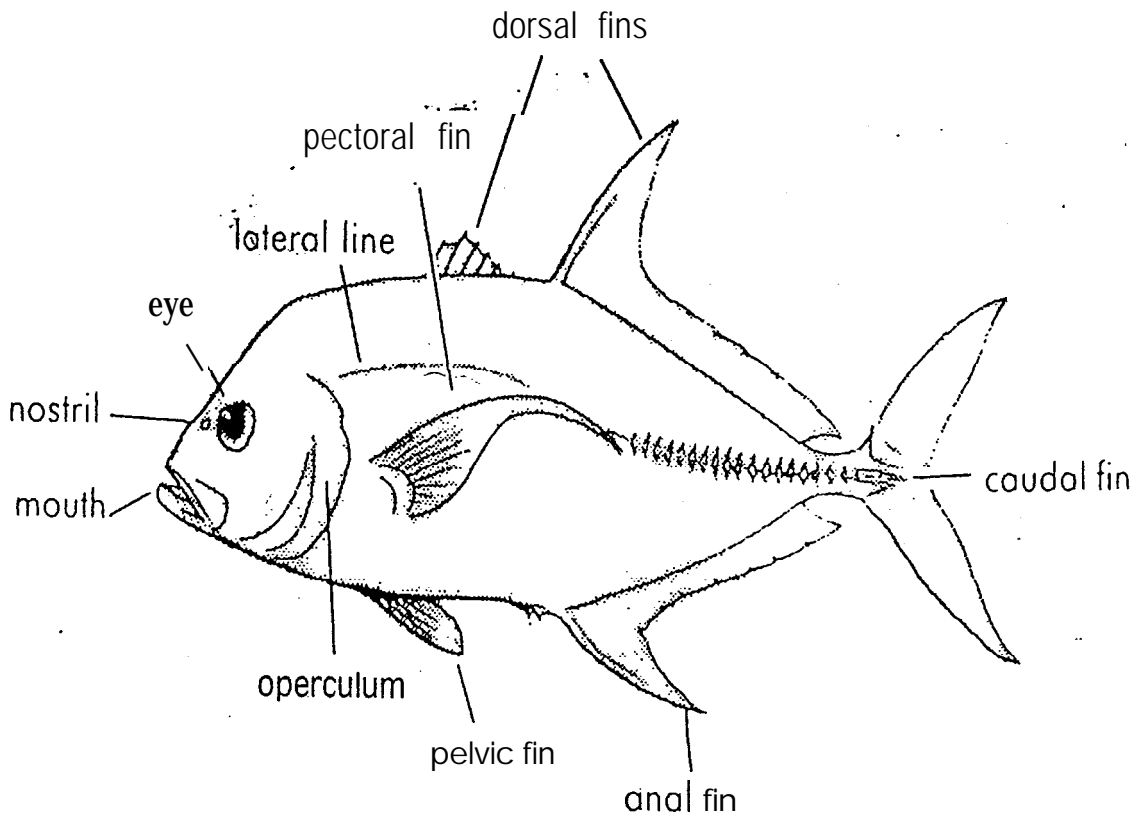
5) Back in the lab, fill four 6-gal. buckets each with 16 L of tap water and treat with chlorine remover. To one pail add 480 g of sea salt to make a 30 ppt solution, to a second add 240 g of sea salt to make a 15 ppt solution, and to a third add 120 g of sea salt to make a 7.5 ppt solution. The fourth pail will contain fresh water. Label each pail appropriately, and stir the pails to which salt has been added until all the salt has dissolved.

6) Place the buckets with the **Spartina** inside the 1.5 or 2-gal. buckets. Then place one bucket in front of each water bucket. Pour enough water from the bucket over the plant next to it so that the water saturates the substrate and fills the pail. After four hours, empty the exterior bucket into the sink and place the plants back in it. Repeat this process for five consecutive days, making sure to pour water of the same salinity over the same plant on all four days. Record observations for each treatment daily.

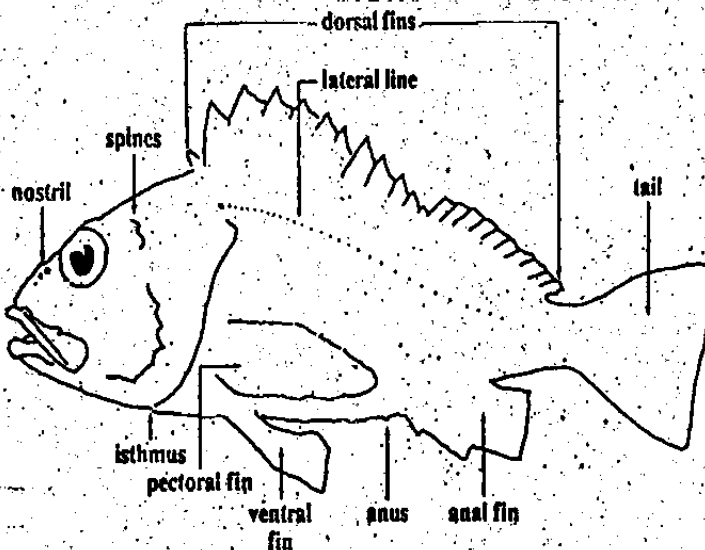
Discussion:

1. Discuss what happened to each piece of **Elodea** over the course of the experiment.
2. How much salt did it tolerate?
3. What does this imply about the salt tolerance of plants in the Hudson-Raritan Estuary?
4. Discuss what happened to the plants in each bucket over the five day period.
5. How did the cordgrass respond to the different salinities?

FISH ANATOMY



CLASS OSTEICHTHYES



Fish anatomy

For good printing results, it's useful to understand fish anatomy.

1. Fins. Most fish have at least one dorsal fin, a tail fin, an anal fin, a pair of ventral fins, and a pair of pectoral fins. Often the first dorsal fin will have hard, sharp spines, while the others will have soft, flexible fin rays. The fin spines and rays are connected by a thin, fleshy material that readily collects excess mucus and ink—which you'll need to wipe off. Some fish (trout and salmon) have a small, fleshy adipose fin that's difficult (but important) to print.

2. Scales. Fish scales vary in structure and reproduction quality.

- Sharks have sandpaperlike scales that are really modified teeth. They're difficult to print and require an extra thick coating of ink.
- Trout, salmon, and smelt have delicate "deciduous" scales that are difficult to print. Sometimes, it's best to remove all scales and print the scale pockets that the scales lie in.
- Many fish have hard, rough scales (perch and rockfish, for instance). Their scales will turn out well in prints, and these fish are the easiest to work with.

3. Lateral line. Most fish have at least one. The lateral line is a series of small organs the fish uses to sense turbulence and pressure changes. If you print correctly, the lateral line will be very striking in your prints.

4. Spines. Many fish have spines around the head. These can be poked through the paper. If properly printed, most of the fish's spines will reproduce beautifully.

5. Mucus. Fish secrete mucus from their bodies to protect themselves from parasites and disease and to help them "slip" through the water easily. The mucus tends to make a fish print less clear and dark in color. For this reason, it's important to remove as much mucus as possible by washing the fish thoroughly. Mucus tends to collect on the fins (and under the pectoral fins) and near the anus, gill cover, isthmus, and nostrils.

6. Body form. Fishes' bodies vary greatly in shape. A flat flounder lies on the ocean bottom, while a round, bullet-shaped tuna needs to swim efficiently to capture prey. Generally, the flatter the fish, the easier it is to print.

Making your print

The first things you do—selecting, cleaning, and setting up the fish—are important. *Take your time with them, and your prints will turn out well.*

Step 1. Clean the outside of the fish with soap and water to remove dirt and mucus. Dry it well. Be careful not to damage the fins or to dislodge too many scales. Plug the anus with a small piece of paper to ensure that the fish won't "leak" onto your printing paper.

Step 2. Place the fish on a newspaper-covered table. Spread the fins on plastic modeling clay. If necessary, pin the fins to the clay to keep them in position.

Step 3. Brush a thin coat of ink on the fish, using a 1/2- to 1-inch brush. If the ink is too thick (especially in hot weather), you may want to thin it slightly. However, thin, watery inks don't work well. When you first apply the ink, stroke your brush from head to tail. Leave the eye blank and paint it in later with a small brush (step 7).

After you cover the entire fish with ink, brush from tail to head. By reversing the direction of your brushing, you catch the ink under the edges of the scales and spines and improve your print.

Step 4. Place the moisture-tolerant paper carefully over the top of the fish. Press the paper firmly with your fingers over the entire inked fish. Be careful not to wrinkle or move the paper excessively. (With round-bodied fish, you may have to move the paper somewhat to avoid wrinkles.) Excessive paper movement can result in "double prints."






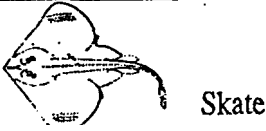

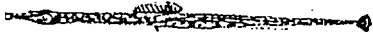
Step 5. Rub the entire fish.

Step 6. When you finish rubbing, gently remove the paper. Then study your results for mistakes, reink the fish, and do another print. A good fresh fish can yield three to ten good prints.


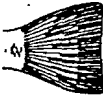



Step 7. With a small brush, paint in the eye.

FISH MORPHOLOGY

BODY SHAPE

Crosssection	Fish	Shape	Locomotion
	 Tuna	Fusiform	Fast-swimming in open water.
	 Tautog	Compressiform	Quick speed for short distances.
	 Skate	Depressiform	Swims like a flying bird.
	 Pipefish	Filiform	Slithers through the water like a snake.

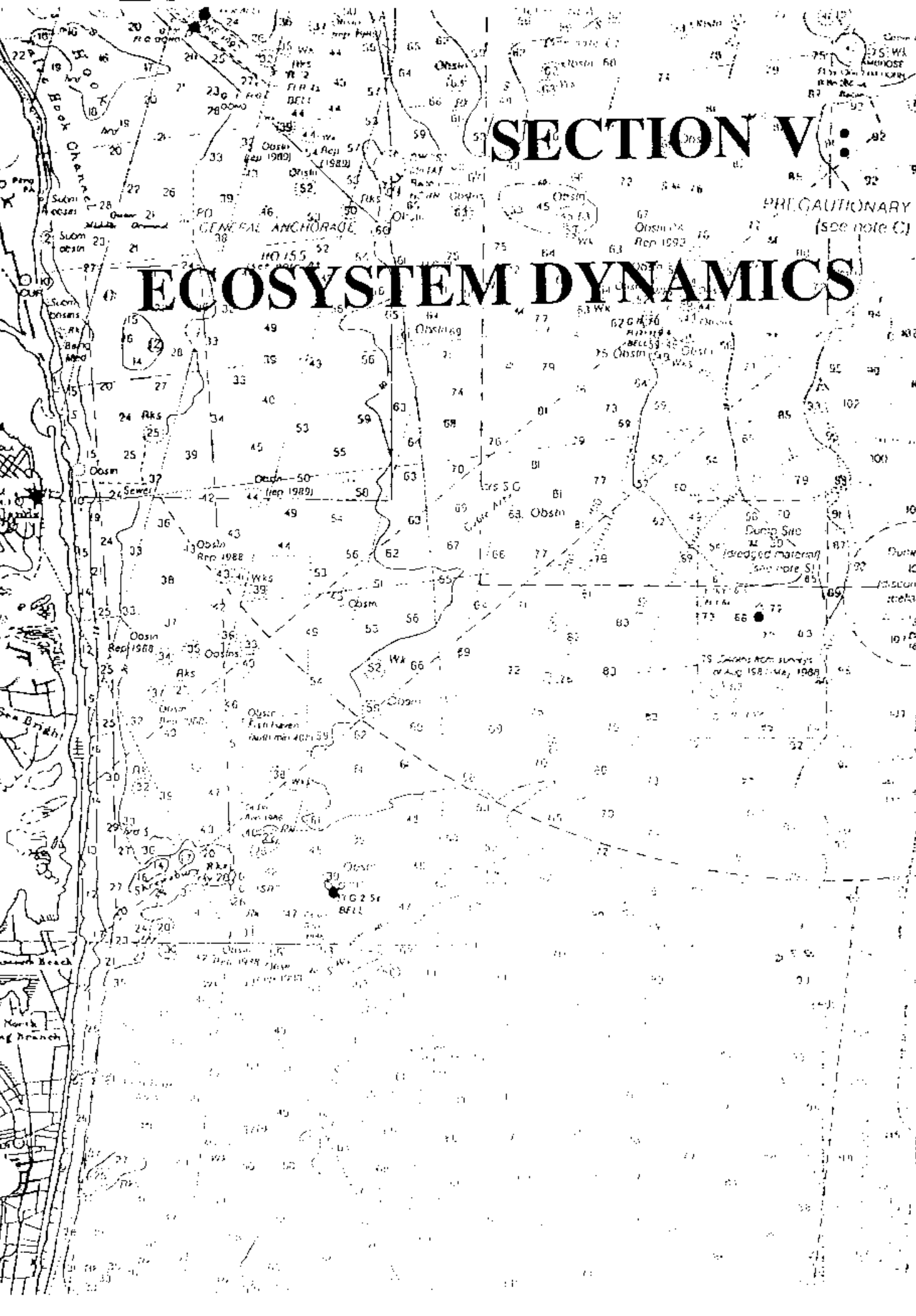
CAUDAL FIN SHAPE

Shape	Function
Rounded 	Large amount of surface area allows for effective acceleration and maneuvering, but creates drag causing fish to tire easily.
Truncate 	Effective acceleration and maneuvering. Not as much drag as a rounded shape.
Emarginate 	Effective acceleration and maneuvering. Not as much drag as a rounded shape or truncate shape.
Forked 	Good acceleration and maneuvering. Less surface area means less drag.
Lunate 	Rigid fin with less surface area means less drag and great acceleration, but decreased maneuvering.

SECTION V

PRELIMINARY
(see note C)

ECOSYSTEM DYNAMICS



ECOSYSTEM DYNAMICS IN THE HUDSON-RARITAN ESTUARY

ECOSYSTEMS

The many land forms surrounding the Hudson-Raritan Estuary create diverse habitats for a variety of plants and animals. Habitats for fish and wildlife include salt and freshwater tidal marshes, shallow bays, barrier beaches and dune systems. Estuaries are nutrient traps and are therefore highly productive systems. Habitats like salt marshes and sea grass beds benefit from the nutrients trapped there and are themselves highly productive. Many estuarine organisms rely on the productivity and protection of salt marshes and sea grass beds. Over time, many complex interrelationships have evolved.

The diversity of habitats is exemplified by areas that range in size from the 15 acre barrier beach at Nassau Beach in New York, which is a nesting site for least terns and piping plovers, to the 64,000 acre Great South Bay, known for its hard clam resource and over-wintering area for waterfowl. The Piermont Marsh, one of the largest wetland areas on the Hudson River, is an intertidal brackish marsh and providing a significant coastal fish and wildlife habitat on the Hudson River.

LOSS OF HABITAT

Although no scientific data exists on the status of the Estuary at the time of the arrival of the first European explorers, it can be assumed that all major river systems emptying into the Estuary were in a pristine state, with a great variety of fresh and saltwater fish in abundance. From available information, an evolving profile of Hudson-Raritan Estuary over the last 300 years can be reconstructed. The reduction in climax forests was the greatest single change occurring in the Hudson-Raritan watershed. Deforestation and plowing led to increased soil erosion which resulted in higher silt loads and greater flooding in the various river systems, Rising water temperatures, also the result of deforestation, have been noted since pre-colonial times.

In 1609 when Henry Hudson explored the area, much of what is now Jersey City, Hoboken, and Bayonne between the Hudson and Hackensack Rivers was an extensive marsh and sand dune delta interwoven with creeks. Liberty and Ellis Island were called Great Oyster Island and Oyster Island, respectively, because of the extensive oyster reefs that surrounded them. Nineteenth century urbanization and industrialization of the entire New York Harbor area resulted in population increases, pollution and wetland development. The development of the marshes, once considered wastelands, was viewed as beneficial since it provided more usable land. Unfortunately, this uncontrolled wetland filling also caused significant reduction in habitat for birds, fish and shellfish.

Exact estimates of wetland loss within the Estuary are not available, but limited historical information does exist. More than one-fourth of Manhattan Island was made by filling 3,650

acres of marsh and underwater lands. Extensive areas of the Jamaica Bay wetlands have been filled since 1897. For example, channels dredged in Jamaica Bay during the 1950's yielded enough spoil to fill 4,500 acres of wetlands now used as runways at JFK Airport. As a result of wetland filling, the flushing capacity of Jamaica Bay has been reduced from 10 or 11 days to about 35 days. Additionally, many shoreline areas were bulkheaded and filled within the harbor for industrial and residential uses.

In 1925, a soil survey for northern New Jersey identified 31,296 acres of tidal marsh. Fifty years later, less than 8,000 acres remained. Damming of the Hackensack River led to the irreversible demise of the associated cedar swamps. Most recently, development has focused on coastal marshes in southern New Jersey. Nearly 25 % of those marshes were filled between 1953 and 1973. In the 1970's the ecological value of wetlands was recognized prompting protective regulations. New Jersey's Wetland Act of 1970 and New York's Tidal Wetland Act of 1973 provided control over the use of wetlands in both states. Annual losses in New Jersey which averaged 32,000 acres prior to the Act of 1970, have been reduced to 50 acres annually today. New York has reduced its loss completely.

HABITAT CHANGES

In general, two types of habitat modifications, non-reversible and reversible have occurred within the Estuary through recorded history. Changes initiated in the area early in recorded history were primarily non-reversible, while changes occurring in the twentieth century are more likely to be reversible, provided that society is willing to support remedial actions. Examples of non-reversible changes in which there is little chance of changing the aquatic habitat to previous conditions include deforestation of climax forests in the Hudson-Raritan catchment area for agricultural, residential, commercial, and industrial development, draining and filling of marshes and wetlands, and bulkheading along waterfront areas.

Examples of reversible habitat changes include removable piers and wharves, accumulation of old ships and vessels and drifting waste and trash. The discharge of agricultural, residential and industrial wastes such as PCB's, hydrocarbons, organic solvents, nutrients and heavy metals can be gradually reduced, decreased and/or eliminated through the natural flushing capacity of the Estuary.

Some habitat modifications, such as the addition of a pier, can have beneficial effects, adding surface area for attachment of seaweeds and invertebrates, and can serve as habitats for certain species of fishes. However, the use of chemical preservatives or toxic antifouling paints on these submerged structures can be harmful to the same biota.

Food Web

Words to Know:

Anatomical adaptation	Herbivore
Autotroph	Heterotroph
Behavioral adaptation	Mutualism
Benthic	Omnivore
Commensalism	Pelagic
Consumer	Physiological adaptation
Decomposer	Predator
Detritus	Prey
Filter feeder	Producer
Food chain	Specialist
Generalist	Symbiosis
Habitat	Trophic level

Materials:

For this activity you will need a whole class of students, 100 feet of rope, species cards made by the students giving the name of a species, what it eats and who eats it, cut out of poster board. Markers are used to write the information on the cards and scissors used to cut them out.

Activity:

The students select an organism from the Hudson-Raritan Estuary for further study, making sure a variety of different organisms are chosen. The animal is researched enough to classify and describe the animal based on where it lives, how it lives, how it eats, what it eats, who or what eats it, and a picture is drawn. One person needs to be the sun researching why the sun is important to food chains. After the information is gathered, have the students stand in a circle. Hand the end of the 100 ft. rope to the person with the sun. The ball of rope then gets passed to the herbivores or primary consumers that eat autotrophs and so forth until a top predator is reached. The ball of rope gets passed to the organism who is eaten by the top predator back down the food chain until the rope gets to the primary producers. This process is repeated until there is no rope left to be passed around. Then scenarios are created that have an impact on some of the food chains which are connected to the whole food web and a breakdown has a strong visual affect that can be understood by all students.

The Competitive Edge

Words to Know:

Carrying capacity
Competition
Generation
Habitat
Niche
Resource
Theory of evolution

Materials:

For this activity you will need a whole class of students, 120 bite sized pieces of candy or small boxes of raisins (180 pieces, if part II is played), 20 recyclable bags, 8 jackets, 28 paper flags, 16 safety pins, 2 desks or table tops, a tape player and music tape. Octopus' Garden by the Beatles is suggested but any music will do. You will also need a clip board with a note pad and pencil.

Activity:

This activity works best in a large open area or by moving all the desks away from the center of the classroom. Twelve students are selected to be Atlantic Silversides and are given a bag. The bag represent their stomachs and the candy or raisins represent zooplankton, Silversides favorite food. The candy or boxes of raisins are scattered around on the ground or two desk tops. As the music is played, the Silversides try to "eat" or scoop up as much "zooplankton" as they can without taking any away from other Silversides. What has been "eaten" is put in their "stomachs". After all food has been eaten, everyone sits down and takes a look in their bags or "stomachs." The results are recorded on a data sheet. Silversides that ate fewer than 9 zooplankton starve to death. Those that ate 9-11 zooplankton, had one offspring, those that ate 12-13 zooplankton had 2 offspring and those that ate more than 13 zooplankton had 3 offspring. The same eating technique is repeated for the next generation. The game is played until the fourth generation. By then, there are less nutrients in the water, less phytoplankton production, less zooplankton, so only about half of the zooplankton remains to be eaten. The results are recorded. For the fifth and sixth round generations, phytoplankton and zooplankton production is back to normal and all 120 "zooplankton" are used. Graph the results on the blackboard. The number of players go on the y-axis (vertical) and the round (generation) number go on the x-axis (horizontal). The line connecting each round represents the carrying capacity of the environment. Part II is an extension to the game which adds predation to the scenario. Part III is a different scenario. The field is set with two shelters, the jackets are used to represent Hermit Crabs shells (protection from predation), and Blue Crabs try to "eat" the hermit crabs before they "pick up" the protection of their shell. This is a good example to the students of predator-prey relationships and survival of the fittest.

Biomagnification**Words to Know:**

Bioaccumulation
Biodegradable
Biomagnification
Food chain
Food web
Labile
Phytoplankton
Refractory
Trophic level
Zooplankton

Materials:

For this activity you will need modeling clay in assorted colors or 16 small styrofoam balls in assorted colors, 16 large clear baggies, 16-3ft lengths of string.

Activity:

In this activity, 16 students represent zooplankton, four students represent Atlantic Silversides, two students represent Bluefish, and one student represents an Osprey. The styrofoam balls represent different chemical pollutants. The zooplankton have accumulated chemical pollutants in their bodies from filtering the water for phytoplankton. The zooplankton are eaten by the Atlantic Silversides and all the chemical pollutants gets passed on to the fish that has eaten him/her. The Atlantic Silversides gets eaten by Bluefish, and the pollutants get passed on when Bluefish get eaten by the Osprey who has the accumulated chemical pollutants that has been distributed in this food chain.

The Habit of Habitat**Words to Know:**

Adaptation
Estuaries
Euryhaline
Eurytolerant
Habitat
Salt marsh
Stenohaline
Stenotolerant
Threshold
Tolerance
Wetland
Zonation

Materials:

For this activity you will need a trip to the salt marsh, a field notebook or a clipboard with a pad, pencil, several field guide books on; seaside plants, birds, invertebrates, and fish. The Peterson Field Guide series are the best choice.

Activity:

While at the salt marsh, you will make several observations: the habitats or zones, the tide, the plants, the birds, the weather conditions, the shells, the animal life, any debris and recording in the field notebooks all that is observed. The elements necessary to a habitat are air, food, water, shelter, and space. Knowing that, students make notes of where in the salt marsh each organism is located, how tolerant the organism is of being exposed to salt water, and details of how the organism looks. For Activity Two, students look at salinity tolerances for different animals. Using a field guide book as reference, the Latin names of species are given and the common name has to be looked up and written.

Food Web

Objectives:

- 1) You will learn some of the food chains of estuarine communities.
- 2) You will learn that estuarine food chains are complex, and estuarine organisms are highly interdependent.
- 3) You will identify what happens if there is a breakdown in the food web due to **anthropogenic effects** (eg. pollution, overfishing, habitat, destruction, etc.)
- 4) You will learn how changes in estuarine communities caused by humans affect food chains and other interactions between organisms.

Background: Water circulation in estuaries is restricted because they are enclosed embayments. This retains nutrients and organic matter necessary for growth, making it a highly productive ecosystem. This is one reason why salt marshes can exist in estuaries. Salt marshes themselves are the most productive habitats in estuarine ecosystems. The high productivity in estuaries begins with the **primary producers** such as phytoplankton, salt marsh grasses, sea grass, and algae. Of these, phytoplankton and **detritus** from salt marsh grasses form the most important food chain bases. Generally, there are five **trophic levels** in the Hudson-Raritan Estuary food web. The primary producers make up the first trophic level, the **primary consumers** which eat the primary producers make up the second trophic level, the secondary **consumers** which eat the primary consumers make up the third trophic level, and tertiary and quaternary consumers make up the fourth and fifth trophic levels. All the organisms in the Estuary are highly interdependent, and a change in one population will always affect other populations.

Words to Know:

Anatomical adaptation
 Anthropogenic effects
 Autotroph
 Behavioral adaptation
 Benthic
 Commensalism
 Consumer
 Decomposer
 Detritus
 Filter feeder
 Food chain
 Generalist
 Habitat
 Herbivore
 Heterotroph
 Mutualism
 Omnivore
 Pelagic
 Physiological adaptation
 Predator
 Prey
 Producer
 Specialist

Symbiosis

Trophic level

Materials:

100 ft. rope
 Poster board, Markers, Scissors

Activity One:

- 1) Look up or review the **“Words to Know”**: before starting this activity.
- 2) Select an organism from the Hudson-Raritan Estuary for further study, making sure a variety of different kinds of organisms are chosen (eg. phytoplankton, zooplankton, blue crab, striped bass, osprey, humans, flounder, grass shrimp, etc.). Make a list of the organisms that it eats. Research the animal you have selected enough to classify and describe the organism based on where it lives, how it lives, how it eats, and what it eats. One person should select the sun. The person researching the sun should study why the sun is important to food chains.
- 3) Draw a picture of the organism you studied to fit on a card approximately 6"x8" made out of

poster board. Write the common and scientific names on the card next to the picture, and write what it eats and what eats it on the back. Each person should in turn present their findings, and as the information is presented, each person will check their information making sure it includes what their organism is eaten by.

4) Have everyone stand in a circle, and hand the end of the 100-ft. rope to the person with the sun. The ball of rope should then be passed to an **autotroph**, with the rope stretched tight between them. The rope then gets passed to the **herbivores** or primary consumers that eat the autotroph, and so forth until a top **predator** is reached. When the ball of rope gets passed to the organism who is eaten by the top predator, head back down a food chain until the rope gets to the primary producers. This process is repeated until there is no rope left to be passed around.

Notice how the term food chain is an oversimplification of trophic interactions in estuaries. What is really going on is a food web.

5) Choose one of the following situations below and discuss what happens to the food web as each scenario occurs. Will other populations grow or decline? Will organisms be forced to change their diet? Leave the area? Are the changes observed physiological or behavioral adaptations?

a) Choose one commercially important fish species. Fishing is often enough to significantly reduce fish populations because of the high demand for fish for human consumption and because new fishing technology is so efficient. Suppose that bluefish are overfished and eliminated from the area (the person holding the bluefish card drops his/her piece of rope). What happens to the populations of organisms eaten by bluefish? What happens to the organisms that eat blue fish? If there is an organisms that eats **only** blue fish, what happens to that organism and why?

b) Choose a bivalve. Suppose a strange shellfish disease sweeps through the area killing this bivalve (the person holding that card drops his/her piece of rope). Answer the same questions as answered in part "a".

c) Suppose there is a dangerous red tide (phytoplankton bloom) because of too many nutrients in the water. All the fish are killed (all

people with fish cards drop their piece of rope). What happens to organisms at the other trophic levels?

d) Suppose there is an oil spill. Most organisms survive the initial effects of the spill, but all the birds get covered in oil and die from exposure (all people with bird cards drop their piece of the rope). Again, what happens to organisms at other trophic levels? What would have happened to fish populations if the **fish** had not been killed by the red tide?

Discussion:

1. What happens to the food web as each scenario occurs?
2. How are all levels of the food web affected by a change at one trophic level?
3. Name the various ways in which organisms sharing a habitat interact. Hint: There are six listed in the "**Words to Know**" section.
4. Find examples of each of these relationships in the Hudson-Raritan Estuary and write a one-page report on the nature of these relationships.

Some suggested organisms for this activity:

Phytoplankton
Zooplankton
Sea Lettuce
Capitellid Thread Worm
Fan Worm
Sand Worm
Blood Worm
Hard Clam
Soft-Shelled Clam
Common Periwinkle
Oyster Drill
Northern Moon Snail
Northern Rock Barnacle
Sea Roach (Isopod)
Hermit Crab
Grass Shrimp
Sand Shrimp
Mud Crab
Blue Crab
Northern Lobster

Horseshoe Crab
Boreal Asterias
Little Skate
Atlantic Silverside
Mummichog
Striped Killifish
Bay Anchovy
Sea Robin
American Eel
Menhaden
Weakfish
Summer Flounder
Winter Flounder
Threespine Stickleback
Bluefish
Striped Bass
Piping Plover
Ring-Billed Gull
Snowy Egret
Great Blue Heron
Osprey
Humans

Biomagnification

Objective: 1) You will be able to understand how and why poisons in the environment accumulate in organisms higher in the food chain.

Background: The natural shoreline of the Hudson-Raritan Estuary has been changed drastically by humans from forests and tidal wetlands to residential communities, industrial areas, ports and cities. Human activity has also dumped pollutants of all kinds into the local waters from quickly **biodegradable** organic pollutants like sewage to nondegradable chemical pollutants like the pesticide DDT. This is a problem in estuaries, which, by nature, trap pollutants. Sewage and nutrient pollution results in algae blooms, low dissolved oxygen and pathogenic bacteria, but the effects are relatively short-term provided the source of the problem is eliminated. More refractory materials remain in the estuary for very long periods of time because they are not used up or degraded, and they are either buried as they bind with sediment particles and sink to the bottom, or they enter the food web. Chemicals that initially enter the food web through air, water, or sediment will accumulate at one level of the food web. Water-soluble chemicals will accumulate in food webs until they reach a concentration in organisms bodies that is in balance with the environment. Fat-soluble chemicals bind to fatty tissues in organisms as they are ingested. Because organisms at higher trophic levels must eat a large number of organisms at lower **trophic levels** to get enough food, these chemicals tend to become **bioaccumulated** in organisms' bodies as they get passed up the food chain.

Words to Know:

Bioaccumulation
Biodegradable
Biomagnification
Food chain
Food web
Trophic level

Materials:

Modeling clay in assorted colors or 16 small
Styrofoam balls in assorted colors
16-Large clear bags
16-3ft lengths of string
23 students

Activity One:

1) Take a piece of string and attach a bag to the string so that it forms a pouch when tied around your waist.
2) Form the clay into small balls and allow these or the styrofoam to represent different chemical pollutants. More advanced students with a background in chemical bonds and molecules should try to create a DDT molecule using the

balls and the toothpicks to emphasize how complex the more refractory pollutants are.

3) Have the class divide into groups that represent organisms at different trophic levels. Because consumers must expend energy to obtain food and maintain their bodies, and because some food is lost as waste material, it takes more organisms at lower trophic levels to nourish organisms at higher trophic levels. The groups that represent organisms at lower trophic levels should be larger. Have sixteen students represent zooplankton, four students represent Atlantic Silversides, two students represent Bluefish, and one student represent an Osprey.

4) Imagine that zooplankton have accumulated chemical pollutants in their bodies from filtering the water to eat phytoplankton. Each zooplankton at this point should have one or more different colored balls in his/her pouch.
5) The zooplankton are then eaten by the Atlantic Silversides. All chemical pollutants that each zooplankton has accumulated in his/her body (pouch) gets passed on to the fish that has eaten him/her. The Atlantic Silversides now have all

the pollutants in their bodies (pouches).

6) The Atlantic Silversides get eaten by the Bluefish, and the pollutants get passed on to them. Lastly, the Bluefish gets eaten by the Osprey, who now has accumulated all of the pollutants originally ingested by the zooplankton in its body.

Discussion:

Think about the concept of a food pyramid. Discuss the different pathways by which energy is lost from one trophic level to the next (i.e. why larger organisms need to eat more smaller organisms to get the amount of food they need to survive, grow, and reproduce). Discuss how this influences biomagnification.

Extension:

Students who have a background in chemistry and understand chemical bonds and molecular structure could use the colored balls to represent different atoms. The atoms could then be connected with toothpicks to form ball-and-stick models of the DDT molecule. The molecular structure could then be discussed in terms of what makes this molecule refractory and fat-soluble.



Cl

CH

Cl



1, 1, 1-trichloro-2, 2-bis(*p*-chlorophenyl)ethane

Have the colored balls represent the pesticide DDT. Have students research or read about how the biomagnification of DDT in food webs has affected birds. When the Osprey has all the DDT in its body (pouch), discuss the plight of the osprey in the area of the Hudson-Raritan Estuary and why it has only just returned to the area in recent years.

The Competitive Edge

- Objectives:**
- 1) You will be able to use a model of a simple food chain.
 - 2) You will be able to understand how organisms compete for food and shelter.
 - 3) You will be able to explain how the availability of a resource can limit a population which depends on that resource.

Background: All organisms occupy a **niche** in a habitat. The most simple definition of a **habitat** is a place where an organism lives. Therefore all the things an organism needs to live must be contained in a habitat. The essentials are air, water, food, shelter, and space. These essentials are called **resources**. Resources, however, are not unlimited. There is only so much food and space available on this earth, and in each habitat, and only a certain number of organisms can be supported. This is called the **carrying capacity** of a habitat. When the number of organisms has reached carrying capacity, the organisms will begin to compete for resources. Some organisms are better competitors than others, and they will survive while the weaker organisms die. This is the basis of Charles Darwin's **theory of evolution** - "survival of the fittest".

Words to Know:

Carrying capacity
Competition
Habitat
Niche
Resource
Theory of evolution

Materials:

A class of students
120 bite-size pieces of candy (wrapped) or small boxes of raisins
20 recyclable or recycled bags
8 jackets
28 paper flags, 16 safety pins
2 desks
A tape player and a music tape ("Octopus' Garden" by the Beatles is appropriate, but any music will do)
A clip board with a note pad
Pencil

Activity:

This activity is best played outside or in a large open area like a gym. Simply moving all desks and chairs away from the center of the room may suffice if the classroom is large enough.

Part I: Competition for Food

- 1) Select 12 students to be Atlantic Silversides, and give them each a bag. The bags are their stomachs, and the candy or raisins represent zooplankton. Silversides love to eat zooplankton.
- 2) Scatter the candy or raisins around on the ground. When the music starts to play, the Silversides will try to "eat" as much zooplankton as they can without taking any away from any other Silverside. As each Silverside "eats" a "zooplankton", he/she puts it in his/her "stomach". When all the zooplankton have been "eaten", stop the music and have everyone sit down in a circle.
- 3) All Silversides should empty their stomachs on the ground in front of them. Did all the Silversides get the same amount of food? The answer is probably no, some fish are better at searching for food than others. Those that ate more produce more offspring. Record the results on a data sheet. Silversides that ate fewer than nine zooplankton starve to death, those that ate 9-11 had 1 offspring, those that got 12 or 13 zooplankton had 2 offspring, and those that ate more than 13 zooplankton had 3 offspring.
- 4) Repeat the game for the next generation of Silversides. The number of Silversides in this round should equal the number of offspring from the last round. Rescatter the "zooplankton", and

have the new Silversides “eat”. Record the results again and repeat the game again.

5) For the fourth round generation, pretend that there were less nutrients in the water. There was less phytoplankton production, and therefore there was less zooplankton production because zooplankton eat phytoplankton. Remove half of the zooplankton, and repeat the game. For the fifth and sixth round generations, phytoplankton and zooplankton production returns to normal and all 120 “zooplankton” are used.

6) Back in the classroom, graph the results on the blackboard. Plot the number of players (Silverside offspring) on the y-axis (vertical) and write the round number (generation) on the x-axis (horizontal). The number of players initially should be marked at zero along the x-axis, the number of offspring from the first round of the game at round (generation) 1, and so forth. Draw a dotted line across the graph representing the carrying capacity (K) of the environment. This is the number of organisms that can be supported at any point in time. For generation 4, $K=6$, and for all other generations and the initial population, $K=12$.

Discussion:

Discuss how the numbers of offspring relate to the carrying capacity of the environment. Even though there was enough food at first for all of the Silversides, some were better at competing for food than others, and they used this extra food to reproduce. The better competitors had more offspring. If this trick or adaptation is inherited, the next generation will also be better at finding food, and more animals in the next generation will be more fit competitors because the better competitors have more offspring.

Part II

1) Go back outside for two more rounds. There is no need to record results this time. For the first round, start with twelve Silversides. Have two people represent Bluefish that prey on the Silversides, and have one side of your field represent saltmarsh cordgrass which provides a good hiding spot for the Silversides. Mark this side of the field with two desks. Once a Silverside passes between the two desks, it cannot

be eaten by a Bluefish. Once again, scatter the “zooplankton” on the field and begin to play. This time, each Silverside has a paper flag pinned to his/her back, which the Bluefish try to tear off. If the Bluefish tears off a Silverside’s flag, the Silverside must give the Bluefish his/her “stomach” and leave the playing field. When all the food is gone, stop the music and count the number of offspring each surviving Silverside had. How did predation on the Silversides reduce competition for food among Silversides?

2) For the final round, increase the number of zooplankton to 180 and keep the number of Silversides at 12. There will be no predators for this round. Scatter the food over the field and play again. Count the number of offspring produced. Did the number of offspring increase toward the new carrying capacity of the environment (**18**)? If you like, play enough rounds to get the population to meet environmental carrying capacity.

Part III: Competition for Shelter

1) Set up your playing field for a different scenario. Place two desks at opposite ends of the field as shelter. Each shelter is only large enough for two organisms, but these two organisms are safe from predators when in the shelter. Scatter eight jackets around the playing field. Have three students playing Blue Crabs ready to eat newly settled Hermit Crabs.

2) Select sixteen students to play Hermit Crabs that have just settled out of the plankton. These Hermit Crabs need to find shells (jackets) to live in to protect them from being eaten by predators. Each Hermit Crab has a flag pinned to its back, representing its life.

3) Begin playing the music, and have the Hermit Crabs move out onto the field. The Hermit Crabs need to find shells (jackets) before they are eaten by the Blue Crabs. Meanwhile, the Blue Crabs try to take the flags off the Hermit Crabs’ backs. If a Hermit Crab loses his/her flag, he/she must leave the field. When all jackets are gone, all shelters are occupied, and there are no more hermit crabs to be eaten, turn the music off and end the game.

Discussion:

1. How does this activity relate to the real life situation?
2. Discuss how the more fit Hermit Crabs found shelter and escaped being eaten.
3. How does predation pressure help prevent the number of organisms exceeding environmental carrying capacity?

The Habit of Habitat

- Objectives:**
- 1) You will know what a habitat is.
 - 2) You will be able to describe how a habitat is defined.
 - 3) You will understand how the characteristics of estuarine habitats affect what organisms live in it.

Background: Estuaries are places where saltwater and freshwater meet and mix, where land meets water, where there is variable wave action, and where a wide range of extremes exist. All these factors contribute to the wide variety of habitats found in estuaries. You probably already know that a **habitat** is a place where organisms live, and it is usually described by the dominant life form (eg. sea grass meadows) or a defining physical parameter (eg. intertidal zone). Habitats are in fact defined by a multitude of different physical environmental parameters. In estuaries, some of those parameters include salinity (fresh to marine), bottom type (hard substrate or sediment), sediment type (sandy or muddy), coverage (vegetated or un-vegetated), tidal influence (intertidal or subtidal), water depth (shallow or deep), or wave energy (high or low). The reason physical parameters are used to define habitats relate to organisms **adaptations**. Physical parameters influence where an organism lives as determined by the organism's **tolerance thresholds**. A habitat is also defined by the organisms using it. For example, the osprey may utilize all aspects of a salt marsh, thereby defining the entire salt marsh as its habitat. On the other hand, salt meadow hay (*Spartina patens*) can only be found in the high intertidal zone, so the upper part of the low marsh is its habitat. Different salt marsh habitats exist in part because of the amount of time that area of the marsh is covered by water. This tidal influence is responsible for how organisms use a habitat and results in **zonation**. Zonation reflects the different tolerances of plant and animal species to salt water.

Words to Know:

Adaptation
Estuary
Euryhaline
Habitat
Salt marsh
Stenohaline
Threshold
Tolerance
Wetland
Zonation

Materials:

Several field guide books with at least one for each of the following categories: seaside plants, birds, invertebrates, and fish (the Peterson Field Guide series is best)
Field notebook or a clipboard with a pad
Paper and pencils

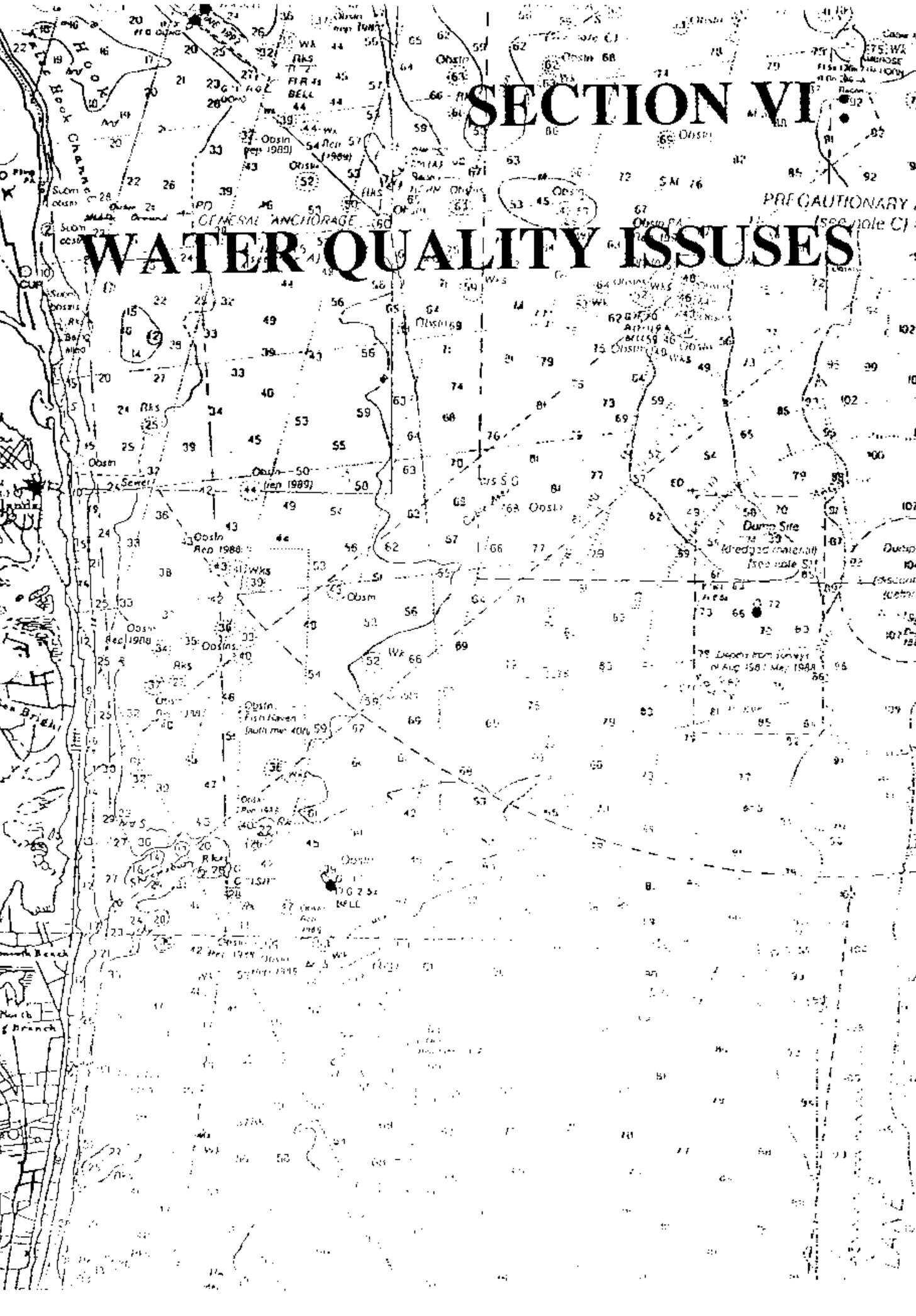
Activity One:

- 1) Take a trip to a salt marsh. Make observations about the habitats or zones, the tide, the plants, the birds, the weather conditions, the shells, the animal life, and any debris. When you are hiking near the marsh, how many habitats or zones do you see at first glance? What makes these habitats different? Where are the mean high tide line and the mean low tide line? How can you locate them?
- 2) Recall the elements necessary to have a habitat - air, food, water, shelter, and space. Identify as many plants and animals as you can using your field guides without disturbing the marsh. Make note of where in the salt marsh each organism is located. Speculate on how their habitat provides the five requirements, and how tolerant the organisms are to being covered with salt water. For example, fish and seagrass need to be covered by water all the time, so they are only found in the marsh creek. Meanwhile,

bayberry and beach plum can only tolerate exposure to saltwater spray, so they are found in the high marsh.

SECTION VI

WATER QUALITY ISSUES



PRECAUTIONARY (see note C)

Dump Site (redged material) (see note C)

Deposits from surveys of Aug 1961, May 1968

WATER QUALITY ISSUES

Although water quality varies greatly, it is clear that the waters of the Hudson-Raritan Estuary have been substantially impacted by contaminants attributable to urban development. Water quality conditions are especially varied because the area is home to a major seaport, large industrial complexes and residential and commercial facilities serving large industrial and domestic needs. Consequently, much of the Hudson-Raritan Estuary is not considered fishable or swimmable.

Many sources contribute to the pollution of the Hudson-Raritan Estuary. Some contaminants enter the Hudson-Raritan Estuary from the rivers and streams that drain into this watershed. Some enter the Estuary directly from outfalls, runoff, and rainfall. Rainfall and runoff are major source of water for the Hudson-Raritan Estuary. The old view that rainwater is a substance of high purity has been displaced in the past twenty years by the realization that pollutants in the air are incorporated into rain. Resulting precipitation can carry significant concentrations of these pollutants.

Major sources of pollution include controlled point sources, such as from industry and sewage treatment; uncontrolled point sources, such as combined sewer overflows and storm sewer discharges; non-point sources, such as urban and agricultural runoff; dredging; leachate from landfills; chronic and acute spills of oil and other contaminants; thermal pollution and air pollution deposition from nearby and distant locations. Floatable debris from various sources is a visible problem. The extent of illegal dumping is unknown, but may be significant.

FLUSHING CAPACITY AND POLLUTANT TRANSPORT

Freshwater flow is one of the mechanisms that transports pollutants within and out of the system. Large amounts of pollutants are brought to the Estuary from upstream sources. The movement of waters between various bodies of water within the Estuary governs the probable paths of pollutants that are discharged from various point and nonpoint sources. Movement of water in, out, and through the Hudson-Raritan system affects water quality. Circulation within the Hudson-Raritan Estuary, the transport of material through the Estuary, and the exchange of the estuarine water with the Atlantic Ocean are complex processes. The time scale of these varies from a few hours to several months. The irregular form and depth of the Estuary contribute to the complexity of all water quality issues. Sea level variations at the Estuary's connections with the open ocean, regional and local winds, and freshwater discharge are additional contributing factors.

The physical and chemical characteristics (shallow depth, poor circulation, and mixing of fresh and saltwater) cause pollutants to be flushed relatively slowly. There is a tendency for pollutants to settle to the bottom. The most critical period for water quality occurs during the summer months. At this time, river flows are at minimums, causing low flushing capacity in the system. Water temperature is at a maximum, causing lower saturated oxygen levels and higher biological productivity.

INDICATORS OF DEGRADATION

Although much of the Estuary's water quality is good enough to support a healthy, diverse population of aquatic organisms, pollution and overuse of the Hudson-Raritan Estuary cause many problems. In some cases pollution impairs human use of the Estuary. In other cases pollution damages the health and functioning of the estuarine ecosystem. Evidence of ecosystem stress in the Hudson-Raritan Estuary includes chemical contamination, fishery closures, fish consumption advisories, fish diseases and fish kills, changes in the distribution and abundance of living organisms, eutrophication and algal blooms, bathing beach closures, and aesthetic degradation.

CHEMICAL CONTAMINATION

- . Many estuarine systems in the United States are used as depositories for toxic and non-toxic waste. These chemicals enter the system from sewage, industrial, and non-point sources. The Hudson-Raritan Estuary is no exception and is continuously exposed to varying concentrations of chemical mixtures.

Chemicals considered to be contaminants in an estuarine environment are contained in three basic reservoirs: water, sediment, and biota. The biota reservoir is extremely important since organisms in an estuary can be adversely affected, and human health hazards can arise through consumption of the affected organisms. The quantity of the contaminants in the biota reservoir is small, however, compared to the water reservoir which, in turn, is much smaller than the sediment reservoir. The consequence of this hierarchy is that, at any point in time, the great majority of contaminants in an estuary reside in the sediments.

Reports of chemical pollution in Hudson-Raritan Estuary sediments have identified metals, petroleum hydrocarbons, pesticides and halogenated hydrocarbons as the major contaminants. Trace metal contaminants include high concentrations of zinc, copper, lead, cadmium and mercury. The sediments act as a sink or reservoir for both heavy metal and organic contaminants, taking toxic chemicals from the water column and releasing them when environmental conditions are suitable. Sediments in many parts of the Estuary are also heavily contaminated with oil and grease. Newark Bay and the Arthur Kill appear to be the most severely contaminated. Within Newark Bay the highest concentrations occur in the vicinity of the mouths of the Passaic and Hackensack Rivers and the Arthur Kill.

The salt marshes which still exist along the shoreline of the Estuary appear to have become sinks for heavy metals. Extremely high concentrations of metals have been found in marsh sediments along the Arthur Kill, yet the creeks draining these marshes do not appear to be exporting the metals. The Harbor is the ultimate sink for toxins associated with sediments for the entire Hudson/Mohawk basin within New York State. Similarly, Passaic River sediments are believed to be a major source of dioxin to the area. Many of the contributing industries (e.g., metal refineries) no longer exist but their discharged wastes still remain within the sediments. Sediments in this case, are the memory of past abuses.

Unfortunately, many sources of pollutants are still present. Point and nonpoint discharges and other inputs continue to contaminate sediments. Ocean disposal of dredged material and sludge may also impact the area.

Raritan Bay is one of fifty national sites studied in the National Oceanic and Atmospheric Administration (NOAA) National Status and Trend Program for marine environmental quality. Sediments were analyzed for various metals, pesticides, PCBs, PAHs and sewage-by-products. Of the sites monitored throughout the country, the sediments of Raritan Bay had the fifth highest PAH (polyaromatic hydrocarbons) levels and the third highest PCB and DDT levels.

One of the most important questions concerning the sediments of the estuarine system is whether the contaminants contained within them can be released. Much of the Hudson-Raritan system consists of relatively shallow water where bottom sediments are subject to tidal currents, storms, waves, and boat propellers. Studies have shown that dredging of the shipping channels, agitation of sediments, and mild oxidation will cause the release of contaminants from sediments. Human-induced changes in the Estuary have the potential to increase the natural processes which can release metals and organic contaminants from the sediments. One decision which must be made is whether the release of contaminants can be tolerated. At this point, data is not adequate to indicate the rates of introduction of the various contaminants into the water column and whether they will then pass out of the system quickly enough not to affect the biota. The release may not occur at a high enough rate to warrant concern. However, it should be investigated before large-scale efforts are launched which would affect the present equilibrium in the system.

Sources which contribute to the high levels of these toxic metals in the Estuary include wastewater discharges, urban runoff, atmospheric pollutants, accidental spills, landfill leachate and tributary discharges. Wastewater might be the major contributor of most types of pollutants, but in some cases other sources are equally important. Innovative management strategies must be explored to control these sources.

FISHERY CLOSURES AND ADVISORIES

Seafood suffers contamination from two major classes of pollutants - toxic chemicals and pathogens. Evidence of such contamination may result in closure of shellfish beds or fishing grounds and the issuance of advisories about eating certain species. Health advisories seek to limit the number of fish eaten and may reduce consumption completely by creating the impression that eating fish is harmful. Several commercially and recreationally important species in the Hudson-Raritan Estuary have become unmarketable due to public concern about the accumulation of contaminants in their tissues and the resulting concern that eating them would pose a health risk to human consumers.

Toxic chemicals may present a health risk to people who consume contaminated fish and shellfish. PCB's and dioxin appear to be the major toxic chemicals contaminating finfish in the Hudson-Raritan Estuary. Fish become contaminated by ingesting tainted water and/or

food, or directly through gills and skin. Exposure to contaminated sediments also has an adverse affect on fish. Levels of contaminants found in fish are regulated by the species' fat content and amount of exposure to the contaminant in question. However, the effects of the chemicals on the fish themselves is not well understood. Studies have shown a reduction in egg hatchability and an increase in egg and larval abnormalities because of elevated pollutant levels. Metals also tend to accumulate in crustaceans. For example, cadmium levels are high in the hepatopancreas of blue claw crabs caught in the Hudson River by the Tappan Zee Bridge. PCB's and dioxin also accumulate at high levels in the hepatopancreas of lobsters from this area.

Because of chemical contamination, stringent consumption advisories have been required for many important commercial and recreational species. In New York State, the advisory suggests limiting consumption of any fish caught in New York waters to one meal per week. New York and New Jersey have issued advisories limiting consumption of bluefish, striped bass, and American eels caught in the Hudson-Raritan Estuary. In New Jersey, channel catfish are subject to an advisory and in New York, an advisory against consuming the hepatopancreas portion of lobsters and blue crabs, known as the "mustard" or "tomalley, has been issued.

The closure of fisheries due to polychlorinated biphenyls (PCB) and dioxin contamination has had major economic impact. Closure of shellfish beds due primarily to fecal contamination is another major loss of economic value in the Estuary. Shellfish concentrate bacteria and other pathogens during their normal feeding process. If these shellfish are consumed by humans, it may cause disease.

Contamination of shellfish by pathogens in the Hudson-Raritan Estuary is caused mainly by sewage and nonpoint source pollution. In recent years the contamination has declined slightly as the number and quality of sewage treatment plants have increased. On the other hand, contamination from stormwater runoff appears to be increasing. At present, shellfish beds in the Estuary are closed to harvest with the exception of some beds in Raritan Bay, Sandy Hook Bay, and the Shrewsbury and Navesink River system which are open for harvesting with the condition that the shellfish be depurated in clean water for a period of time to allow them to rid themselves of pathogenic contaminants.

FISH DISEASES AND FISH KILLS

For finfish and invertebrates remaining in the system, elevated incidence of a variety of diseases, both infectious and non-infectious, have been reported. Pollution weakens these organisms, making them more susceptible to infections and other diseases. Certain hardy species in the Estuary, such as softshell clams, grass shrimp and killifish, seem to have adapted to the polluted environment by becoming resistant to certain chemicals. However, for other species, lifespans and adaptability to environmental variables has been reduced. Although there is some evidence of disease in fish associated with pollution in the Hudson-Raritan Estuary, additional research is needed to identify the types, combinations and

concentrations of pollutants contributing to physiological stress in fishes.

Fish and shellfish in the Estuary may suffer from a variety of diseases including fin rot, shell disease, tumors, and ulcers. Shell disease, a natural occurrence affecting lobsters, crabs and shrimp, is more widespread and severe in polluted areas. Other diseases, associated with pollution are caused by viruses and bacteria. Diseases include lymphocystis, a herpes-like virus, vibriosis, shell disease, fin rot, skeletal anomalies, and "black gill". Neoplastic diseases include epidermal papilloma, stomatopapilloms and hepatoma. In each of these cases, the prognosis for the afflicted animal varies. Some diseases are fatal while others have little effect on their hosts.

"Fish Kills" affecting both fish and shellfish are frequently associated with decreased levels of dissolved oxygen in water. Lowered oxygen levels are often caused by excessive algal growth, stimulated by an oversupply of nutrients such as nitrogen and phosphorus. Although these nutrients can come from natural sources, they are also added to water by sewage and other wastes. Hypoxia or lowered oxygen levels can also be caused directly by decomposition of organic matter. There are many contributing factors to low dissolved oxygen (DO) levels in the area; municipal discharges, incoming biological oxygen demand (BOD) from upstream point and nonpoint sources, combined sewer overflows (CSOs), urban runoff, industrial discharges, landfill leachate, benthic deposits and low flow due to upstream diversions. Dissolved oxygen problems are further aggravated by thermal discharges from non-contact cooling water. Our Estuary is susceptible to DO problems.

Low DO can induce stress in organisms and modify chemical reactions in the water column. Many marine organisms use these waters during critical life stages. Low DO can affect abundance of population, reduce growth rates, and lead to avoidance of an area, placing stress on adjacent areas.

CHANGES IN DISTRIBUTION AND ABUNDANCE OF ORGANISMS

The ecological resources of the Hudson-Raritan Estuary have been negatively impacted by anthropogenic influences such as pollution from industrialization, raw sewage disposal, wetland filling and shoreline alteration, damming, dredging and overfishing. Species that depend on rivers and estuaries are particularly vulnerable to the negative effects of human activities. Available information indicates that the numbers of many species of fish and shellfish in the Hudson-Raritan Estuary region have declined. Some of this decline is due to natural fluctuations and overfishing, but there is evidence that pollution and destruction of habitats are contributing factors.

Sturgeon, smelt, and oysters provided good catches for colonial fishers, but by the late nineteenth century this declined sharply. Between 1900 and 1920, the fisheries collapsed completely. Disease, water pollution and declining numbers of fish due to overfishing and habitat destruction (e.g., dam building) were responsible factors. Oyster beds, once abundant in Raritan Bay, were also destroyed by pollution and overfishing. In the mid-1800's, there

were over 400 boats and 1,000 to 3,000 people employed in the oyster industry. By the early twentieth century few remained.

Paralleling the decline in the oyster industry, studies made during the 1920's recorded considerable reduced species richness due to environmental deterioration. This trend continued and in 1971, 34 of 80 benthic samples taken from various sites within the Estuary appeared totally devoid of benthic invertebrates that are common in similar, less stressed environments.

EUTROPHICATION AND ALGAL BLOOMS

Eutrophication and resulting low dissolved oxygen level affect the biological resources of the Estuary. Overly high nutrient levels allow phytoplankton to grow too much, promoting algal blooms. Algal blooms are always present in coastal waters but favorable winds, water temperatures and an over-abundant supply of nutrients cause population explosions within a single species. Single species blooms, also known as red, green, or brown tides depending upon the species involved, may discolor water or cause it to smell.

In Raritan Bay and nearby waters, there are typically two periods of intense growth of phytoplankton; one in the spring dominated by diatoms and one in summer when a small green alga is most abundant. "Red tides" or blooms of small mobile species called phytoflagellates most frequently occur from late June through August. Most phytoflagellate blooms last from one to two weeks, but may persist for up to six weeks. Initial bloom development is promoted by calm weather. Blooms often spread into coastal waters one or two days later, especially when the Estuary is flushed by substantial rainfalls. These blooms can extend as far south as Manasquan. During years when summertime stratification of the water column develops early (due to wet, warm springs), this may seed hypoxia. Strong stratification prevents mixing of dissolved oxygen from the surface to the bottom waters whereby bottom waters become oxygen depleted. When algae blooms die, they fall to the bottom using more oxygen as they decompose, adding to the problem. Although fish can escape hypoxic conditions by moving to different areas, bottom dwelling shellfish cannot. An event of this type occurred in 1976 destroying most of the surf clam populations off New Jersey.

Blooms causing water discoloration have occurred for the past 25 years along the shores of New Jersey and New York. Factors contributing to these blooms include warm temperatures, ample sunlight, an abundance of nutrients (especially nitrogen and phosphorus) in these waters, and quiescent weather conditions allowing cells to concentrate. Wastewater contributes about two-thirds of these nutrients and urban and agricultural runoff contributes the rest. Extensive algal blooms will continue to occur as long as favorable blooming conditions prevail. Much of the Hudson-Raritan system has high nutrient levels, especially the Arthur Kill, Kill Van Kull, East River, and Newark Bay. This region is considered eutrophic, subject to algal blooms and low dissolved oxygen levels.

Reductions in nutrient levels both in the Hudson-Raritan and along the coast would lessen the

frequency and severity of blooms, as well as resulting dissolved oxygen problems. Since phosphorus is easier and less expensive to control than nitrogen, nutrient reduction programs often concentrate on phosphorus. However, phosphorus control alone may not have the desired result. A recent study indicated that phosphorus removal in the Hudson-Raritan would reduce algal growth there and in adjacent coastal waters.

BATHING BEACH CLOSURES

Beaches are scattered throughout the Hudson-Raritan Estuary from New York City to the Raritan Bay and Sandy Hook Bay shorelines. Floatables and pathogens are two major causes of beach closures. Floatable debris has been a major cause of beach closures in recent years. Materials such as styrofoam, paper products, wood, tar balls, sewage, and medical wastes frequently wash up on beaches. This debris comes from a variety of sources such as overflow of sewers that carry both stormwater and sewage, stormwater discharges, commercial and recreational boat traffic, beach users, and accidental releases from sewage treatment plants or solid waste transfer operations.

Pathogens are disease-producing organisms such as certain bacteria and viruses. They are present in sewage and in runoff from land. Health authorities measure levels of coliform bacteria as an indicator of pathogen contamination. Even though few serious illnesses from water contact have been reported in recent years, elevated coliform bacteria levels indicative of pathogen contamination can cause beach closures. Although a significant portion of the Estuary could be used recreationally, high bacteria levels caused by the discharge of inadequately treated sewage and discharges from combined sewer overflows and storm sewers have often prevented swimming. Aesthetic pleasure derived from the estuarine environment may be decreased as a result of many factors. Debris in water and on beaches, unpleasant sights and smells due to algal blooms, noxious conditions and fish kills caused by lack of oxygen in the water all detract from the recreational potential of our Estuary.

Variations in Water Quality

Words to Know:

Turbidity
Clarity
Patterns

Materials:

For this activity you will need a salinity test kit, hydrometer or refractometer, pH paper, LaMotte or Hach Company test kits for dissolved oxygen, pH and salinity, non-glass thermometers, clear plastic bottles or jars, safety goggles, buckets, watch with a second hand, secchi disk or white meter stick, sieves, dip net, notebook, pencils, topographic and or land use maps and a trip to a location along the Hudson-Raritan Estuary any time of the year.

Activity:

For this activity the students need to be familiar with all water quality testing equipment. Be sure to take time to prepare a water quality testing plan and learn how to read and interpret results. Implement safety procedures. Follow the directions that come in the LaMotte or Hach water quality test kits. The students need to develop a data sheet for field work. Some of the things on the data sheet would include: observer's name, site location, data, time, rainfall, weather conditions, tidal stage, wind direction, temperature, salinity, dissolved oxygen, and wild life observations. This is an exercise used to develop the use of scientific observational skills, data recording, and water quality issues in the Hudson-Raritan Estuary.

Point and Non-point Pollution Involvement

Words to Know:

Point sources
Non-point sources
Pollution
Pollutants
Waterways

Materials:

For this activity you will need soil test kits (local garden center), poster board, video camera and tape, Styrofoam pellets, small aquarium, spoon, and various floatable and non-floatable objects.

Activity:

The students have an opportunity to do research into local pollution from public, private, and industrial sources, to perform a soil test to tell the pH and nutrient levels present in the soil, and develop a plan for responsible lawn care. In the form of posters, radio broadcasts, mailings, newspaper articles, or even a video, the students have the opportunity to educate the community. For Activity Two the students place various objects into a small aquarium, use a spoon to push the objects around and observe what happens. This activity helps students to learn what happens to trash that gets discarded overboard from a vessel, what affect wave action has on floatables, and how some things get suspended in the system.

Nutrients- Too Much of a Good Thing

Words to Know:

Eutropic
Eutrophication
Nutrients
Hypoxia

Materials:

For this activity you will need five one-quart glass jars, Estuary or aquarium water, fertilizer, and several weeks to complete this activity.

Activity:

In this activity the students observe first hand what happens when water contains too many nutrients. Jars are labeled one through five with varying levels of nutrients added to each jar and the results are observed over time. This activity uses long term observational skills and data recording.

Oil spill Clean up

Words to Know:

Absorption
Skimming
Coagulating
Sinking

Materials:

For this activity you will need paper towels, straw, styrofoam pieces, twigs tied together, detergent, sand, a small fish net, basins of water and oil, feathers, shells, and fur.

Activity:

This activity compares various methods used in cleaning up an oil spill. The students get to study the various methods of oil spill clean-up available, then, using basins filled with water, experiment by creating an oil spill and determining the best method to clean it up.

Plastic and Fish

Words to Know:

Decay
Environment
Hypothesis
Impact
Microhabitat
Non-biodegradable

Materials:

For this activity you will need a collection of plastic waste from home from over a two day period.

Activity:

The plastic waste materials brought in from home are separated into categories and classified in terms of how they might be perceived by aquatic wildlife. The students make a hypothesis about how these materials might affect aquatic animals and those affects are checked with current findings. The school ground or community gets surveyed for plastic litter and an action plan is developed that will increase awareness of the problem, including setting up a plastic recycling depot. This activity helps students to become aware of plastic waste materials, to get involved in educating the community, and to help solve the plastic waste material problem.

Variations in Water Quality

- Objectives:**
- 1) You will be able to investigate variations in water quality by water sampling.
 - 2) You will be able to interpret data collected.

Background: Determining what actually constitutes water of good quality is quite difficult. Many factors, including dissolved oxygen, bacterial content, **turbidity** or **clarity**, sedimentation rates, salinity, pH and temperature are measured in water quality research. To be valuable, data from a location must be compared with many other measurements over previous seasons in order to observe trends which might indicate a change in quality. In addition to being measured over time, these factors must be measured at various depths and locations. Indicator species-plants and animals associated with water of various quality- are also useful in evaluating water. Dissolved oxygen is an important indicator, since most species require oxygen. Sometimes oxygen levels can drop dramatically because of sudden algae population explosions or blooms caused by excess nutrients. In daylight, the algae produce more oxygen than they consume. However, such blooms usually result in a net loss of oxygen, since oxygen continues to be consumed by algae during the night. Estuaries are particularly vulnerable to low dissolved oxygen in summer, when warmer water, which holds less oxygen than cold water, promotes algae growth.

Words to Know:

Turbidity
Clarity
Patterns

Materials:

Salinity test kit, hydrometer or refractometer
pH paper
LaMotte or HACH company test kits (dissolved oxygen, pH, salinity)
Non-glass thermometers
Clear plastic bottles or jars
Safety goggles
Buckets
Watch with second hand
Secchi disk or white meter stick
Sieves
Dip net
Notebook, Pencils
Topographic and or land use maps
Trip to a location along the Hudson-Raritan Estuary

Activity:

1) Before the trip prepare a water quality testing plan. Water quality testing usually involves the

use of chemicals and chemical testing procedures. Before attempting these activities you need to become competent with the specific kits you will be using, learn how to read and interpret results, and be prepared to implement appropriate safety procedures. Follow directions that come in the LaMotte or HACH company water quality test kit.

2) Develop a data sheet for field work. The data sheet should include: pH, temperature (in degrees C or F), salinity, dissolved oxygen (DO), and answer the following questions: is the water tidal or nontidal?, if tidal, what was the tidal stage at the time of water testing? You can also include turbidity of the water. Develop ideas of how to detect if pollution is present.

3) Visit the test area to become familiar with the aquatic environment and select at least two test sites. Try to visit the test areas twice during at different seasons and compare the test results. Save the results and compare with other test results.

4) At the test site you will record the following information: observer's name, site location, date, time, rainfall, weather conditions, tidal stage, wind direction, water transparency (turbidity),

water depth, water temperature, salinity, dissolved oxygen, algae bloom index value (0-4), submerged aquatic vegetation index value (0-2), and any wild life observations. Look for **patterns** and trends.

Discussion:

1. Do you get different results at different sites and dates?
2. What negatively impacts the local environment? What cancels out or compensates?
3. What improves the local environment?
4. What goes into the water? The air? The earth?

Point and Non-point Pollution Involvement

- Objectives:**
- 1) You will learn that pollution problems may begin in your home town.
 - 2) You will discover that floatable debris can be stopped at its source because unlike some forms of pollution, this problem begins at home.
 - 3) You will be able to identify specific action you can take to help remedy the problem and educate your own community on this issue.

Background: The Hudson-Raritan Estuary receives more than its share of pollutants from a wide variety of **point** (knowing the source) and **non-point** sources (not knowing the source). **Litter** washed off streets is carried either directly into the water or into storm sewers. Many storm sewers are combined with sanitary sewers and the debris passes through the sewage treatment plants (STP). With a combined system, moderate rainfall overloads the STP. Sewage and floatables, is discharged as raw combined sewer overflow (CSO) directly into the **waterways**. CSO's are the greatest source of floatables in the Northeast. This **pollution** poses health risks to people who consume fin- fish and shellfish harvested from contaminated waters. This can cause beach and fishery closings with great loss of income to our state's economy. Although a significant portion of our Estuary could be used for recreation, it is not, due to unsightly garbage, noxious odors and unsafe, unhealthy conditions. Can individuals contribute solutions to this seemingly overwhelming problem? The answer is yes, and the place to start is in your own backyard!

Words to Know:

Litter
Point and non-point sources
Pollution-pollutants
Waterways

Materials:

Soil test kits
Poster board
Video tape (blank) and camera
Styrofoam pellets
Small aquarium
Various small floatable and non-floatable objects
Spoon

Activity One:

- 1) Cite at least five local sources of pollution that could affect estuarine waters. Investigate public, private and industrial sources. The list might include sewage effluent, agricultural run-off, inefficient septic tanks, residential use of pesticides, industrial release, over-population and development. Once the list has been compiled, investigate solutions and alternatives.
- 2) Residential lawn treatment is often a source of

pollution when pesticides are used indiscriminately. Soil test kits can be obtained from your local garden center or County Cooperative Extension office. Perform a soil test at home or in the schoolyard. The tests will tell the pH and nutrient levels present in the soil sample. Determine the levels of nitrogen, potassium, phosphorous and lime that your soil really needs. Ideally soil should have a neutral pH (between 6.5 and 7.5) allowing it to support good micro-organisms and worms and easily give up nutrients to plants. If the pH of your soil sample is not within this range, investigate steps to correct this problem.

- 3) Contact the local garden center, library or County Cooperative Extension office for information, remedies, facts, and tips for responsible lawn and garden care. Develop a plan to get the word out to the community about this critical problem and the possible, easily accomplished solutions. Consider making posters, radio broadcasts, mailings, newspaper articles or even a video-infomercial to re-educate the community.

Discussion:

1. Has the soil been over-nutriented?
2. Could run-off from your area pose a danger to the Hudson-Raritan Estuary waters?
3. What can you do to educate the community about this problem? Name three steps you can take.

Activity Two:

Floatable debris is a controllable problem. Unlike some forms of pollution, this problem begins at home. Put various small objects in the water of an aquarium and use a spoon to push the objects around. Observe.

Discussion:

1. List the objects that float and sink and what wave action does to the system.
2. Are some things suspended in the water column beneath the water surface?

Nutrients-- Too Much of a Good Thing

- Objectives:**
- 1) You will learn the basis of eutrophication.
 - 2) You will be able to demonstrate how unnatural nutrient input can impact our aquatic environment.

Background: Nutrients, such as nitrogen and phosphorus, are substances required for plant and animal growth. When these same life-sustaining **nutrients** are added to our waters in unnatural amounts, a devastating form of pollution, known as eutrophication can occur. Much of the Hudson-Raritan Estuary is considered **eutrophic**. Eutrophic water is over-enriched, resulting in too much plant growth, particularly algae. When algae clouds the water, it blocks sunlight needed to sustain other underwater vegetation. Especially effected are estuary grasses which serve as crucial suppliers of food and shelter to the living animals of the estuary. The algae does not live forever, and when it dies it decomposes, using up inordinate amounts of oxygen. The result is that the water becomes dangerously low in dissolved oxygen. Fish soon suffocate and die under these conditions in a process known as **hypoxia**.

Words to Know:

Eutropic--eutrophication
Hypoxia
Nutrients

Materials:

Five one quart glass jars
Estuary or aquarium water
Fertilizer
Allow several weeks to complete this activity.

Activity One:

This activity will allow you to observe firsthand what happens when water contains too many nutrients.

- 1) Label five glass one-quart jars with the numbers one through five. Fill jar #1 with tap water and set it aside. This is your control sample since no algae should grow in this jar. Fill the remaining four jars with water from the Hudson-Raritan Estuary system. If this is unavailable, aquarium water that has been in the tank for at least one month, is adequate.
- 2) Label jar #2, "No Nutrients Added" and set it aside.
- 3) Following the directions on the plant food label, mix enough fertilizer with the water in jar #3 to make the regular suggested solution.

- 4) In jar #4 add enough plant food to make a solution that is three times stronger than suggested.
- 5) In jar #5 mix a solution six times stronger than suggested. Label the jars according to Nutrient Level (#3: one dose, #4: three doses, #5: six doses.)
- 6) Cover the jars lightly with foil to prevent evaporation. Place the jars in a cool, sun-lit place, avoiding direct sun light. Every few days, stir the contents of each jar to simulate wave action. Tip the jar to see if algae is growing on the glass (seen as a grey or green film.) Be patient as algae may take weeks to become visible, especially in the low dosage samples.

Discussion:

Observe results over time.

1. Do all five jars look the same?
2. Which jar has the most algae? Least algae?
3. What will happen as more time passes?
4. Why does fertilizer (plant food) have an effect on the growth of algae?
5. Look at a drop of water from each jar and record observations, including species identification and drawings, when appropriate. Are there any small living organisms observed? Can they be identified?

Oil Spill Clean Up

- Objectives:**
- 1) You will identify the types of methods available for clean-up of oil spills.
 - 2) You will learn what methods work best and invent new ones.

Background: Scientists and engineers are always studying ways to clean up oil spills. Several methods used include containing the spill, **absorption, skimming, coagulating**, and sinking of the oil. The method used depends upon the type of oil spilled and where the spill occurs. Sometimes several methods are used on one spill. In this age of supertankers ferrying oil across the seas, there is always a chance of an accidental oil spill. Since crude oil is less dense than sea water, it can cause serious ecological problems. Winds, tides, and currents act to spread the oil spill.

Words to Know:

Absorption
Coagulating
Skimming

Materials:

Paper towels
Straw
Styrofoam pieces
Twigs tied together
Detergent
Sand
Small fish net
Basins for water and oil
Feathers
Shells
Fur
Squirt bottles
Watering can

Activity One:

- 1) This activity compares various methods used in cleaning up an oil spill. Imagine that you are working on an EPA (Environmental Protection Agency) team rushed to the site of a grounded tanker spilling oil. You are to use the best possible method to clean up the oil spill
- 2) Fill basins 2/3's full with water. Add 100ml of motor oil to each basin. Using a straw, simulate waves and wind. Rain in the basins using watering cans and squirt bottles.
- 3) Using the list of materials below, devise a method of cleaning up the oil spill. Test the method

for containment and/or removal and record the results. If there are other student groups doing this activity at the same time, you can create a master chart and share the findings with all the groups.

Methods and Materials

Paper towel
Straw and styrofoam pieces
Twigs tied together
Soda straw--blow bubbles under oil, a ring of bubbles will contain spill.
Detergent--add a drop to disperse oil.
Sand--sprinkle on the surface of oil spill.
Aquarium net--scoop up oil
Any additional methods you can come up with.

Discussion:

1. What method appeared to work best?
2. Does the method have any negative effects on the environment?
3. Who should be responsible for the cleaning up of an oil spill?
4. Dip a feather, shell and fur into the oil spill. Observe. Try to clean the feather, shell or fur by using the methods described. Record the results.
5. Did the feather, shell, and fur clean up easily? What can you do to help the animals that get covered in oil because of the oil spill?

Plastic and Fish

- Objectives:**
- 1) You will be able to describe the potential effects of plastic waste on aquatic wildlife.
 - 2) You will be able to identify specific actions you can take to help remedy the problem of plastic waste.

Background: In the Hudson-Raritan Estuary **environment**, plastic waste materials have potential negative **impacts** on wildlife. Some aquatic animals mistake plastics for food. Sometimes they become entangled in plastic debris and subsequently die. It is estimated that six million tons of litter enter the sea each year. Most of this is the product of merchant ships and their practice of dumping garbage overboard. Among the most damaging kinds of solid waste from litter are **non-biodegradable** plastics. Plastics do not **decay**. Commercial **fishing** fleets are estimated to have lost nearly 300 million pounds of plastic fishing gear in one year alone. Plastic nets pose a great hazard to marine life. Few fish or marine mammals can swim backward. Once entangled, nearly all animals perish. Plastics pieces have also been found in the stomachs of whales, dolphins, fish, and birds. Leatherback turtles often mistake plastic bags floating in the water for jellyfish, one of their favorite foods. Some creative actions are also being explored to use plastic materials to enhance, rather than damage habitat for wildlife. Wildlife specialists are experimenting with ways to use plastics intentionally to provide anchoring sites for aquatic organisms. Some are using plastic bottles and jugs to provide a **microhabitat** for certain fish.

Words to Know:

Decay
Environment
Hypothesis
Impact
Microhabitat
Non-biodegradable

Materials:

Plastic waste from home

Activity:

- 1) Collect and save every piece of plastic waste produced in your home for a two day period. Bring these materials to school. Be sure to clean the plastics before bringing them to school so that they are free of food or drink remains. Also be careful with toxins such as ammonia, chlorine bleach, etc. which may be in the containers. These should be emptied and rinsed completely.
- 2) Separate these plastic waste materials into categories. Classify them in terms of how they might be perceived by aquatic wildlife as food. Identify the species that might attempt to eat plastic. Classify the materials according to the likelihood of specific animals becoming entangled

with them and subsequently dying.

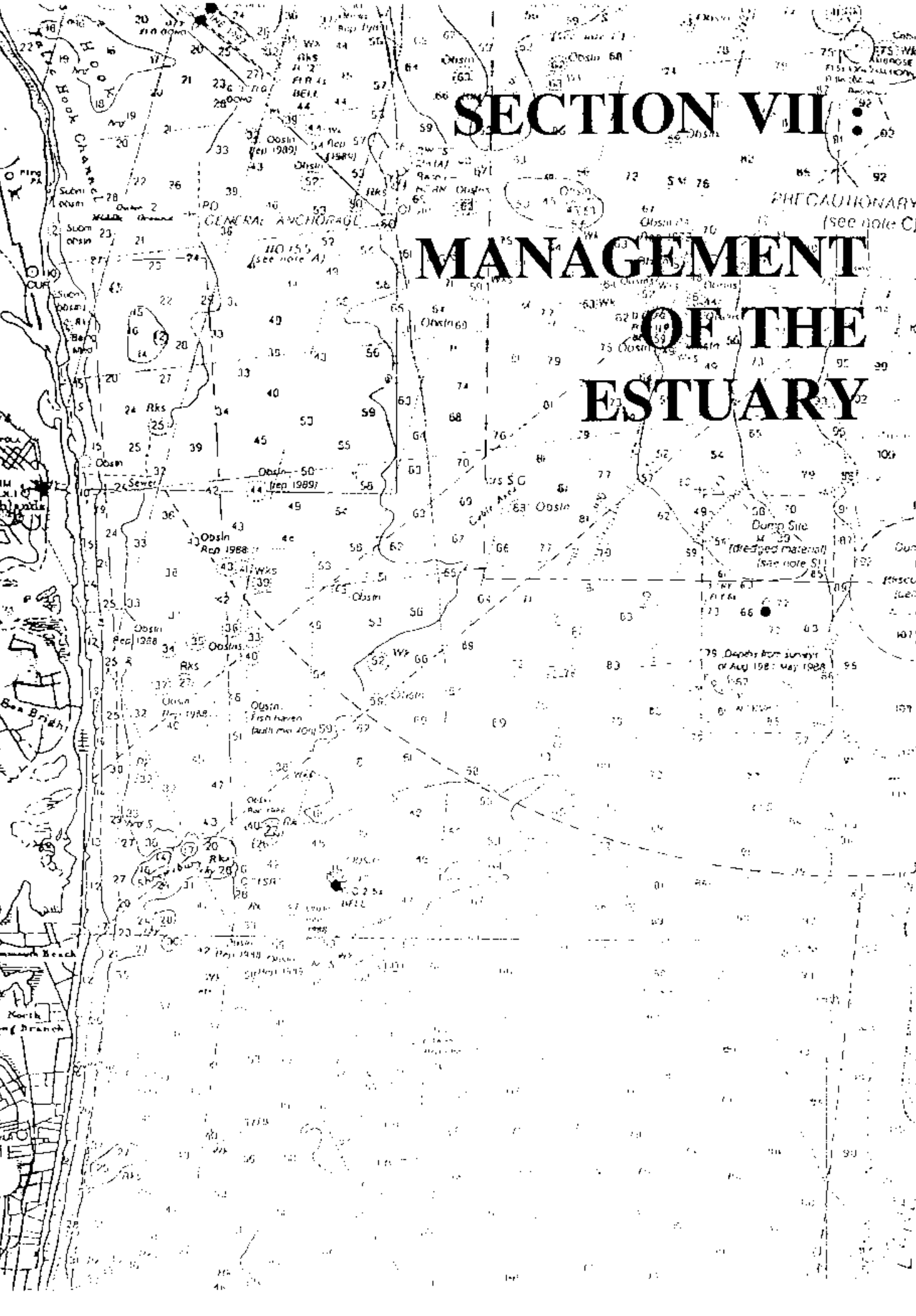
- 3) Hypothesize about how these materials might affect aquatic animals. Check your **hypothesis** with current findings. Summarize what you have learned about the potential hazards to aquatic wildlife from plastic waste materials.
- 4) Survey the school grounds or community for plastic litter to see where and if it exists. Investigate its potential negative impact on animals in the community.
- 5) If there is damaging plastic litter in the community, create an action plan that will increase awareness of the problem and help take care of it, e.g. setting up a plastic recycling depot.

Discussion:

1. Give three examples of ways that plastic waste could enter the Hudson-Raritan Estuary food chain.
2. For each example given above, discuss two possible consequences of plastic waste entering the food chain.
3. Describe some actions you and others can take to help remedy the problems associated with plastic wastes.

SECTION VII:

MANAGEMENT OF THE ESTUARY



MANAGEMENT OF THE ESTUARY

HISTORICAL USES

The Hudson-Raritan Estuary has experienced centuries of use and abuse. Its shoreline has been altered and its communities used for food, recreation, and livelihood. From the earliest European settlement to the present, these uses have resulted in constant change including shifts of water quality, available fish resources, recreational opportunities, and aesthetic values. In spite of this conflict of usage, it is still a productive and valuable Estuary.

The counties bordering the Hudson-Raritan Estuary were first settled by Europeans in the mid-seventeenth century. By 1880, some 4.3 million acres of improved farmland were in production. This represented a great loss of virgin, broadleaf forest. After 1880, the acreage of improved farmland began to decline due to increasing urbanization until there were only about 1.1 million acres of farmland left by 1960. The human population also increased from initial settlement in the mid-seventeenth century to 400,000 by 1790, then increasing more than tenfold to 5,500,000 by 1900. By 1980 the population was more than 15 million.

Many acres of low-lying marsh and tidal lands have been filled and drained throughout the years. During the 1700's approximately 500 acres of land were created around Manhattan Island by filling marshes and shallow tidal areas. A further 450 acres of additional land were created around Manhattan using the same methods during the nineteenth century. In the 1800's in Essex County, New Jersey most salt marshes were drained and filled. By 1918 about 96 percent of the county's salt marshes were gone. Waterfront development also occurred during the latter part of this period. Initially, piers and wharves were built, but as time progressed many of the piers were bulkheaded and filled in. The region now contains virtually no rural lands, except in the upper reaches of the tributary waterways. The direct drainage of the Estuary is the heart of the most populous metropolis in the United States. Heavy industrialization, major marine transport, and highly congested urban living all contribute to the burden placed on these waters.

COMMERCE

The Port of New York and New Jersey is one of the premier ports of the United States and the world. A world-class container port, it handles tens of millions of containers annually. Over 100 steamship lines have the port as a port-of-call. Besides container terminals, the Port of New York and New Jersey hosts passenger ships and is the final destination for refined petroleum, fruit, coffee, and general cargo.

Bulk cargo import items entering the port include residual fuel oils, gasoline, crude petroleum, distilled fuel oils, lime, and building cement. Imported general cargo items include beverages, cars, bananas, and hydrocarbons. Major exported general cargo items include waste paper, plastic, textile wastes, steel plates and sheets, and machinery. Exported bulk cargo include

iron/steel scrap, anthracite coal, gasoline, non-ferrous scrap, and inedible tallow.

FISHERIES AND FISHING

The Hudson-Raritan Estuary is an area of diverse aquatic life. The Estuary is utilized by numerous species of finfish and shellfish, including several commercially and recreationally important species. Economically important marine fishes common in the Estuary include bluefish, weakfish, winter flounder, summer flounder, tomcod, menhaden, and spot. Important forage species include mummichogs, silversides, and bay anchovies. Oysters as well as hard and soft clams were common throughout the Estuary, and formed the basis for extensive commercial fisheries until their decline. Commercial lobster and blue crab fisheries also operate, although at decreased levels since their peak in the 1930's. A recreational blue crab fishery has been in existence since the late 1800's.

RECREATION

The Hudson-Raritan Estuary provides opportunities for a variety of marine recreational activities including fishing, boating, swimming, and sightseeing. The area supports numerous recreational angling opportunities. Recreational fishing occurs from shoreline areas and aboard private, charter and party boats. Catches of bluefish, striped bass, summer and winter flounder and blue crabs are significant. Other species sought by anglers include eels, tomcod, weakfish, spot, bluefish, and white perch.

Boating opportunities in the region abound. Recreational boating is enhanced by the availability of marinas and launch ramps throughout the region. In addition to private boats, boat tours around the Harbor are also available. Tourist attractions in the region include the Statue of Liberty-Ellis Island complex, the Cloisters, Battery Park and North Hudson Park. Popular beaches in the region include the units of the Gateway National Recreation Area at Sandy Hook in New Jersey and Jamaica Bay in New York.

THE FUTURE OF OUR ESTUARY

The Hudson-Raritan Estuary has been subjected to serious pollution and other modifications, beginning with the clearing in Colonial times of over four million acres of water-conserving virgin forest. Changes accelerated during the late nineteenth and early twentieth centuries.

Legislation, regulation, and enforcement to abate pollution and slow aquatic habitat loss gained momentum during the 1970's. The public became conscious of what had been lost, and gained a sense that determined action could restore this valuable resource. Filling of wetlands began to be restricted although dredging and waste disposal continued under more careful control. Secondary treatment was also added to the primary sewerage treatment.

Although water quality is beginning to improve in some instances as a result of these actions, nagging problems still remain. For example, closures and restrictions on fish and shellfish harvesting are still needed to protect public health. Objectionable floating debris interferes with enjoyment of beaches and waterways and the input of toxic contaminants continues. Whether the Estuary returns maximum value for the people of New Jersey depends on the way waters and surrounding lands are treated.

In recognition of the importance of the Hudson-Raritan Estuary and the need to protect and restore the environments of the area, the region was formally recognized as an estuary of national significance in July 1988 under The National Estuary Program. The National Estuary Program was established by the U.S. Congress in 1987 with passage of the Clean Water Act. The objective of this program is to set up regional management conferences that are responsible for maintaining the ecological integrity of our nation's estuaries through long-term planning and management. The New York-New Jersey Harbor Estuary Program is a partnership of public officials, scientists, and the general public working together to establish and maintain a healthy, productive ecosystem and full beneficial uses of the Estuary. In order to achieve this goal the program will focus on the achieving the following:

- Restore and maintain an ecosystem that supports an optimal diversity of living resources on a sustained basis;
- Preserve and restore ecological important habitat;
- Attain water quality that fully supports bathing and other recreational uses of the Estuary;
- Ensure that fish and shellfish in the Estuary are safe for unrestricted human consumption;
- Restore and enhance the aesthetic quality of the Estuary;
- Actively address emerging issues that impact the Estuary;
- Manage and balance the competing uses of the Estuary to improve environmental quality and
- Manage pollutants within the Estuary so that they do not contribute to use impairments outside the Estuary.

Use and Misuse: The Consequences

Words to Know:

Carnivore
Ecological balance
Habitat
Herbivore
Food web
Food pyramid

Materials:

For this activity you will need the use of all the students in class, labels that say zooplankton, phytoplankton, crabs, mummichogs, etc. designated Herbivore or Carnivore, and markers or tea bags or sugar bags.

Activity:

In this activity, students simulate the natural order of the food web in the Hudson-Raritan Estuary and what happens with human intervention. The class gets labeled herbivore or carnivore, what they are, (zooplankton, phytoplankton, etc) and what they eat. Marker or tea bags or sugar bags represent food units, with 10 markers being enough food for herbivores to reproduce and survive. Carnivores will need 20 markers and top carnivores will require 40 markers to survive. The game is played in an open area allowing students to “tag” each other for their food markers. The student that is tagged gives up its food and sits down or observes from the sidelines. The tagging continues until everyone either has gotten enough to eat, runs out of food, or has been eaten. The activity is repeated adding human intervention -pollution, over fishing etc.; a prediction is made of what the out come will be and enough time for discussion is allocated.

Recycle and Reuse

Words to Know:

Environmental
The Center For Marine Conservation
Waterways

Materials:

In this activity you will need the ingredients for two lunches (or cut outs of food items from magazines, pasted on posterboard and covered with plastic to be used over and over like a card game,) a trip to the estuary to collect marine debris and a data card to be filled out after the trip.

Activity:

In this activity students will be able to trace the biodegradability of products from their source to their destination after use, and identify the types of products that can be recycled and reused. They will be able to develop and practice responsible conservation behaviors about refuse. In activity one, students pack two lunches. Picking and choosing the right ingredients to make a nutritious lunch and one that generates the least amount of garbage. Activity two the students take a trip to the estuary to collect garbage and fill out a data collection card or can one of their own. The debris collected is of great

interest to The Center for Marine Conservation which the students are encouraged to contact. The Center analyzes data cards. The results become a tool in finding the sources of marine debris and having it stopped. The students make an advertisement to educate other people of ways to use recycling.

The Great Debate

Words to Know:

Conserve

Conservation

Hypothetical situation

Materials:

For this activity students will need posterboard, markers, and presentation skills.

Activity:

In this activity students are given a hypothetical situation in which a land developer has proposed building a medium-sized shopping mall. The controversy is that the site borders a salt marsh. The students hold a mock hearing to debate the developers proposal. The class of students gets divided into four special interest groups: the developers, the environmentalists, the town planners and the area residents. Each group researches the proposal and its relationship to their interest group, then formulates their group's viewpoint on the issue. During the debate each group presents their description of the situation and their recommended solutions. After the debate a compromise plan that combines and meets at least one objective from each group is found. Time is allocated for discussion.

Use and Misuse: The Consequences

- Objectives:**
- 1) You will identify the types of human activities that can alter natural feeding relationships within the Hudson-Raritan Estuary.
 - 2) You will find out what you can do to become a positive influence.

Background: The region surrounding the Hudson-Raritan Estuary is one of the most densely populated areas of our country. Over the past three hundred years, our estuary has been subject to landfill projects that have drained and filled most of our existing wetlands. In Essex county alone over 96% of existing wetlands were drained and filled before 1920! When **habitat** like this is removed it causes detrimental change up and down the food chain. Less obvious but no less detrimental than pollution, this change upsets the natural, **ecological balance** of those areas. The damage is both widespread and pervasive. Despite the damage resulting from over-population and drainage, the estuary is still a valuable and productive area.

Words to Know:

Carnivore
 Ecological balance
 Food web
 Food pyramid
 Habitat
 Herbivore
 Hypothetical situation

Materials:

Labels: Herbivores, Carnivores
 Markers or tea bags or sugar bags
 Use of other students in the class

Activity One:

The following activity needs to be done twice. The first time represents the natural order of the food web of the Hudson-Raritan Estuary. The second represents the effect of human intervention. Record results after each round so that results can be compared when the demonstrations are concluded.

1) Designate three-quarters of the class as herbivores, (zooplankton, Phytoplankton, clams, insects.) Two students need to play the role of top carnivores, (egret, osprey, human). The remaining students will represent the carnivores in the mid-section of the **food pyramid** of the Hudson-Raritan Estuary. Give each herbivore 10 markers representing food units. This represents enough food for herbivores to reproduce and survive.

Carnivores will require 20 markers and top carnivores will require 40 units to survive. When a student has been tagged by his or her appropriate predator, that student should give up its food units and sit down. This tagging should continue until everyone has either gotten enough to eat, run out of food, or has been eaten. Record the results. Repeat this activity, introducing human intervention. Predict the new outcome of the activity as before now that two organisms no longer exist.

Discussion:

1. Record the outcome and compare it to the predictions.
2. Did a balance occur?
3. Did some members at each level of the food pyramid survive?
4. Name the human activities affecting the food chain.
5. Can you name some of the animals of the Hudson-Raritan Estuary already suffering the adverse affects of careless human activities?
6. A **hypothetical situation**-- if the Atlantic Silverside, a small fish providing food for carnivores, like the ospreys and bluefish, were over-fished by humans, what would be the effect on the food web of the Hudson-Raritan Estuary? Include the effects to the environment, plants and animals, local economics, recreation and aesthetics.

Recycle and Reuse

- Objectives:**
- 1) You will be able to trace the biodegradability of products from their source to their destination after use.
 - 2) You will be able to identify the types of products that can be recycled and reused.
 - 3) You will be able to develop and practice responsible conservation behaviors about refuse.

Background: The Hudson-Raritan Estuary has been subjected to serious pollution. Although water quality is beginning to improve because of legislation, regulation, and enforcement to abate pollution, nagging problems still remain. Closures and restrictions on fish and shellfish harvesting to protect public health are still in effect. Objectionable floating debris interferes with enjoyment of beaches and waterways. Whether the Estuary returns maximum value to the people of New Jersey depends in large part on the changes that are made in the way we treat the waters and surrounding lands now and in the future.

Words to Know:

Environmental group
The Center for Marine Conservation
Waterways

Materials:

Cloth lunch bag
Thermos
Two plastic containers
Sandwich
Cookies
One brown bag
Zip lock bags
Juice box
Packaged cheese and crackers
Container of yogurt
Granola cookie (these materials can be made from cut-outs from magazines, pasted on Posterboard and covered with plastic to be used over and over like a card game.)

Activity One:

1) Packing a lunch can become an automatic and habitual daily routine. Often not much thought is given to this activity. The connection with the natural world and the consequences of not using recyclable products rarely is made. In this exercise you will pack two lunches. In the first one, (lunch #1), will go a thermos with water, plastic

container with sandwich made with luncheon meat, a piece of fruit, and two cookies in a small plastic container. In the other lunch, (lunch #2), you will pack a brown bag lunch with a cheese sandwich in a zip lock bag, a juice box, store bought prepackaged cheese and crackers, store bought yogurt and a prepackaged granola bar. 2) After each lunch is made and consumed, answer the following questions: which one has the least amount of garbage? Which one has more nutritional value? Can you come up with some ideas on how to have a good lunch packed with recyclable materials? How can you educate your school community on the subject of lunch recycling and how it affects our waters with marine debris?

Discussion:

1. Make a list of the items you can use every day to become a responsible recycler. Let the list include household items, furnishings, and anything else you can think of. Discuss with other students the list you made and why you think these things can be recycled.

Activity Two:

- 1) Take a trip to the Estuary to collect garbage. Fill out a garbage data card from a local environmental group or make your own. The Center for Marine Conservation in Washington D.C. is interested in your findings, (write to them: 1725 DeSales Street, NW, Washington, DC 20036.) Proper data collection is extremely important. The Center analyzes data cards and the results become a powerful tool in finding the sources of marine debris, helping to find solutions and developing effective control strategies to help prevent the problem.
- 2) If you make your own data card there are general categories to include: plastics, foamed plastics, glass, rubber, metal, paper, wood, and cloth. You can get specific after each category. For example, Plastic: bags, bottles, buckets, caps, cigarette butts, cigarette lighters, utensils, diapers, fishing line, fishing lures, fishing nets, hard hats, light sticks, pieces, rope, sheeting, 6-pack holders, strapping bands, straws, tampon applicators, toys, vegetable sacks, other plastics (specify).
- 3) Organize a group of students who can act before a group or on video to educate others about recycling ideas, programs, or daily routines people can adopt to make more use of recycling. This can take the form of a short play, commercial advertisement, or pantomime.

The Great Debate

Objectives: 1) You will be able to make educated, conscientious choices balancing human use of natural resources with informed conservation.

Background: The need to conserve, protect and restore the natural environment of the Hudson-Raritan Estuary is well recognized. On the other hand, use of natural resources is the key to human existence on Earth. Obviously, a balance must be reached with a goal of life and conservation. Reaching this balance is far from simple because people have different values and standards. Careful examination of the issues and our values are required to make informed, intelligent decisions.

Words to Know:

Conserve
Conservation
Hypothetical situation

Materials:

Posterboard
Markers
Use of presentation skills

Activity:

1) The following is a hypothetical situation: A land developer has proposed building a medium-sized strip-type shopping mall. The proposal includes a three story building, located in the mall's center that will house amusements such as video games to an otherwise depressed area. The chosen site borders on a salt marsh, with a stream running through it. The stream is home to small fish and a colony of egrets that nest nearby. Plan a mock hearing to debate this proposal. Gather enough students to divide into four special interest groups: the developers, the environmentalists, the town planners, the concerned citizens and area residents.

2) Each group should research the proposal and its relationship to their interest group before formulating a viewpoint on the issue.

3) During the debate, each group will present their description of the situation and their recommended solutions. The particular benefits of a planned action should also be included. After the four groups have made their presentations, there should be time for a question answer period.

4) After the debate, draw up a compromise plan that combines and meets at least one objective from each interest group.

Discussion:

Keep in mind the need to conserve, protect and restore the natural environment. Although there is no right answer to this debate, possible compromises might include:

1. Moving the buildings back as far as possible from the marsh area.
2. Landscaping the area with native plant life.
3. Moving the parking lot away from the stream and using gravel instead of asphalt to reduce runoff.
4. Maintaining a nature trail that is both educational and aesthetic.
5. Installing silt fences during construction to prevent erosion.

A detailed map of the Hook Point area, showing the coastline, Hook Channel, and various land parcels. The map is overlaid with a grid of numbered data points (1-100) representing species profiles. Key features include 'Hook Channel', 'Highlands', 'Sea Branch', and 'North Branch'. Numerous annotations are scattered across the map, such as 'Obsn', 'Rks', 'Wks', 'Cosin', 'Subm', 'Genl Anchr Raile', 'H.O. 115', 'H.O. 116', 'H.O. 117', 'H.O. 118', 'H.O. 119', 'H.O. 120', 'H.O. 121', 'H.O. 122', 'H.O. 123', 'H.O. 124', 'H.O. 125', 'H.O. 126', 'H.O. 127', 'H.O. 128', 'H.O. 129', 'H.O. 130', 'H.O. 131', 'H.O. 132', 'H.O. 133', 'H.O. 134', 'H.O. 135', 'H.O. 136', 'H.O. 137', 'H.O. 138', 'H.O. 139', 'H.O. 140', 'H.O. 141', 'H.O. 142', 'H.O. 143', 'H.O. 144', 'H.O. 145', 'H.O. 146', 'H.O. 147', 'H.O. 148', 'H.O. 149', 'H.O. 150', 'H.O. 151', 'H.O. 152', 'H.O. 153', 'H.O. 154', 'H.O. 155', 'H.O. 156', 'H.O. 157', 'H.O. 158', 'H.O. 159', 'H.O. 160', 'H.O. 161', 'H.O. 162', 'H.O. 163', 'H.O. 164', 'H.O. 165', 'H.O. 166', 'H.O. 167', 'H.O. 168', 'H.O. 169', 'H.O. 170', 'H.O. 171', 'H.O. 172', 'H.O. 173', 'H.O. 174', 'H.O. 175', 'H.O. 176', 'H.O. 177', 'H.O. 178', 'H.O. 179', 'H.O. 180', 'H.O. 181', 'H.O. 182', 'H.O. 183', 'H.O. 184', 'H.O. 185', 'H.O. 186', 'H.O. 187', 'H.O. 188', 'H.O. 189', 'H.O. 190', 'H.O. 191', 'H.O. 192', 'H.O. 193', 'H.O. 194', 'H.O. 195', 'H.O. 196', 'H.O. 197', 'H.O. 198', 'H.O. 199', 'H.O. 200'.

SECTION VIII

SPECIES PROFILES:

FISH, BIRDS,

AND

INVERTEBRATES

BE CAUTIONARY AB
(see note C)

GENERAL ANCHOR RAILE
(see note A)

Obsn
Rep 1992

Obsn
Rep 1988

Obsn
Rep 1983

Obsn
Rep 1980

Obsn
Rep 1977

Obsn
Rep 1974

Obsn
Rep 1971

Obsn
Rep 1968

Obsn
Rep 1965

BIOLOGY OF THE HUDSON-RARITAN ESTUARY

SPECIES GUIDE

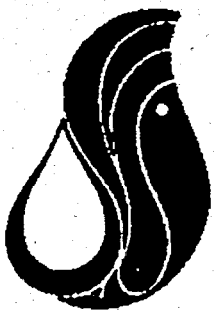
**TO COMMON FISH, BIRDS AND INVERTEBRATES
OF THE HUDSON-RARITAN ESTUARY
AND ADJACENT NEW YORK BIGHT**

Produced by the Staff of the
Education Program
at the
New Jersey Marine Sciences Consortium
Building 22, Fort Hancock
Sandy Hook, New Jersey 07732

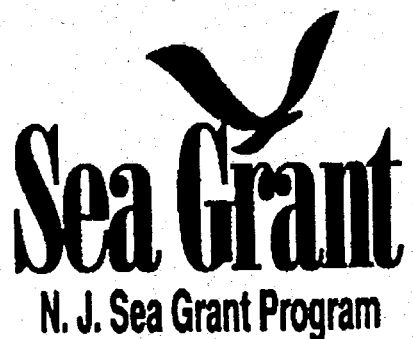
Funded by the
Geraldine R. Dodge Foundation

and the

New Jersey Sea Grant College Program.



**NEW JERSEY
MARINE SCIENCES
CONSORTIUM**



THE BIOLOGY OF THE HUDSON-RARITAN ESTUARY

COMMON FISHES OF THE HUDSON-RARITAN ESTUARY. AND ADJACENT NEW YORK BIGHT

INTRODUCTION

The waters of the Hudson-Raritan Estuary are rich with a diversity of fish species. Some fish reside year-round within the Estuary while others spend only part of the year in area waters as they migrate to and from ocean waters and other estuaries..

Seasonal occurrence and distribution of fish in the Hudson-Raritan Estuary is related to life history patterns. Studies have identified over 145 species representing more than 50 families of resident and migratory fin fish. In addition, 81 species of fish have been recorded during sampling efforts conducted in the Jamaica Bay region, adjacent to the Estuary.

The Hudson-Raritan Estuary is a major spawning and nursery ground for many species of fish and shellfish. Studies have found close to two dozen species of fish in egg and larval stages in upper New York Bay alone. Most fish spawn in early spring and summer. During this time eggs and larvae are found throughout the Hudson River-but are concentrated in particular areas according to species. Other studies have shown that the lower bay region serves as an important area for juvenile and young-of-the-year fish of many species.

Year-round residents, or fish that spawn and remain within the estuary for their entire life cycle, include the silverside, killifish or mummichog, white perch, and bay anchovy. They are important forage organisms for seasonally abundant carnivores and may attract other coastal species into the estuary.

Common Fishes of the Hudson-Raritan Estuary and Adjacent New York Bight profiles species frequently encountered in the Hudson-Raritan Estuary. It is designed to complement the Peterson Field Guide on Atlantic Coast Fishes by C.R. Robins, G.C. Ray, J. Douglass and R. Freund, 1986, Houghton Mifflin Company and the Illustrated Guide to Hudson River Fishes by J.M. Haynes and N.J. Frisch, 1993, SUNY College at Brockport.

ACKNOWLEDGMENTS

This guide was prepared by the staff of the New Jersey Marine Sciences Consortium Education Program including Claire Antonucci, Education Program Coordinator, John Tiedemann, Director of Education and Special Projects, Mike Danko, Manager of Marine Operations, Rosemary Higgins, Program Associates, Liesl Hotaling, Education Specialist, Kerry Lynch, Marine Specialist, and Thomas Lynch, Station Biologist. The staff of the Education Programs also wishes to acknowledge the contributions of Dr. Donald Dorfman, Professor of Biology at Monmouth University.

Information contained in this guide is a compilation of many sources including the Peterson Field Guide to Atlantic Coast Fishes by C.R. Robins, G.C. Ray, J. Douglass and R. Freund (Houghton Mifflin Company), Fishes of Chesapeake Bay by S.F. Hildebrand and W.C. Schroeder (T.F.H. Publications, Inc.), Fishes of the Gulf of Maine by H.B. Bigelow and W. C. Schroeder, The Illustrated Guide, to Hudson River Fishes by J.M. Haynes and N. J. Frisch (SUNY College), The Peterson Field Guide to Eastern Birds by Roger Tory Peterson (Houghton Mifflin Company), The Audubon Society Encyclopedia of North American Birds by John K. Terres, Marine Animals of Southern New England and New York by Howard M. Weiss, Ph.D. (D.E.P. Maps and Publications), Peterson Field Guide to The Atlantic Seashore by Kenneth L. Gosner (Houghton Mifflin Company) as well as many other unpublished sources. It is hoped that this guide will prove useful to students and teachers attempting to study and identify the species inhabiting the Hudson-Raritan Estuary and its adjacent coastal waters.

This guide was made possible through the generous support of the Geraldine R. Dodge Foundation and the New Jersey Sea Grant College Program. The New Jersey Marine Sciences Consortium (NJMSC). NJMSC is a private, non-profit organization comprised of member colleges, universities and private groups interested in marine affairs. The New Jersey Sea Grant Education and Outreach Program supports the education goals of the Consortium by planning and conducting a wide range of precollege, college, teacher and public education programs.

COMMON FISHES OF THE HUDSON-RARITAN ESTUARY AND ADJACENT NEW YORK BIGHT

INTRODUCTION

The waters of the Hudson-Raritan Estuary are rich with a diversity of fish species. Some fish reside year-round within the Estuary while others spend only part of the year in area waters as they migrate to and from ocean waters and other estuaries.

Seasonal occurrence and distribution of fish in the Hudson-Raritan Estuary is related to life history patterns. Studies have identified over 145 species representing more than 50 families of resident and migratory fin fish. In addition; 81 species of fish have been recorded, during sampling efforts conducted in the Jamaica Bay region, adjacent to the Estuary.

The Hudson-Raritan Estuary is a major spawning and nursery ground for many species of fish and shellfish. Studies have found close to two dozen species of fish in egg and larval stages in upper New York Bay alone; Most fish spawn in early spring and summer. During this time eggs and larvae are found throughout the Hudson River but are concentrated in particular areas according to species. Other studies have shown that the lower bay region serves as an important area for juvenile and young-of-the-year fish of many species.

Year-round residents, or fish that spawn and remain within the estuary for their entire life cycle, include the silverside, killifish or mummichog, white perch, and bay anchovy. They are important forage organisms for seasonally abundant carnivores and may attract other coastal species into the estuary.

Common Fishes of the Hudson-Raritan Estuary and Adjacent New York Bight profiles species frequently encountered in the Hudson-Raritan Estuary. It is designed to complement, the Peterson Field Guide on Atlantic Coast Fishes by CR. Robins, G.C. Ray, J. Douglass and R. Freund, 1986, Houghton Mifflin Company and the Illustrated Guide to Hudson River Fishes by J.M. Haynes and N.J. Frisch, 1993, SUNY College at Brockport.

Selected species are identified using the following categories:

Common and Scientific Names: The common and scientific names used follow the 1980 AFS check list. Scientific names are used universally by scientists, while common names vary. Scientific names are italicized, with the first letter of the genus capitalized and the species name lower cased.

Identification: Included is a brief description of the species, focusing on characteristics that are obvious and easy to recognize. Descriptions generally begin with the head and progress to the tail. In addition, other distinctive characteristics are included such as color and special behaviors.

Size: Lengths and weights are at maximum recorded levels.

Range: The range is given in a north to south direction and is very general. Range is often useful for identifying species.

Local Distribution: Local distribution provides specific information on a species level of occurrence in the Hudson-Raritan Estuary.

Habitat: Lists the types of habitat they preferred including substrate type, water composition and depth. This information can be useful in identification, as many species are habitat specific.

Spawning Information on spawning is provided to help understand the life cycles of a particular species. Detailed information is not currently available on all species, therefore some species may have more detail than others.

Feeding: Explains how the species feed and includes a list of their preferred food items.

Definitions of unfamiliar terms included ***Common Fishes of the Hudson-Raritan Estuary and Adjacent New York Bight*** may be found in the glossary section of this curriculum guide.

COMMON FISHES OF THE HUDSON-RARITAN ESTUARY

SCIENTIFIC NAME

COMMON NAME

Class Elasmobranchiomorphi

Family Carcharhinidae

Mustelis canis

Smooth dogfish

Family Squalidae

Squalus acanthias

Spiny dogfish

Family Rajidae

Raja eglanteria

Clearnose skate

Raja erinacea

Little skate

Raja laevis

Barndoor skate

Raja radiata

Thorny skate

Class Osteichthyes

Family Acipenseridae

Acipenser brevirostrum

Shortnose sturgeon

Acipenser oxyrinchus

* Atlantic sturgeon\

Family Anguillidae

Anguilla rostrata

* American eel

Family Clupeidae

Alosa aestivalis

* Blueback herring

Alosa mediocris

American Hickory Shad

Alosa pseudoharengus

* Alewife

Alosa sapidissima

* American Shad

Brevoortia tyrannus

* Atlantic menhaden

Family Engraulidae

Anchoa mitchilli

* Bay anchovy

Family Osmeridae

Osmerus mordax

Rainbow smelt

Family Synodontidae

Synodus foetens

Inshore lizardfish

Family Batrachoididae

Opsanus tau

* Oyster Cracker

Family Gadidae

Microgadus tomcod

* Atlantic tomcod

Pollachius virens

Pollock

Urophycis chuss

* Red hake

Family Belonidae

Strongylura marina

* Atlantic needlefish

Family Cyprinidontidae

Cyprinodon variegatus

* Sheepshead minnow

Fundulus heteroclitus

* Mummichog

Fundulus majalis

* Striped mummichog

Family Atherinidae

Menidia menidia

* Atlantic silverside

Family Gasterosteidae

- Apeltes quadracus* * Fourspine stickleback
- Gasterosteus aculeatus* * Threespine stickleback

Family Syngnathidae

- Hippocampus erectus* * Lined Seahorse
- Syngnathus fuscus* * Northern pipefish

Family Percichthyidae

- Morone americana* * White perch
- Morone saxatilis* * Striped bass

Family Serranidae

- Centropristis striata* * Black sea bass

Family Pomatomidae

- Pomatomus saltatrix* * Bluefish

Family Sparidae

- Stenotomus chrysops* * Scup

Family Sciaenidae

- Cynoscion regalis* * Weakfish
- Leiostomus xanthurus* * Spot
- Menticirrhus saxatilis* * Northern kingfish

Family Labridae

- Tautoga onitis* * Tautog
- Tautoglabrus adspersus* * Cunner

Family Mugilidae

Mugil cephalus

* Mullet

Family Ammodytidae

Ammodytes americanus

American Sand lance

Family Gobiidae

Gobiosoma sp.

Goby

Family Triglidae

Prionotus carolinus

* Northern searobin

Prionotus evolans

* Striped searobin

Family Cottidae

Myoxocephalus aeneus

* Grubby

Myoxocephalus octodecimspinosus

* Longhorn sculpin

Family Bothidae

Paralichthys dentatus

* Summer flounder

Scophthalmus aquosus

* Windowpane.

Family Pleuronectidae

Pleuronectes americanus

* Winter flounder

Family Soleidae

Trinectes maculatus

* Hogchoker

Family Tetradontidae

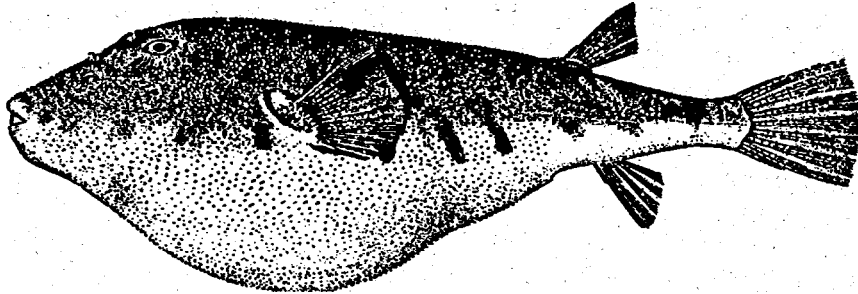
Sphoeroides maculatus

* Northern puffer

* species detailed in ***Common Fishes of the Hudson-Raritan Estuary and Adjacent New York Bight***, Danko M., Dorfman D., Higgins R., Hotaling L., Lynch T., and Tiedemann J.,

NORTHERN PUFFER

Sphoeroides maculatus



Identification:

- Small mouth located at the tip of the snout.
- Mouth without true teeth. Jaw bones form cutting edges.
- Gill openings small and set oblique.
- Rough skin.
- Dorsal fin close to caudal peduncle.
- Dark olive green on top.
- Sides greenish yellow with 6 to 8 dark bands or blotches.
- Bottom white.
- Can inflate themselves with air or water and float at the surface.
- Commonly known as a blowfish.

Size:

Length to 14 in. (36 cm). Females usually larger than males of the same age.

Range:

Atlantic coast of the United States from Cape Cod to Florida, occasionally straying farther north.

Local Distribution:

Puffers become abundant in the Hudson-Raritan Estuary in mid May and remain until early fall when waters begin to cool. They migrate into deeper waters to spend the winter, where they lie on the bottom in a dormant state.

Habitat:

- An inshore fish.
- Found in depths up to 50 feet (15 m).
- Enter brackish water in various estuaries.

Spawning:

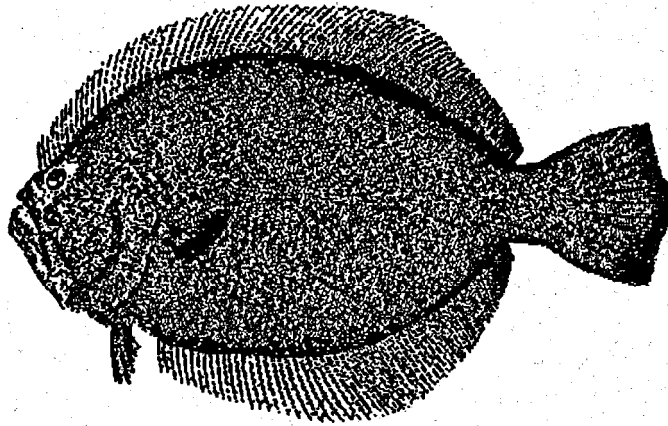
- Spawning takes place in New Jersey from mid May until June.
- A single female can contain up to 180,000 eggs.
- Eggs are round and adhere to each other or to anything they come in contact with when they sink.
- Hatching occurs in about 3 to 5 days.

Feeding:

- Voracious feeders.
- Diet consists of small crustaceans, especially crabs, shrimps, isopods, small mollusks, worms and sea urchins.

SUMMER FLOUNDER

Paralichthys dentatus



Identification:

- Large mouth with prominent teeth.
- Eyes on left side of head.
- A flat fish upon reaching the juvenile stage.
- Brown or olive on top with varied colored spots.
- Bottom white.
- Commonly known as a fluke

Size:

Length to 12-16 in. (30-40 cm) and weigh between 3/4-2 lbs. (1/3-1 kg); however, can grow up to 25 in. (94 cm) and 26 lbs. (12 kg).

Range:

Atlantic coast of the United States from Maine to North Carolina.

Local Distribution:

Summer flounder follow inshore-offshore migrations. They begin their residence in the Hudson-Raritan Estuary in April. They continue to move inshore through May and June and reach peak abundance in the Hudson-Raritan Estuary in July or August. As water temperatures begin to drop in early fall, summer flounder leave local bays and estuaries and start their offshore migration. By late fall all summer flounder reach their wintering grounds, in depths of 70 to 155 m. They remain there until spring when they begin their inshore migration.

Habitat:

- . Migrate inshore in the summer.
- . Frequent ocean waters, bays, and estuaries.
- . Prefer sandy, muddy sand, mussel beds and clay bottoms.
- . Winter months they migrate offshore to depths of 70 to 155 m.

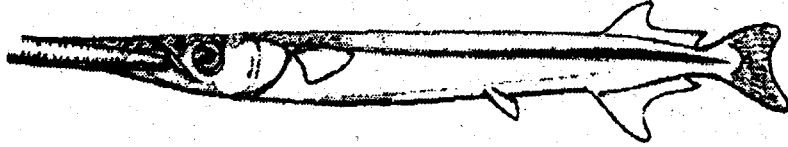
Spawning:

- . Spawning occurs from Southern New England to Cape Hatteras during their offshore migration in the autumn months.
- . Maturation occurs during their third year of life,
- . A 16 inch (40 cm) female produces 300,000 eggs while a 26 inch (65 cm) female produces 3.5 million eggs.
- . Eggs are buoyant and drift towards shore:
- . Hatching occurs in 2-6 days.
- . Larvae resemble other fishes and have eyes symmetrically placed on either side of the head.
- . Pelagic larvae go through a metamorphosis.
- . Eyes migrate to the left side of the head.
- . At this point they settle to the bottom.
- . When they take up a benthic existence they migrate to nursery areas in estuaries.
- . Remain in the estuary until they migrate with the adult population.
- . Growth is rapid during warmer months.

Feeding:

- . Voracious feeders.
- . Depend on sight to feed.
- . Feed only during daylight hours.
- . Diet consists of worms, shrimps, squid, rock crabs, silversides, killifish, American sand lance, juvenile bluefish and weakfish.

ATLANTIC NEEDLEFISH
Strongylura marina



Identification:

- Bill-like mouth filled with prominent teeth.
- Long slender body.
- Caudal fin bluish.
- Side of head pale below the center of the eye.
- Green on top.
- White bottom.

Size:

Length to 2 ft. (61 cm).

Range:

Atlantic coast of the United States from Maine to Florida; Northern Gulf of Mexico south to Brazil.

Local Distribution:

Needlefish move into the Hudson-Raritan Estuary in early July as water temperatures rise and remain in the region until the middle of October.

Habitat:

- Ocean waters, bays and estuaries.
- Enters fresh water.

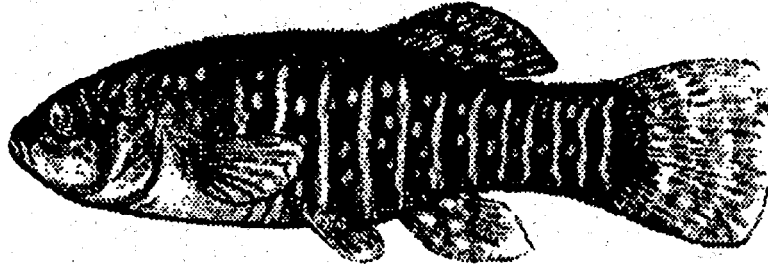
Spawning:

- Little is known about the spawning habits of this species.
- They possibly migrate up river mouths to spawn in protected waters.

Feeding:

- Diet consists of all smaller fishes.

MUMMICHOG
Fundulus heteroclitus



Identification:

- Small mouth.
- Stout body with a blunt head.
- Back and belly rounded.
- Males darkish green or steel blue on top, white and yellow spots, and silver bars on the sides.
- Females paler than the males. Uniform olive to green, lighter below, darker above without definite markings.
- Bottom, pale yellow or orange.
- Commonly known as killifish.

Size:

Length to 5 in. (12 cm).

Range:

Atlantic coast of North America from Gulf of St. Lawrence to Florida.

Local Distribution:

The mummichog is a year-round resident in the Hudson-Raritan Estuary. When water temperatures are warm they inhabit the edges of tidal creeks and saltwater marshes. When temperatures drop during late fall the mummichog lie in a sluggish state on the bottom, or burrow in the mud in these same areas.

Habitat:

- Prefer shallow waters near the shoreline in estuaries.
- Often trapped in tidal pools.
- Can survive extreme temperature and salinity fluctuations.

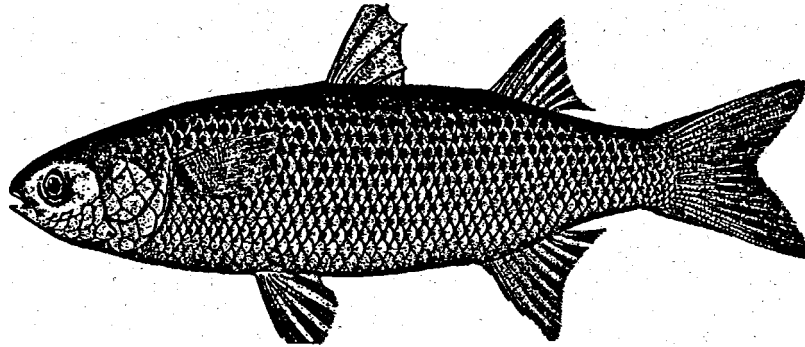
Spawning:

- Spawning occurs from June into August.
- Males court and pursue the females, sometimes fighting over a mate.
- Eggs are non-buoyant and sticky; stick to anything they come in contact with.
- Hatching occurs in 9 to 18 days.
- Hatching is temperature dependent.

Feeding:

- Omnivorous, diet consists of a variety of plants and animals.
- Diet includes diatoms, eelgrass, shrimp, other crustacea and small fish.

MULLET
Mugil cephalus



Identification:

- Small mouth.
- Long cigar shaped body.
- Spinous dorsal fin.
- Bluish on top, silver bottom.

Size:

Length to 15 in. (38 cm), but reported to reach 36 in. (91 cm.).

Range:

Nearly worldwide in warm waters Atlantic coast of North America from Nova Scotia to Florida; south to Brazil.

Local Distribution:

Arrive in the Hudson-Raritan Estuary in late spring early summer and spend the summer New Jersey's bays, creeks and estuaries. When water temperatures fall they funnel out of the inlets and begin to migrate south, following the coastline.

Habitat:

- Inshore waters, bays, estuaries and lagoons.

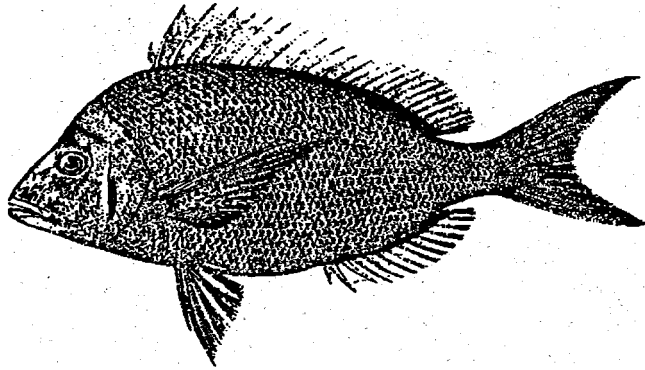
Spawning:

- Spawning takes place offshore in southern waters.

Feeding:

- Diet consists of mud, debris and plankton.

SCUP
Stenotomus chrysops



Identification:

- Teeth small and incisor like.
- Mouth terminal.
- Body deep and compressed.
- Back elevated.
- Front section of dorsal fin is spinous.
- Silvery on sides.
- Sides marked with faint dark bars.
- Milky or yellowish white on the bottom.

Size:

Length to 18 in.(46 cm) and weigh up to 4 lbs.(1.8 kg).

Range:

Atlantic coast of North America from Nova Scotia to Florida.

Local Distribution:

Scup are summer fish arriving in the Hudson-Raritan Estuary in June and leaving in October.

Habitat:

- Inhabit estuaries and continental shelf waters.
- Prefers hard or sandy bottom.

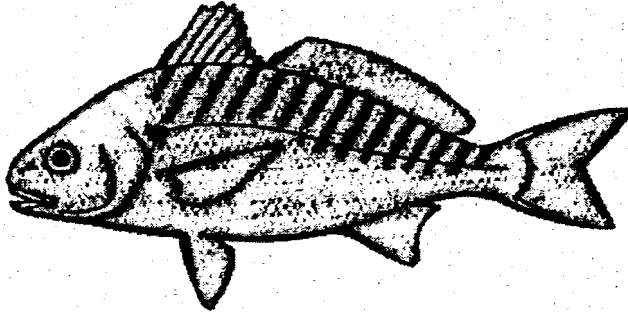
Spawning:

- Spawning occurs May through August.
- Eggs are buoyant, transparent and spherical.
- Hatching occurs in approximately 40 hours.
- Growth is rapid.

Feeding:

- Strictly bottom feeders.
- Diet consists of crustaceans, mollusks, worms and small fish.

SPOT
Leiostomus xanthurus



Identification:

- Small mouth.
- Body deep and compressed.
- Back elevated.
- Distinct brown spot on shoulder.
- 12-15 narrow, diagonal dark lines on upper body.
- Bluish to brownish above.
- Brassy on sides.
- Silvery or white below.
- Forked caudal fin.

Size:

Length to 14 in. (36 cm).

Range:

Atlantic coast of the United States from Massachusetts to Florida.

Local Distribution:

Spot are summer fish arriving in the Hudson-Raritan Estuary in June and leaving in October.

Habitat:

- Inhabit bays, estuaries and continental shelf waters.

Spawning:

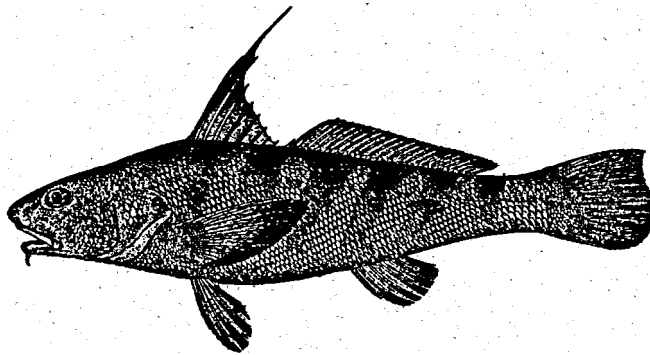
- Spawning occurs from October through March.
- Growth is rapid.

Feeding:

- Strictly bottom feeders.
- Diet Consists of crustaceans, mollusks, worms and small fish.

NORTHERN KINGFISH

Menticirrhus saxatilis



Identification:

- Mouth contains no teeth.
- Upper jaw extends past the lower.
- Blunt nose and snout overhang the mouth.
- Lower jaw with single barbel.
- First dorsal fin longer than other fins.
- Dusky grey to black on top.
- Sides cross marked with dark bars.
- Milky or yellowish white on the bottom.

Size:

Length to 17 in.(43 cm) and weigh up to 3 lbs.(1.4 kg).

Range:

Atlantic coast of the United States from Cape Cod to Florida.

Local Distribution:

Kingfish are summer fish arriving in the Hudson-Raritan Estuary in May and leaving in October. They migrate south to warmer waters.

Habitat:

- Inhabit ocean coastlines and river mouths.
- Prefers hard or sandy bottom.

Spawning:

- Spawning occurs in bays and sounds from June until August, but may occur later if waters do not warm sufficiently.
- Growth rapid.
- Measure 4 to 6 inches (10-15 cm) by their first winter.
- Maturity is reached by males and females at age 3.

Feeding:

- Strictly bottom feeders..
- Diet consists of shrimp, small mollusks, worms and young fish.

AMERICAN EEL

Anguilla rostrata



Identification:

- Mouth filled with small teeth.
- Body elongate and snakelike.
- Covered With a slime coating.
- Color varies from brown to dark green on top.
- Bottom cream to white.

Size:

Length to 5 ft. (1.5 m) and weigh up to 16.5 lbs.(7.5 kg); females usually larger than males of the same age.

Range:

Coastal regions of North America including Greenland, Labrador and Newfoundland south to the Gulf of Mexico.

Local Distribution:

Eels occur year-round in rivers and creeks of the Hudson-Raritan Estuary.

Habitat:

- Coastal and open ocean waters, estuaries and freshwater rivers.
- Prefer mud, grass, rocks or other substrate where they can hide.
- Females move farther up rivers and remain there for 7 to 8 years.
- Males live close to, or in, tidal waters until females migrate.

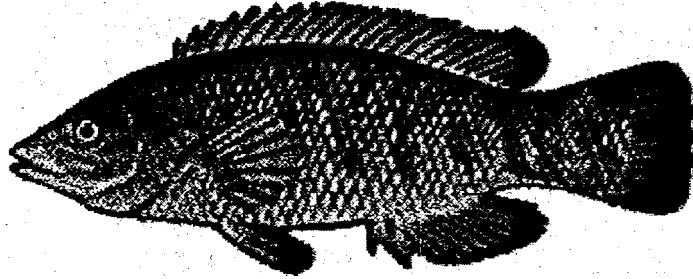
Spawning:

- Catadromous, spawning in saltwater and migrating to freshwater to grow,
- Spawning takes place in the Atlantic ocean in the Sargasso Sea.
- Spawning occurs as early January and may continue into August.
- Eels undergo oceanic, estuarine and river phases.
- Females release 10 to 20 million eggs.
- Hatching begins in February and continues into August.
- Larval stage may last for more than a year, this is followed by the “glass eel” stage.
- At this point they are unpigmented.
- As they develop pigment they migrate into freshwater and become elvers.
- Remain in freshwater for several years and are called yellow eels.
- Yellow eels mature and undergo changes in color and body shape and begin to migrate down river to the ocean spawning grounds. At this point they are called bronze eels.
- After spawning the adults die.
- Growth takes place very slowly.
- Male eels mature at age 3 and females at age 4-5.
- May live for 20 years.

Feeding:

- Benthic feeders..
- Feed predominantly at night.
- Diet consists worms, crustaceans, mollusks and fish.

C U N N E R
Tautoglabrus adspersus



Identification:

- Small mouth.
- Several rows of conical teeth.
- Color is usually a uniform greenish grey with blotching. Color can vary greatly depending on the bottom they are inhabiting.
- Commonly known as a bergall.

Size:

Length to 15 in. (38 cm) and weigh up to 2.2 lbs. (1 Kg.).

Range:

Atlantic coast of North America from Newfoundland and Gulf of St. Lawrence to Chesapeake Bay.

Local Distribution:

Cunners are present in the waters of the Hudson-Raritan Estuary year-round, but move offshore during the colder months.

Habitat:

- Inhabit waters from shallow bays out to deep shelf waters.
- Prefer rocky areas, around pilings, seawalls and wrecks.

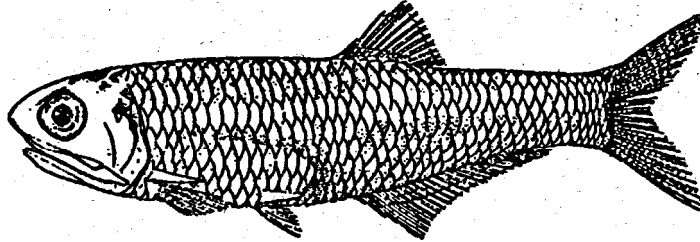
Spawning:

- Spawning takes place in June, July, and August along the coastline.
- Eggs are buoyant and transparent.
- Hatching occurs in about 40 hours.
- Growth is rapid, measuring 2.5-3.5 inches (5-7 cm) by the fall.

Feeding:

- Aggressive scavengers
- Feeding occurs along the bottom.
- Diet consists of small mussels, clams, worms and crabs, but will eat almost anything.

BAY ANCHOVY
Anchoa mitchilli



Identification:

- Wide mouth.
- Large eyes.
- Large, thin detached scales.
- Narrow silvery stripe running from gill opening to caudal fin.
- Whitish silvery translucent fish.

Size:

Length to 4 in. (10 cm).

Range:

Atlantic Coast of North America from the Gulf of Maine to Florida; Gulf of Mexico south to Yucatan.

Local Distribution:

The bay anchovy occurs in the Hudson-Raritan Estuary from May through October.

Habitat:

- Shallow bays and estuaries.
- Prefer shallow waters with salinity ranges of 24 to 30 parts per thousand.

Spawning:

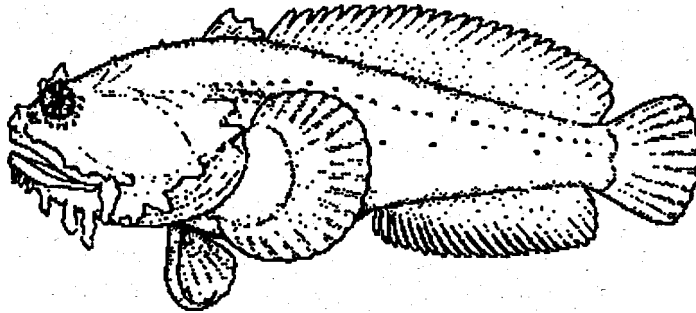
- Spawning in mid April to July.
- Most spawning occurs early in the evening.
- Eggs are buoyant and nearly transparent.
- Hatching occurs in approximately 24 hours.
- Growth is hard to follow because of the long spawning season.

Feeding:

- Diet consists mainly of zooplankton, copepods, small gastropods, annelids and bivalves.

OYSTER CRACKER

Opsanus tau



Identification:

- Large flat head and mouth.
- Tapering body with plump belly.
- Mostly soft rayed fish.
- Fleshy flaps on upper and lower jaws, on cheeks and over each eye.
- Skin covered with a thick layer of mucus.
- Color ranges from dark muddy olive green to brown or yellow. Darker on top and lighter on bottom.
- Irregularly marked with bars and marblings.
- Like many bottom fish it adjusts coloring to blend with the substrate.
- Commonly known as a toadfish.

Size:

Length to 15 in. (38 cm).

Range:

Atlantic coast of North America from Cape Cod to Cuba; occasionally straying northward to Maine.

Local Distribution:

Oyster Crackers are year-round residents in the Hudson-Raritan Estuary and undergo little movement.

Habitat:

- Largely coastal, rocky bottoms, jetties and wrecks.
- Tolerate polluted waters.

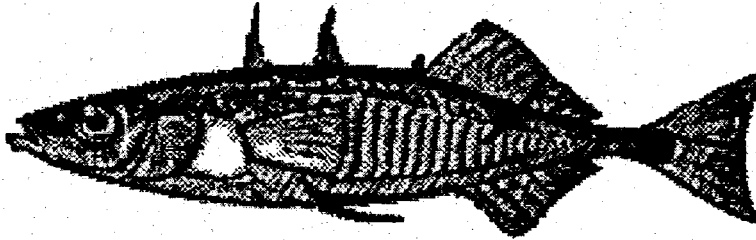
Spawning:

- Spawning occurs in June and early July.
- Large eggs are laid in holes, under stones, shells and among eelgrass.
- Eggs adhere in a single layer to whatever serves as a nest.
- Male guards the eggs for about three weeks until they hatch.
- Larvae remain attached to the nest by an adhesive disc until they reach 5/8 of an inch (15 mm.).

Feeding:

- Voracious, omnivorous fish.
- Feeding takes place on or near the bottom.
- Lie in wait for prey and dart out to grab it as it passes.
- Diet consists of worms, amphipods, shrimps, crabs, mollusks, squid and small fishes.

THREE SPINE STICKLEBACK *Gasterosteus aculeatus*



Identification:

- Small mouth.
- Three dorsal spines.
- Body usually with bony plates on side.
- Dark on top.
- Silvery on sides and on bottom.

Size:

Length to 4 in.(10 cm).

Range:

Baffin Island and Hudson Bay to North Carolina; circumpolar and in eastern N. Pacific.

Local Distribution:

Three spine sticklebacks are year-round residents in the Hudson-Raritan Estuary. They enter the mouths of creeks and streams in the spring to spawn, and go into deeper waters for the winter.

Habitat:

- Prefer shallow water near shore,
- Frequently occur in floating vegetation or beds.

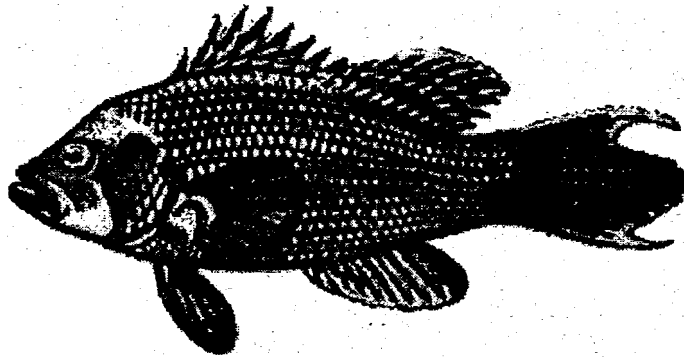
Spawning:

- Occurs in brackish water from May to June.
- Have an elaborate nest building process.

Feeding:

- A pugnacious species that uses its spines to drive away other species.
- Diet consists of invertebrates, small fish and fish eggs.

BLACK SEA BASS
Centropristis striata



Identification:

- Large mouth and thick head.
- Spinous dorsal fm.
- Caudal fin round.
- Head and body bluish black to dark brown, bottom is bluish gray.
- Color tends to vary with age and type of structure they occupy.
- Males develop a hump on the nape.

Size:

Length to 2 ft.. (60 cm) and weighs up to 8 lbs. (3.6 Kg).

Range:

Atlantic coast of North America from Maine to northeast Florida and east Gulf of Mexico.

Local Distribution:

Black sea bass begin to appear in large numbers in the waters of the Hudson-Raritan Estuary when water temperatures begin to rise in the spring. They reach peak abundance by the beginning of the summer. When water temperatures warm considerably they will migrate to the north. When water temperatures begin to fall they become abundant again as they migrate south and offshore. They spend the winter in the southern part of their range.

Habitat:

- Prefer to live near rocks, wrecks, pilings or any type of structure that offers protection and food.
- Young enter brackish water.

Spawning:

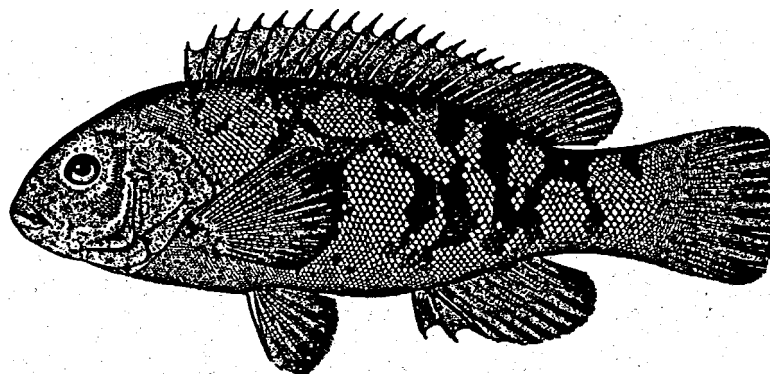
- Spawning takes place May to June.
- Eggs are buoyant.
- Hatching occurs in approximately 75 hours:
- Black sea bass begin life as females and transform into males.
- Sex reversal takes place between two and five years of age.

Feeding:

- Feeding occurs along the bottom.
- Use their large mouth to capture prey.,
- Diet consists of crustaceans, mollusks and fish.

TAUTOG

Tautoga onitis



Identification:

- Conical teeth, with two or three in the front of each jaw much larger than the others.
- Heavy stout fish with thick lips.
- Dark fish, generally chocolate grey, with mottling or blotches of darker color.
- Color tends to vary with age, and type of structure they occupy.
- Commonly known as a blackfish.

Size:

Length to 3 ft. (91 cm) and weighs up to 22 lbs. (10 Kg).

Range:

Atlantic coast of North America from Nova Scotia to South Carolina.

Local Distribution:

Tautog begin to appear in large numbers in the waters of the Hudson-Raritan Estuary when water temperatures begin to rise in early spring. They reach peak abundance by mid spring. When water temperatures warm considerably they begin their northerly migration. When water temperatures begin to fall they become abundant again as they migrate south and offshore. They spend the winter in the southern part of their range. Those that remain in the Hudson-Raritan Estuary area move off to deeper waters.

Habitat:

- Rarely stray more than 10 to 12 miles from shore or depths of 100-150 feet (30-45 m.).
- Enter brackish water.
- Prefer to live near rocks, wrecks, pilings or any type of structure that offers protection and food.

Spawning:

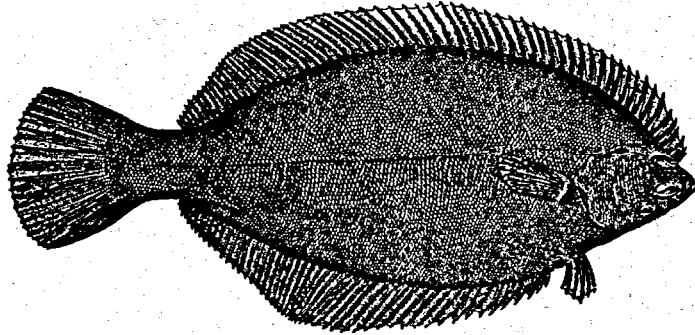
- Spawning takes place in June.
- Eggs are buoyant.
- Growth is slow.

Feeding:

- Feeding occurs along the bottom.
- Use their large front teeth to pry mussels or barnacles off the structure on which they grow, then use their back teeth to crush them.
- Often they lie dormant until a certain stage of the tide, and then feed.
- Diet consists of invertebrates, preferring mussel, barnacles, crabs, hermit crabs and worms.

WINTER FLOUNDER

Pleuronectes americanus



Identification:

- Small mouth with lips and no teeth.
- A flat fish upon reaching the juvenile stage.
- Eyes on right side of head..
- Color varies from brown, and reddish-brown to grey on top and white on the bottom.
- When brown in color they often have spots.

Size:

Length to 10-14 in. (25-35 cm) and weigh 3/4-2 lbs. (1/3-.9 kg); however can grow up to 25 in. (64 cm) and 8 lbs (3.5 kg).

Range:

Atlantic coast of North America from Labrador to Georgia: Most abundant from Gulf of St. Lawrence to New Jersey.

Local Distribution:

Winter flounder migrate from bays and estuaries offshore to cooler coastal waters as water temperatures warm in late spring. Large fish are less tolerant of warmer waters and begin the migration first. When water temperatures cool in the fall the fish begin to move back into lower portions of the Hudson-Raritan Estuary. Populations in local bays and estuaries are at their highest between December and April.

Habitat:

- Prefer waters between 3-426 feet (1-130 m)
- Found on sand, clay, gravel and muddy-sand bottoms.
- Enter mouths of estuaries and extend into water that is nearly fresh during winter.
- In warmer parts of their range they can be found in deeper waters during late spring and summer months.

Spawning:

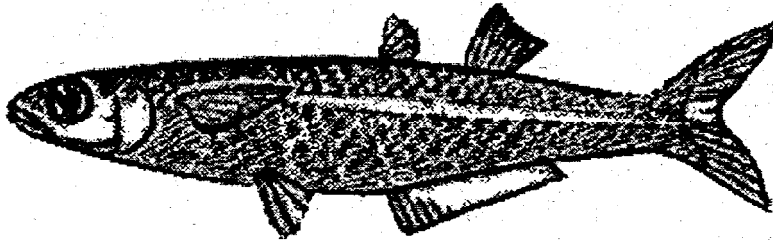
- Spawning takes place from mid winter to early spring.
- Spawn in water 6-20 feet (2-6 m) deep in the upper reaches of the estuary.
- Eggs are not buoyant, sink to the bottom and stick to each other in clusters.
- When the eggs hatch the larvae resemble those of other laterally compressed fish, but as they grow they go through a metamorphosis and settle to the bottom as a flat right handed fish.
- Juveniles, because of their larger size, fight the currents and migrate downstream.
- Eventually leave the estuary to follow the adults in their migration.
- Females mature at 2-3 years of age.

Feeding:

- Feeding takes place along the bottom.
- Depend on sight for feeding therefore they feed only during the day.
- Move about in search of food.
- Diet consists of small worms, crustaceans, mollusks and some plant material.

ATLANTIC SILVERSIDE

Menidia menidia



Identification:

- Small mouth lacking teeth.
- Slender, thin bodied fish with a round belly.
- Large eyes.
- Translucent bottle green on top.
- Silver band running along each side outlined in black.
- Bottom is white.
- commonly known as a spearing.

Size:

Length to 6 in. (15 cm).

Range:

Atlantic Coast of North America from Gulf of St. Lawrence to northeast Florida.

Local Distribution:

Atlantic silverside is a resident species in the Hudson-Raritan Estuary. In the warmer months they abound in the shallow waters of local bays, creeks and estuaries. In the colder months they enter deeper water within the estuary.

Habitat:

- Live in brackish as well as high salinity waters.
- Prefer sandy or gravelly shores along the waters edge.

Spawning:

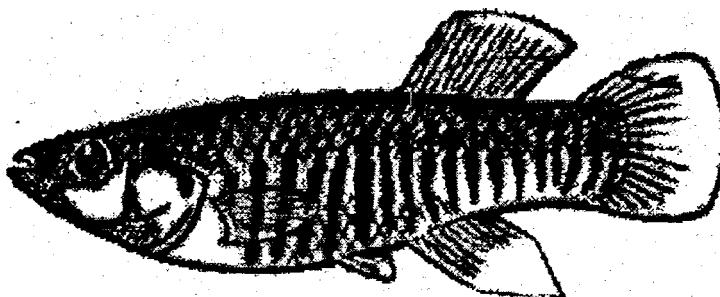
- Spawn in May, June and early July.
- Gather in schools and deposit their eggs on sandy bottoms.
- Eggs sink and stick together in clusters or sheets.
- Hatching occurs in 8-10 days.
- Growth is rapid with maturity reached at approximately 1 year of age.

Feeding:

- Omnivorous.
- Diet consists of algae, copepods, shrimp, young squid, worms, insects and fish eggs.

STRIPED MUMMICHOG

Fundulus majalis



Identification:

- . Male has 15-20 black vertical bars on side.
- . Female with 2-3 black horizontal stripes.
- . Body is more slender and snout more pointed than the common mummichog.
- . Dark olive green on top, with silver sides and greenish-yellow on the bottom.
- . Commonly known as a killifish.

Size:

Length to 7 in. (18 cm).

Range:

Atlantic Coast of North America from New Hampshire to northeast Florida; north Gulf of Mexico.

Local Distribution:

The striped mummichog is a resident species of the Hudson-Raritan Estuary. It winters in the deeper waters of the estuaries.

Habitat:

- . Often found along the open beach.
- . Live in nearshore shallow waters.
- . Prefer high salinity waters.

Spawning:

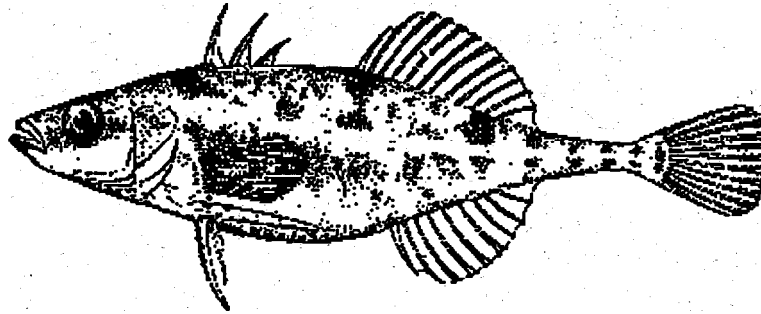
- . Spawning occurs from April to September in shallow water.
- . Eggs are large and only a small number are produced.
- . Eggs are laid on sand.

Feeding:

- Diet consists of small mollusks, crustaceans, insects and fish.

FOUR SPINE STICKLEBACK

Apeltes quadracus



Identification:

- Four to five dorsal spines.
- No bony plates on side.
- Skin has no scales.
- Flat belly and sharp back differs from other sticklebacks.
- Brownish olive or greenish brown on top, with dark mottling.
- Bottom is silvery white.

Size:

Length to 3 in. (7 cm).

Range:

Atlantic coast of North America from the Gulf of St. Lawrence to North Carolina.

Local Distribution:

Four spine sticklebacks are a year-round resident in the Hudson-Raritan Estuary. They enter the mouths of creeks and streams in the spring to spawn, and enter slightly deeper water for the winter.

Habitat:

- Prefer shallow near shore waters.
- Inhabit both vegetation beds and floating vegetation.

Spawning:

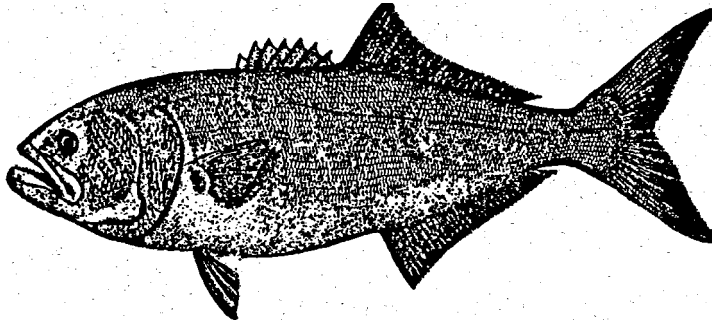
- Spawning occurs from May to July.
- Go through an elaborate nest building process.
- Male builds a nest of plant fragments.
- The nest is conical, with an opening at the top.
- The male picks up the eggs laid by the female and deposits them at the top of the nest..
- Eggs sink and stick together in clumps when inside the nest.
- Hatching occurs in six days.

Feeding:

- A pugnacious species that uses its spines to drive away other species.
- Diet consists of small invertebrates, small fish and fish eggs.

BLUEFISH

Pomatomus saltatrix



Identification:

- Mouth large with prominent sharp teeth.
- Deeply forked tail.
- Greenish or bluish on top.
- Silvery on sides and on bottom.

Size:

Length to 45 in(1.1 m) and weigh up to 27 lbs. (12 kg).

Range:

Atlantic Coast of North America from Nova Scotia to Florida; Bermuda to south Argentina. Widely but irregularly distributed elsewhere in the Atlantic and Indian oceans.

Local Distribution:

Bluefish arrive in the New York Bight sometime in late spring. A buildup of fish occurs in the Hudson-Raritan Estuary until it reaches a peak in mid-summer. When water temperatures begin to drop in fall they begin a extensive migration along the coast that can last until December, if the waters do not cool too quickly.

Habitat:

- Oceanic in nature, but can be found in bays, creeks and estuaries.
- Prefer warm waters.
- Generally not found in abundant numbers in water temperatures below 60 degrees Fahrenheit.
- Like to congregate around some type of structure. This can range from rockpiles to rises in the sea floor.

Spawning:

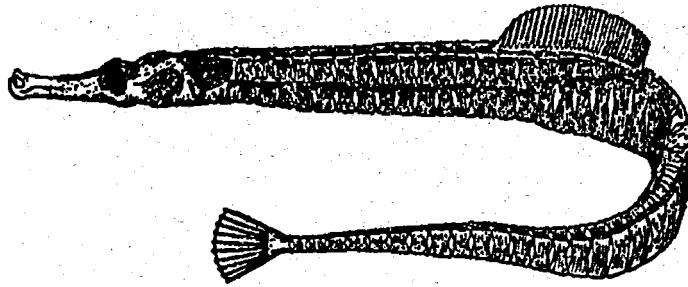
- Spawn offshore twice a year, in the spring and in the summer.
- A mature fish contains about 900,000 eggs.
- Young bluefish, from the spring spawn migrate inshore and spend the summer in local bays, creeks, and estuaries.
- Fish from the summer spawn swim towards the coast and migrate south in the fall.
- Become sexually mature at age two.

Feeding:

- Feeding occurs throughout the water column.
- Rely primarily on sight to find food.
- Feed on a variety of invertebrates and fishes.
- Diet consists of shrimp, squids, crabs, worms and fishes.

NORTHERN PIPEFISH

Syngnathus fucus



Identification:

- Snout is tube-like and mouth is toothless.
- Body long and slender, similar to a pipe cleaner.
- Head occupies one eighth to one ninth of body length.
- Sides marked by brown bars and many white dots.
- Color is greenish, olive or brown on top.
- Bottom golden yellow.

Size:

Length to 12 in. (30 cm).

Range:

Atlantic Coast of North America from the Gulf of St. Lawrence to Florida; Gulf of Mexico.

Local Distribution:

Pipefish are believed to be a resident species in the Hudson-Raritan Estuary.

Habitat:

- Commonly found in seagrass beds in bays and estuaries.
- Rarely venture far from shore and occasionally enter freshwater.

Spawning:

- Breeding occurs from March to August.
- The female lays the eggs in the male's pouch.
- Male pipefish maintain eggs in brood pouch.
- Incubation lasts ten days.

- The young remain in the pouch until they are about 5/16 in. (9 mm) long.
- Young are independent after leaving pouch.

Feeding:

- In order to capture prey they expel water from the trumpet-like mouth, the resulting vacuum returns water that contains food.
- Diet consists of minute copepods, amphipods, fish eggs and other small marine animals.

LINED SEAHORSE

Hippocampus erectus



Identification:

- Snout is tubular with small mouth at end.
- Horse-like head.
- The head is surmounted by a pentagonal star shaped coronet.
- Neck, body and tail are covered with bony plates.
- Long tail that curves inward.
- Male has a brood pouch.
- The dorsal fin is located about midway along the length of the fish.
- Color varies from light brown to gray.
- Various mottling and blotching with paler and darker colors.

Size:

Length to 4-6 in. (10-15 cm).

Range:

Atlantic coast of North America from Massachusetts to South Carolina.

Local Distribution:

The seahorse is believed to be a resident species in the Hudson-Raritan Estuary.

Habitat:

- Prefer to live among eelgrass and seaweed.
- Cling to objects with their prehensile tail.

Spawning:

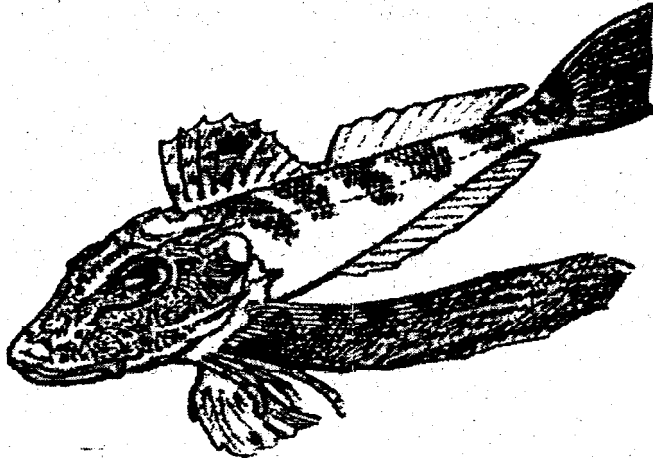
- Breed in the summer.
- Eggs are deposited a few at a time in the pouch of the male.
- Up to 150 eggs may be deposited in the pouch.
- When the yolk sac is absorbed they are squeezed out of the pouch and resemble the parents.

Feeding:

- Feed by sucking in minute crustacea and anything else that fits in their mouth.

NORTHERN SEA ROBIN

Prionotus carolinus



Identification:

- Large mouth lacking teeth.
- Large head with tapering body.
- Head encased in bony plates.
- Fanlike pectoral fins.
- The three lower rays of the pectoral fins are modified into feelers
- Body is reddish brown or gray in top.
- Black spot located in the center of the dorsal fin.
- Generally five blotches along side and white to pale yellow on the bottom.

Size:

Length to 15 in. (38 cm).

Range:

Atlantic coast of North America from Nova Scotia to Florida.

Local Distribution:

The northern sea robin undergoes an inshore offshore migration in the Hudson-Raritan Estuary. As water temperatures begin to warm sea robins begin to migrate inshore from depths of 300 feet (100 m) or more. They inhabit waters in the Hudson-Raritan Estuary as shallow as the tide line. When water temperatures begin to drop in the fall they migrate to deeper waters.

Habitat:

- Keep to the bottom but are active swimmers.
- Generally found on smooth, hard bottom, and often bury themselves in the sand.

Spawning:

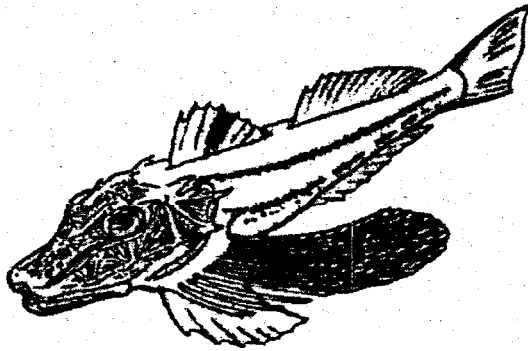
- Spawning occurs from June to September
- Eggs are buoyant, and hatching occurs in 60 hours or more.
- Spawning and incubation varies with temperature. Warmer temperatures result in earlier spawning, as well as shorter incubation. The opposite applies for colder temperatures.

Feeding:

- A voracious feeder.
- Diet consists of squid, shrimp, bivalve mollusks, worms, crabs and small fish.

STRIPED SEA ROBIN

Prionotus evolans



Identification:

- Large mouth lacking teeth.
- Large head with tapering body.
- Head encased in bony plates.
- Fanlike pectoral fins.
- The three lower rays of the pectoral fins are modified into feelers
- Body is reddish brown or gray in top.
- Two black stripes along body.
- Dark blotch between dorsal spines 4-5.
- White to pale yellow on the bottom.

Size:

Length to 18 in. (45 cm).

Range:

Atlantic coast of North America from Nova Scotia to Florida.

Local Distribution:

The striped sea robin undergoes an inshore offshore migration in the Hudson-Raritan Estuary. As water temperatures begin to warm sea robins begin to migrate inshore from depths of 300 feet (100 m) or more. They inhabit waters in the Hudson-Raritan Estuary as shallow as the tide line. When water temperatures begin to drop in the fall they migrate to deeper waters.

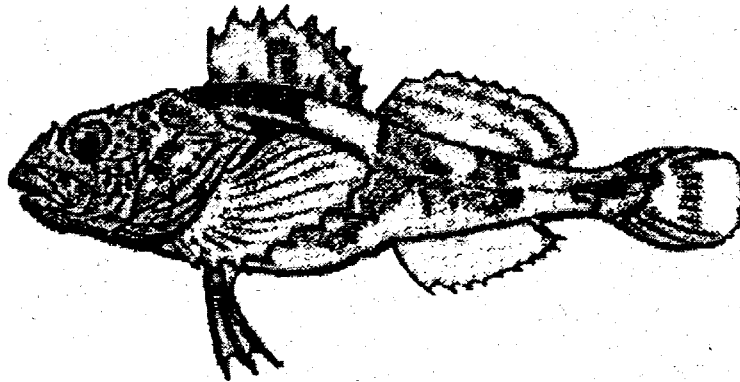
Habitat:

- Keep to the bottom but are active swimmers.
- Generally found on smooth, hard bottom, and often bury themselves in the sand.

Feeding:

- A voracious feeder.
- Diet consists of squid, shrimp, bivalve mollusks, worms, crabs and small fish.

GRUBBY
Myoxocephalus aeneus



Identification:

- Large mouth.
- Large head with tapering body.
- Body unscaled.

Size:

Length to 7 in. (18 cm).

Range:

Atlantic coast of North America from Strait of Belle Isle and Gulf of St. Lawrence to New Jersey.

Local Distribution:

Grubby's are believed to be a resident of the Hudson-Raritan Estuary.

Habitat:

- Estuaries to 420 feet (130 m).

LONGHORN SCULPIN
Myoxocephalus octodecemspinosus,



Identification:

- Large mouth lacking teeth.
- Large head with tapering body.
- Head encased in bony plates.
- Long preopercular spine.
- Body is reddish brown or gray in top.

Size:

Length to 18 in. (46 cm).

Range:

Atlantic coast of North America from East New Foundland and north Gulf of St. Lawrence to Virginia.

Local Distribution:

The longhorn sculpin undergoes an inshore offshore migration in the Hudson-Raritan Estuary. As water temperatures begin to cool longhorn sculpins begin to migrate inshore from deeper offshore waters. When water temperatures begin to rise in the spring they migrate to deeper waters.

Habitat:

- Estuaries and continental shelf waters.

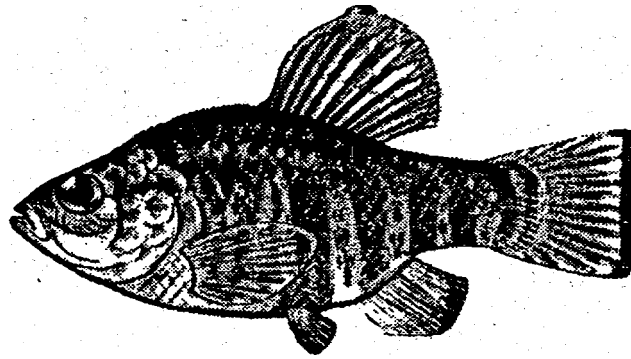
Spawning:

- Spawning occurs from November to January.
- Eggs are demersal and adhesive.
- Hatching occurs in three months or less.

Feeding:

- A bottom feeder.
- Diet consists of mainly of crustacea, particularly *Cancer* crabs, fish and fish eggs.

SHEEPSHEAD MINNOW
Cyprinodon variegatus



Identification:

- Large, wedge shaped teeth.
- Upper profile slightly concave, deep-bodied.
- Thick caudal peduncle.
- Ocellus on rear of dorsal fin in females.
- Irregular bands and dark spot at base of dorsal fin.
- Males have dark-edged caudal fin. Breeding males display brilliant blue nape and orange cheeks.
- Commonly known as a killifish.

Size:

Length to 3 in. (7 cm).

Range:

Atlantic coast of North American from Cape Cod to Florida; Bahamas and Gulf of Mexico.

Local Distribution and Movement:

A year-round resident in the Hudson-Raritan Estuary.

Habitat:

- Common in weedy areas.
- Found in fresh to full seawater.

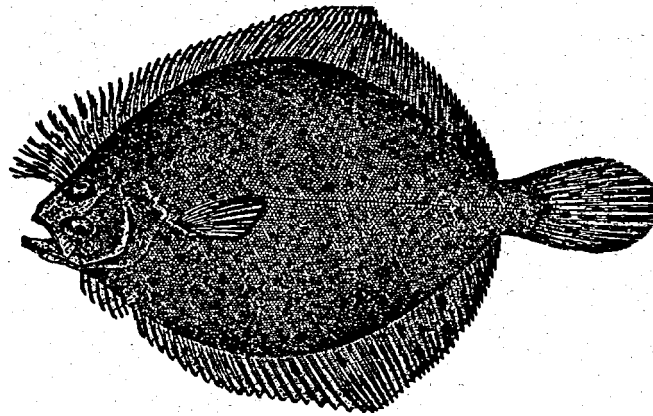
Spawning:

- . Spawning occurs from April to September.
- Males fight for females, clasping them with dorsal and anal fin, while eggs and milt are released.
- Eggs sink, sticking together in clumps, hatching in 5 or 6 days.

Feeding:

- . Diet consists of both plants and animals.

WINDOWPANE
Scophthalmus aquosus



Identification:

- . Large mouth with small teeth.
- Thin, roundish body.
- Left handed flatfish.
- Pale and translucent greenish olive or light slaty brown on top often dotted with small brown spots.
- White bottom.
- Commonly known as a sundial.

Size:

Length to 18 in. (45 cm).

Range:

Atlantic coast of North America from the Gulf of St. Lawrence to Florida.

Local Distribution:

The windowpane is found year round in the Hudson-Raritan Estuary. They move inshore into the Hudson-Raritan Estuary as water temperatures rise in the spring and migrate offshore as temperatures cool in the fall.

Habitat:

- Prefer sandy coastal bottoms.
- Found in depths up to 148 ft. (45 m).

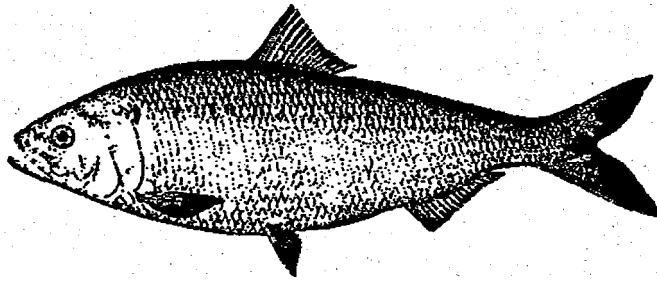
Spawning:

- Spawn in the bight from April to December.
- Eggs are transparent and buoyant,
- Incubation lasts about eight days.
- Larvae swim upright and have eyes on both sides of their head.
- Eyes migrate to left side and they take up a bottom existence.
- Measure approximately 7/16 of an inch (10 mm) by this stage.

Feeding:

- Diet consists of a variety of annelid worms, crabs, squid, mollusks and crustacea.

AMERICAN SHAD
Alosa sapidissima



Identification:

- Deep body.
- Saw edge on belly; called razor belly.
- Forked tail.
- Dark spot on shoulder just behind operculum followed by 3 to 27 small spots.
- Silver color.

Size:

Length to 30 in. (75 cm) and weigh up to 12 lbs. (5 kg).

Range:

Atlantic coast of North America from Newfoundland to Florida.

Local Distribution:

Shad are anadromous. They enter the waters of the Hudson-Raritan Estuary in early spring, depending on water temperature. They reach peak abundance in the rivers by middle to late spring. Once spawning occurs they descend the rivers and return to their offshore grounds.

Habitat:

- Found in freshwater in the spring where oxygen levels are high.
- In the ocean they are found on continental shelf waters.
- Populations of different rivers mix on the wintering grounds.

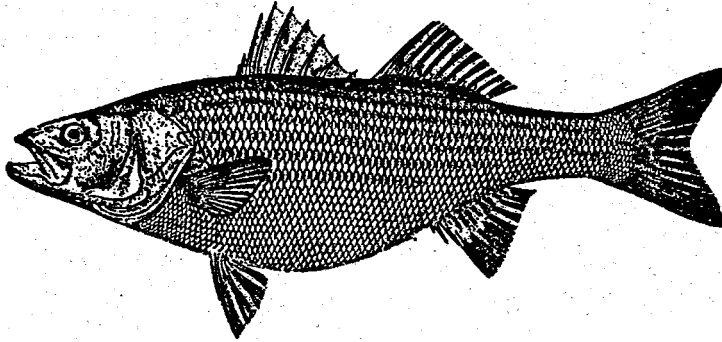
Spawning:

- An anadromous species spawning in freshwater and maturing in the sea.
- In the spring adult shad migrate to the upper reaches of their natal rivers.
- Prefer to spawn over sand, gravel, or mud.
- Spawning begins in the late afternoon and continues into the night.
- Females release from 100,000 to 600,000 eggs, depending on the size of the female.
- Eggs are nonadhesive and heavier than water. They are dependent on currents to carry them and keep them afloat.
- Eggs generally hatch in 4 to 6 days.
- Small teeth develop in the jaws of the larvae.
- Growth is rapid and within 4 to 6 weeks they become juveniles.
- Juveniles lose their teeth.
- These young form schools migrating downstream to tidal portions.
- In the fall they migrate into the sea to their wintering grounds.
- After spawning adults return to the sea, although many die on their return to sea as a result of exhaustion from the spawning process.

Feeding:

- Adults do not feed on their upstream migration.
- Juveniles diet consists of a variety of invertebrates, including crustaceans and insects while in freshwater.
- In saltwater their diet consists of zooplankton including copepods, mysids and euphausiids.

STRIPED BASS *Morone saxatilis*



Identification:

- Large mouth lacking teeth.
- Spinous dorsal fin.
- 7-8 stripes.
- Dark green to black on top.
- White bottom.

Size:

Length to 5 ft. (1.5 m) and weighs up to 125 lbs. Adults average approximately 18-30. in. (45-75 cm) and weigh between 1-15 lbs. (.5-7 kg).

Range:

Atlantic coast of North America from St. Lawrence to North Florida. They have been established in several landlocked lakes and on the west coast of North America.

Local Distribution:

The striped bass is a year-round resident in the Hudson-Raritan Estuary. Peak abundance is reached in the spring and fall, when they undergo extensive migrations to and from winter and summer grounds.

Habitat:

- Anadromous .
- Schools in rivers, bays, estuaries, and the ocean.
- Do not have a preference for particular bottom types, prefer to congregate around structure.

Spawning:

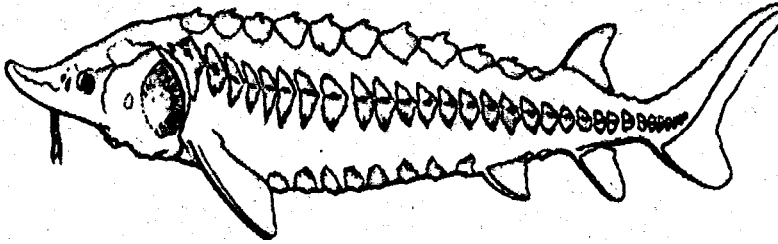
- Adult striped bass return to their natal rivers to spawn.
- Spawning begins in March and continues until June.
- Females carry between 62,000-112,000 eggs per pound of fish.
- Eggs are nonadhesive and heavier than freshwater.
- Current is required to keep the eggs from settling and being smothered by silt.
- hatching occurs from 30-74 hours.
- Juveniles remain in fresh or slightly saline, water and seek shelter along protected shorelines until fall.
- In late fall they move into the deep holes of the river and remain there until spring.
- In their second summer they migrate into bays and sounds.
- Three year old fish will begin to migrate into the ocean and join the adult, population along the coast.

Feeding:

- Voracious predators, high on the food chain.
- Prey upon invertebrates and small fishes.
- Diet consists of clams, calico crabs, herring, menhaden, and mullet.
- When feeding, bass will gorge themselves.

ATLANTIC STURGEON

Acipenser oxyrinchus



Identification:

- . Mouth sub-terminal, with four barbels on snout.
- . Snout long and pointed.
- . Covered by five rows of bony plates.

Size:

Length to 10 ft. (3 m) and weigh up to 250 lbs. (1.13 kg).

Range:

Atlantic coast of North America from Labrador and Newfoundland to St. Johns river, Florida.

Local Distribution:

The Atlantic sturgeon is a year-round resident in portions of the Hudson-Raritan Estuary.

Habitat:

- . Inhabit fresh, brackish and saltwater.
- . Prefer large rivers where they can swim upstream to spawn.
- . Examples are the Delaware, Raritan and Hudson Rivers.

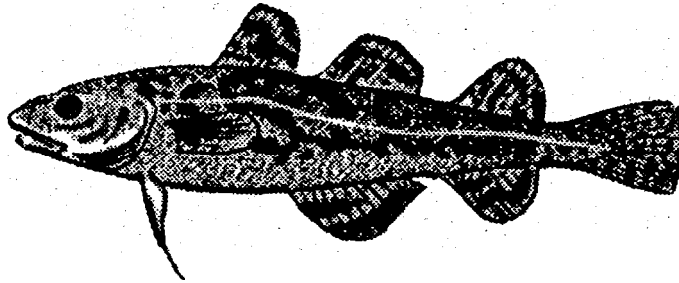
Spawning:

- . Anadromous, spawning in freshwater and spending the rest of its life in saltwater.
- . Spawn during May and June in the upper reaches.
- . Eggs are broadcast in flowing water over rubble or gravel and become widespread.
- . Hatching occurs from 4 to 7 days, and is temperature dependent.

Feeding:

- Bottom feeders.
- Use snout to stir up bottom and barbels to find food.
- Diet consists of mollusks, polychaete worms, gastropods, shrimps and small benthic fishes.

ATLANTIC TOMCOD
Microgadus tomcod



Identification:

- Three dorsal and two anal fins.
- Large subterminal mouth with single barbel on lower jaw.
- Olive or muddy-green on top,
- Spots or blotches forming a mottled pattern on its sides.
- Whitish on bottom.

Size:

Length to 16 in. (40 cm) and weigh up to 1 1/4 lbs. (0.5 kg).

Range:

Atlantic coast of North America from Labrador and the Gulf of St. Lawrence to Virginia.

Local Distribution:

Tomcod occur throughout the year in portions of the Hudson-Raritan Estuary.

Habitat:

- Inhabit brackish water and fresh water in winter months.
- Prefer depths of 6-8 ft. (2-3 m) or less.
- Congregate near some type of cover, preferably rocky bottom or patches of grass.

Spawning:

- Spawning occurs in November to February in brackish or saltwater.
- Eggs sink to bottom and attach to rocks or algae.
- Large females produce 40-45,000 eggs.
- Eggs hatch in one month.
- Growth is slow, juveniles are approximately 3 in. (75 mm) after one year.

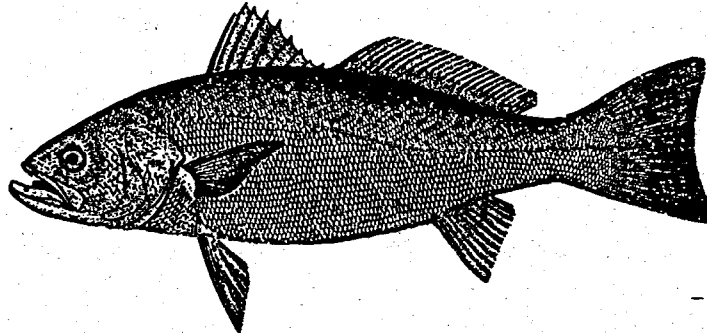
Feeding:

- Bottom dwellers that use their barbell to detect food.
- Diet consists of shrimp, worms, clams, squid and small fishes.

F e e d i n g :

- Bottom dwellers that use their barbell to detect food.
- Diet consists of shrimp, worms, clams, squid and small fishes.

WEAKFISH
Cynoscion regalis



Identification:

- Large mouth and protruding lower jaw.
- Called weakfish because of weak mouth.
- Dark olive or green on top.
- Dark green, sometimes bronze spots on top of body.
- Bottom white or silvery.

Size:

Length to 39 in. (1 m) and weigh up to 20 lbs. (9 kg); adults average 10-20 in. (25-50 cm) and weigh between 2-7 lbs. (1-3 kg)

Range:

Atlantic coast of North America from Massachusetts to Florida.

Local Distribution:

Weakfish migrate in a general north south direction, with older fish migrating more offshore than south. Peak abundance is reached in lower portions of the Hudson-Raritan Estuary by late summer and then, as water temperatures begin to fall, they leave the area.

Habitat:

- A pelagic species.
- Cruise open water in search of food.
- Prefer shallow water, rarely found far from the coast.
- Commonly found in the surf, sounds, inlets, bays and saltwater creeks.

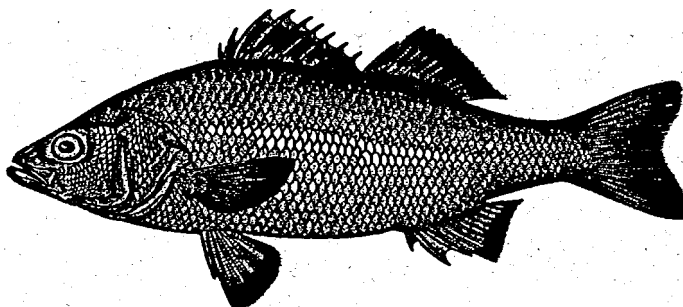
Spawning:

- Spawning occurs from May to October, peaking in May and June in estuaries and nearshore zones.
- Females produce about 286,000 eggs.
- Eggs are buoyant and hatch in approximately 48 hours.
- Growth is rapid and fish measure 8 in. (20 cm) by the end of their first year.
- Young spend summer in protected nursery areas until fall, then migrate southward.
- Young migrate in a north-south direction, while adults migrate in an inshore-offshore direction.
- Females mature at ages 1 and 2.

Feeding:

- Feed throughout the water column.
- When feeding they open their mouth quickly causing a drop in pressure this draws food into their mouth.
- Diet consists of grass shrimp, crabs, worms, and small fishes such as silversides, anchovies, and killifish..

WHITE PERCH *Morone americana*



Identification:

- Similar in appearance to striped bass only body is more compressed and lacks stripes.
- Anal fin has three spines.
- Caudal fin with a shallow fork.
- Olive or dark green on top.
- Silver green on sides.
- Silver on the bottom.

Size:

-Length to 19 in. (48 cm) and weigh up to 4 lbs. (1.8 kg).

Range:

Atlantic coast of North America from Nova Scotia to North Carolina.

Local Distribution:

White perch are year-round residents in the Hudson-Raritan Estuary.

Habitat:

- Prefer shallow water, usually not deeper than 10 feet (3 m).
- Inhabit fresh, brackish and coastal waters, usually near mouths of rivers.
- Roam in search of food.

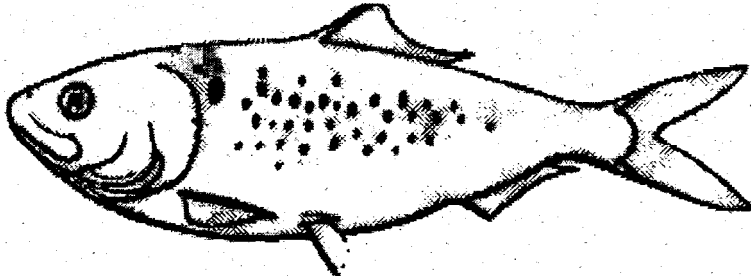
Spawning:

- Spawning occurs in April, May and June.
- Adults swim into fresh or slightly brackish water to spawn.
- Eggs sink, and stick together in masses or to benthic.
- Hatching occurs in about six days.
- Larvae at time of hatching measure approximately 2.3 mm long.
- As juveniles grow they migrate to the lower reaches of their natal rivers and bays.
- Growth is rapid during the summer and early fall months.
- In the winter they gather in large schools and move into deep holes in the river.
- Migrate upstream to spawn in the spring.

Feeding:

- Gregarious and constantly in search of food.
- Diet consists of young squid, worms, shrimps, crabs, killifishes, and fish fry.
- Eat spawn as fish deposit it.

MENHADEN
Brevoortia tyrannus



Identification:

- Dark shoulder spot often followed by many smaller spots.
- Saw-like edges on the belly, near anus.
- Dark bluish-green on top, silvery, with brassy sides,
- Fins pale yellowish.
- Commonly known as a mossbunker.

Size:

Length to 14 in. (35 cm).

Range:

Atlantic coast of North America from Nova Scotia to Florida.

Local Distribution:

Menhaden are common in the waters of the Hudson-Raritan Estuary from May to October. They arrive in the spring as temperatures warm, then migrate south as temperatures cool in the fall. It is not known where they spend the winter. They are last seen around Cape Fear in North Carolina.

Habitat:

- Roaming fish.
- Inhabit bays, estuaries and the open ocean
- Rarely stray more than a couple miles from the coast.
- Travel in schools that number in the thousands.

Spawning:

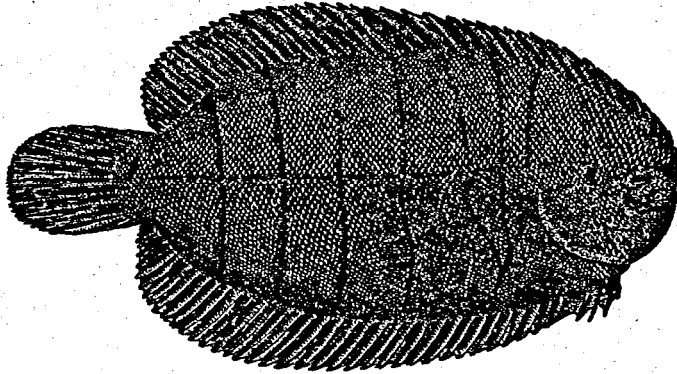
- Spawning begins in June, and continues into August in the northern part of its range, and late autumn into early winter in the southern portion of its range.
- Eggs are buoyant and are carried by the currents.
- Hatching occurs in less than 48 hours.
- Growth is rapid, and fish spawned in the summer will measure 2-3 in. (6-8 cm) by winter.

Feeding:

- Swim with mouth open and gills spread apart.
- Mouth and straining apparatus act in a way similar to that of a plankton net.
- Adult menhaden will filter between 6-7 gallons of water per minute.
- Diet consists of microscopic plants, diatoms in particular, and small crustaceans.
- Feed by filtering the water with a strain-like apparatus consisting of layers of gill rakers.

HOGCHOKER

Trinectes maculatus



Identification:

- Small mouth.
- Right handed flatfish.
- Lack pectoral fin.
- Dark brown with dark bars.
- Blind side frequently blotched or spotted.

Size:

Length to 8 in. (20 cm).

Range:

Atlantic coast of North America from Massachusetts to Florida; Gulf of Mexico to Argentina.

Local Distribution:

The hogchoker is a year-round resident in the entire Hudson-Raritan Estuary.

Habitat:

- Found in coastal waters out to depths of 240 ft. (73 m).
- Enter freshwater hundreds of miles upstream.

Spawning:

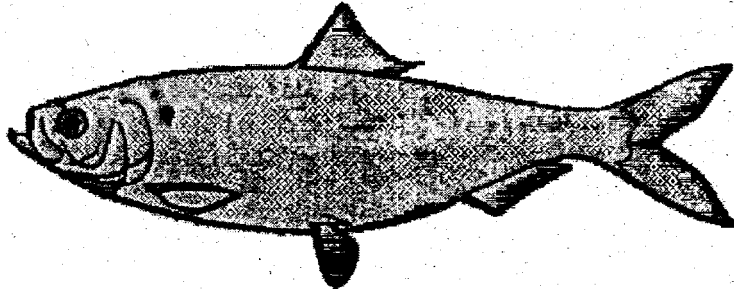
- Spawn in late spring and summer.,
- A female contain about 54,000 eggs.
- Growth is rapid. They measure 2-3 inches (5-8 cm) at one year.
- Hogchokers become mature at approximately 4 inches (10 cm).

Feeding:

- Diet consists of worms_ and small crustaceans.

BLUEBACK HERRING

Alosa aestivalis



Identification:

- Large mouth lacking teeth.
- Usually one small shoulder spot.
- Lining of the body cavity is sooty or blackish.
- Forked tail.
- Similar to alewife.
- Silvery appearance.
- Bluish on top.

Size:

Length to 15 in. (40 cm).

Range:

Atlantic coast of North America from Nova Scotia to Florida.

Local Distribution:

In the spring, blueback herring are abundant in the New York Bight region. They enter the Hudson-Raritan Estuary to spawn, then migrate to the Georges Bank, Gulf of Maine area.

Habitat:

- Use lower reaches of rivers to spawn, then return and remain in the ocean.

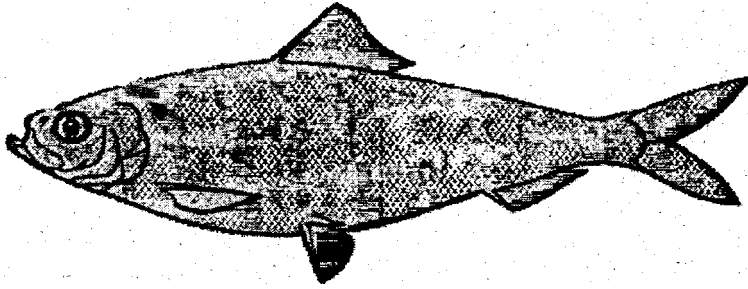
Spawning:

- The blueback herring is anadromous.
- Spawning begins in April, when they begin to ascend fresh and brackish water.
- Spawn in streams over rocky or gravel bottom.
- Approximately 350,000 eggs are laid.
- Eggs sink and will stick to any object.
- Hatching occurs in approximately 50 hours.
- In one month they measure 1-2 inches (3-5 cm).
- Spent fish return to the ocean.

Feeding:

- Filter feeders.
- Feeding is believed to take place mainly during daylight hours.
- Planktonic feeder.
- Diet consists of copepods and pelagic shrimp.

ALEWIFE
Alosa pseudoharengus



Identification:

- Large mouth lacking teeth.
- Usually one small dark shoulder spot.
- Forked tail.
- Similar to blueback herring.
- Lining of body cavity is silver,
- Silvery appearance.
- Greenish on top.

Size:

Length to 15 in. (40 cm).

Range:

Atlantic coast of North America from New Foundland and Gulf of St. Lawrence to South Carolina.

Local Distribution:

In the spring, alewives are abundant in the New York Bight region. They enter the Hudson-Raritan Estuary to spawn, and then migrate to the Gulf of Maine.

Habitat:

- Use lower reaches of rivers to spawn, and return to the ocean.

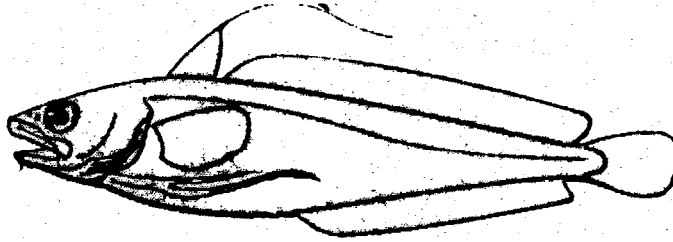
Spawning:

- Alewives are anadromous.
- Become mature between three and five years old.
- Spawning begins in late March and early April.
- Spawning takes place in shallow, quiet areas of streams, ponds of large rivers and small coastal streams.
- Eggs are randomly broadcast and adhesive but lose this property within a few hours of spawning.
- Females deposit 100,000 to 300,000 eggs.
- Hatching occurs in three to five days, depending on water temperature.
- Juveniles remain in the estuary until the summer, when they migrate into the ocean.
- After spawning, mature adult fish return to the sea.

Feeding:

- Alewives are plankton feeders.
- Diet consists of copepods in freshwater and euphausiids, mysids, mollusks and arrow worms in marine waters.

RED HAKE
Urophycis chuss



Identification:

- Small pointed teeth.
- Third ray of dorsal fin is three to five times as long as the rest of the fin.
- Round tail.
- Top of fish is usually reddish, bottom varies from white to yellow.

Size:

Length to 20 in. (52 cm) and weigh up to 6 lbs. (3 kg).

Range:

Atlantic coast of North America from Labrador to North Carolina.

Local Distribution:

Red hake are abundant in the lower portions of the Hudson-Raritan Estuary in late fall to early winter and again in the spring. They spend the rest of the time in deeper waters of the New York Bight.

Habitat:

- A bottom fish.
- Found from inshore to offshore depths of 3000 feet (914 m).

Spawning:

- Spawning occurs from April to May in the New York Bight. The New York Bight is an important spawning and nursery area.
- Eggs are buoyant.
- Young fish are pelagic until 2 to 4 inches (5-10 cm), then settle to the bottom.
- Young fish during their first year enter and live within sea scallops for protection. They live here until they are too large for their hosts, or water temperatures become too low.
- Red hake mature when approximately two years old.

Feeding:

- Red hake feed predominantly at night on or near the bottom.
- Diet consists of squid, shrimp, amphipods, other crustaceans, and small fish.

COMMON BIRDS OF THE HUDSON RARITAN ESTUARY AND ADJACENT NEW YORK BIGHT

INTRODUCTION

The New York Bight is home to a diverse population of resident bird species but is equally important to the migrating, wintering and breeding birds that use the area. The bight is able to support this diversity because of the many types of habitats it has to offer. The habitat can range from open water to marsh and woodlands along the shores. The birds that use these varied habitats can range from large birds of prey, to waterfowl, to passerines.

Birds have evolved in such a way as to make them specialists, each bird occupies a separate niche. Body parts have evolved to perform specific functions. Waterfowl, for example have short legs and webbed feet, this is important because they spend most of their time in the water and need to be strong swimmers. Wading birds have long necks, legs and beaks that enable them to stalk prey in the shallow water habitats they frequent. Meanwhile birds of prey use sharp beaks and powerful legs to grasp prey once it is sighted with their keen eyesight. By inferring from these examples it is easy to see why birds need to specialize. Birds of prey would have no use for webbed feet and waterfowl would find long legs useless. There are countless specializations of body parts among birds, these are just a few examples that are common to the birds of the bight area.

Birds will use areas for different purposes depending on the time of year and species involved. The New York Bight is especially important to birds on their annual spring and fall migrations. It is during the spring and fall when there is abundance of food. This abundance makes the bight area an ideal rest stop. The birds can feed heavily and rest before heading onto their wintering and breeding grounds. Fall migrations are generally the heaviest because they contain progeny from the summer breeding season.

Wintering grounds are very important to all birds. Birds have specific requirements for an area to qualify as wintering grounds. They will often move about quite a bit to satisfy these needs. Plenty of food is a major requirement of all birds. With colder temperatures birds need more energy to survive. In order to produce more energy they must digest faster therefore they need to eat more. Open water is important to waterfowl because this is where they feed. Should an area become iced over they will have to move, in search of open water. Waterfowl prefer the bight because the constant currents ensure there will always be some open water available to them.

The bight area is used as breeding grounds for many species of birds. Breeding areas must also fulfill specific requirements needed by the bird in order for it to qualify as a breeding site. The saltmarsh, beach-littoral zone and uplands with woody vegetation are the most important areas used in the bight. Breeding areas must be able to support a growing population of birds by providing plenty of food and safety. The health of the bight is also very important to a successful brood. Because birds use the same breeding grounds year after year, the health of the bight can be measured on how successful breeding is.

Various types of birds live in and visit the bight area throughout the year. Some of the more common types are waterfowl, wading birds, gulls, terns, raptors and passerines.

Wading birds are water birds that do not swim but wade through the water. In the bight area they consist of herons, egrets and ibises. They wade along the shallow edges of marshes, mud flats and creek stalking their prey. Wading birds have short tails and long legs. They also have long necks and specialized bills. The bills of egrets and herons are used to seize prey in quick motions such as small fishes, frogs and aquatic insects. Ibises on the other hand use their bills to probe into the mud in search of fiddler crabs and mollusks.

Gulls and terns are long winged birds that have hooked bills and are good swimmers. They are probably the most common and visible of all birds in the bight area. The herring gull and the common tern are the most frequently observed in the bight area. Gulls are generally large in size and have a grey and white appearance. Gulls are opportunistic feeders and will feed on almost any food it can find. Terns are smaller and more graceful birds and unlike the gull they sharp have pointed bills. Terns are similar in color to gulls but instead of grey they generally have black caps. Terns are more selective in their preferring small live minnows, squids and shrimps.

Shorebirds inhabit the beach-littoral and marsh zones they include the plovers, sandpipers and oyster catchers. Most shorebirds have long legs and live near areas that are only exposed during low tides. Shorebirds makeup a considerable portion of the birds that migrate through the bight area with only a few remaining to nest. They feed mainly on sand and mud dwelling invertebrates.

Raptors are birds of prey and feed at the top of the food chain. They consist of ospreys, hawks and owls. They feed mainly on fish and small rodents. They are large birds with strongly hooked bills and powerful feet with hooked claws. Raptors are often good biological indicators of the health of the bight area.

Waterfowl spend most of their time on the water as their name would imply. They consist of ducks, geese and swans. Waterfowl have webbed feet and are very good swimmers. They are also strong and swift fliers that enable them to undertake extensive migrations each spring and fall. Migrations begin in the early afternoon and continue through the night. Waterfowl follow specific paths in their migrations and these paths have become known as flyways. Most waterfowl are gregarious, which is advantageous for feeding and safety when migrating.

Passerines are the largest order of birds containing some 59 families. They are made up of sparrows, warblers, ravens and other similar perching type birds. They can range in size from 4-26 inches. Passerines are the most adaptive and intelligent of all birds. They all have three toes pointed forward and one backward: This enables them to perch easily on anything from a branch to a grass stem.

The arrangement of class, families, genus and species follows the taxonomic order of the Peterson Field Guide to Eastern Birds. Within the family, genus are placed in alphabetical order and within each genus, species are listed alphabetically.

Common and Scientific Names: The common and scientific names used in this guide, are latin names which are used worldwide by scientists. Both scientific names are italicized, genus is capitalized and species is not.

Identification: Identification includes a brief description of the species, focusing on characteristics that are obvious and easy to recognize. Descriptions generally begin with the head and progress to the tail, also included are color and anything special they do.

Size: Lengths are maximum total lengths recorded and weights are maximums.

Range: The range is given in a north to south direction and is very general. Range is often useful in the identification of a species.

Local Distribution: Local distribution provides species specific information on a species occurrence in the Hudson-Raritan Estuary.

Habitat: Lists the types of habitat they prefer including substrate, water composition and depth. This information can be useful in identification as many species are habitat specific.

Spawning: Information on spawning is provided to help understand the life cycles of a particular species. Detailed information is not currently available on all species, therefore some species may have more detail than others.

Feeding: Explains how the species feed and includes a list of their preferred food items.

The glossary includes words that are found in the text as well as other words that can be useful when discussing fishes, birds and invertebrates.

BIRD SPECIES OF THE
HUDSON-RARITAN ESTUARY

SCIENTIFIC NAME

COMMON NAME

Order Gaviiformes

Family Gaviidae

Gavia immer

Common Loon

Order Podicipediformes

Family Podicipedidae

Podiceps auritus

Horned Grebe

Podilymbus podiceps

Pied-billed Grebe

Order Pelecaniformes

Family-Phalacrocoracidae

Phalacrocorax olivaceus

Great Cormorant

Phalacrocorax auritus

* Double-Crested Cormorant

Order Ciconiiformes

Family Ardeidae

Ardea herodias

* Great Blue Heron

Butorides striatus

* Green Heron

Florida caerula

Little Blue Heron

Bubulcus ibis

Cattle Egret

Casmerodius albus

* Great Egret

Egretta thula

* Snowy Egret

Nycticorax nycticorax

Black Crowned Night Heron

Family Threskiornithidae

Plegadis falcinellus

* Glossy Ibis

Order Anseriformes

Family Anatidae

Subfamily Cyginae

Cygnus olor

Mute Swan

Olor columbias

Whistling Swan

Subfamily Anserinae

Branta canadensis

* Canada Goose

Branta bernicla

Brant

Chen caerulescens

Snow Goose

Subfamily Anatinae

Anas platyrhynchos

* Mallard

Anas rubripes

Black Duck

Anas strepera

Gadwall

Anas acuta

* Pintail

Anas crecca

Green-winged Teal

Anas discors

Blue-Winged Teal

Anas americana

* American Widgeon

Anas clypeata

Northern Shoveler

Subfamily Aythyinae

<i>Aythya americana</i>	Redhead
<i>Aythya collaris</i>	Ring-necked Duck
<i>Aythya valisineria</i>	* Canvasback
<i>Aythya merila</i>	Greater Scaup
<i>Aythya affinis</i>	Lesser Scaup
<i>Bucephala clangula</i>	Common Goldeneye
<i>Bucephala albeola</i>	* Bufflehead
<i>Clagula hyemalis</i>	Oldsquaw

Subfamily Oxyurinae

<i>Oxyura jamaicensis</i>	Ruddy Duck
----------------------------------	------------

Subfamily Merginae

<i>Mergus serrator</i>	Red-breasted Merganser
-------------------------------	------------------------

Order Falconiformes

Family Accipitridae

Subfamily Buteoninae

<i>Haliaeetus leucocephalus</i>	Bald Eagle
--	------------

Subfamily Circinae

<i>Accipiter striatus</i>	* Sharp-Shinned Hawk
----------------------------------	----------------------

<i>Circus cyaneus</i>	* Marsh Hawk
------------------------------	--------------

Family Pandionidae

<i>Pandion haliaetus</i>	* Osprey
---------------------------------	----------

Order Gruiformes

Family Rallidae

<i>Rallus elegans</i>	King Rail
<i>Rallus longirostris</i>	Clapper Rail
<i>Rallus limicola</i>	Virginia Rail
<i>Laterallus jamaicensis</i>	Black Rail
<i>Gallinula chloropus</i>	Common Gallinule
<i>Fulica americana</i>	American Coot

Order Charadiiformes

Family Haematopodidae

<i>Haematopus palliatus</i>	* American Oystercatcher
-----------------------------	--------------------------

Family Charadriid

<i>Charadrius semipalmatus</i>	Semipalmated Plover
<i>Charadrius vociferus</i>	* Killdeer
<i>Charadrius melodus</i>	* Piping Plover

Family Scolopacidae

<i>Calidris pusilla</i>	Semipalmated Sandpiper
<i>Bartramia longicauda</i>	Upland Sandpiper
<i>Tringa melanoleuca</i>	Greater Yellowlegs
<i>Tringa flavipes</i>	Lesser Yellowlegs
<i>Tringa solitaria</i>	Solitary Sandpiper
<i>Catoptrophorus semipalmatus</i>	Willet

<i>Actitis macularia</i>	Spotted Sandpiper
<i>Arenaria interpres</i>	Ruddy Turnstone
<i>Limnodromus griseus</i>	Short-billed Dowitcher
<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher
<i>Calidris alba</i>	*Sanderling
<i>Caladris minutilla</i>	Least Sandpiper
<i>Calidris alpina</i>	Dunlin

Family Laridae

Subfamily Larinae

<i>Larus marinus</i>	* Great Black-backed Gull
<i>Larus argentatus</i>	*Herring Gull
<i>Larus delawarensis</i>	Ring-billed Gull
<i>Larus atricilla</i>	* Laughing Gull
<i>Larus philadelphia</i>	Bonaparte's Gull

Subfamily Sterninae

<i>Gelochelidon nilotica</i>	Gull-billed Tern
<i>Sterna forsteri</i>	Forster's Tern
<i>Sterna hirundo</i>	*Common Tern
<i>Sterna dougalli</i>	Roseate Tern
<i>Sterna albifrons</i>	Little Tern
<i>Sterna maxima</i>	Royal Tern

Family Rynchopidae

Rhychops niger

* Black Skimmer

Order Strigiformes

Family Strigidae

Asio flammeus

Short-eared Owl

Order Coraciiformes

Family Alcedinidae

Megaceryle alcyon

* Belted Kingfisher

Order Passeriformes

Family Alaudidae

Eremophila alpestris

Horned Lark

Family Corvidae

Cyanocitta cristata

Blue Jay

Corvus ossifragus

Fish Crow

Family Paridae

Parus atricapillus

Black-capped Chickadee

Family Troglodytidae

Cistothorus palustris

Long-billed Marsh Wren

Family Turdidae

Turdus migratorius

Robin

Family Parulidae

Geothlypis trichas

Yellow Throat

Family Icteridae

Agelaius phoeniceus

Red-winged Blackbird

Family Fringillidae

Ammospiza caudacuta

Sharp-tailed Sparrow

Ammospiza maritima

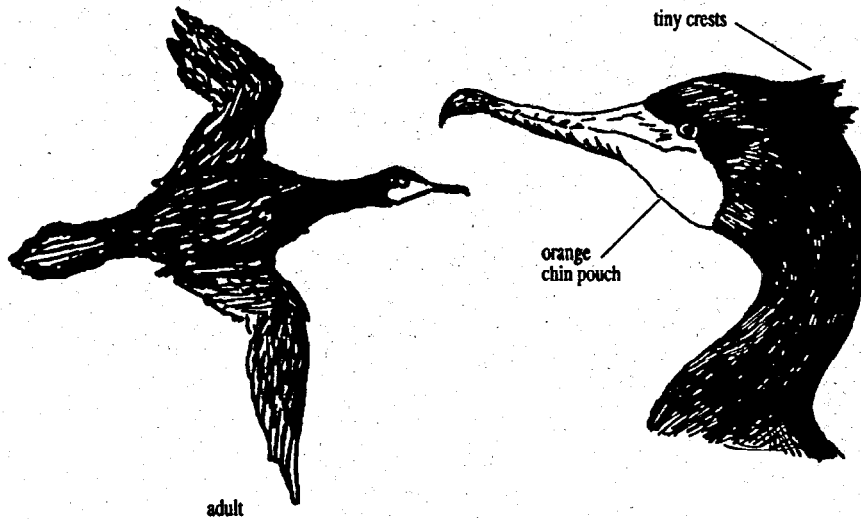
Seaside Sparrow

Melospiza melodia

Song Sparrow

DOUBLE-CRESTED CORMORANT

Phalacrocorax auritus



Identification:

- Mostly black with a white breast and a darker belly.
- Bill slender with a hook tip
- Orange chin pouch

Size:

A mature adult will probably grow to approximately 33 in. (83 cm).

Range:

Most of North America

Local Distribution:

The Double-Crested Cormorant arrives in the New York Bight region in late winter and early spring and remains abundant throughout the summer and fall. Migrates south in the winter.

Habitat:

Salt and brackish waters, mostly bays and rivers.

Breeding:

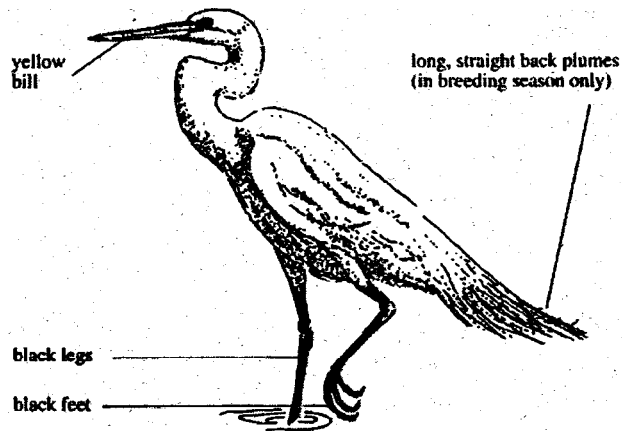
- Nest in colonies built by both sexes on ground or trees:
- Nest built of sticks and weed stems, lined with leafy twigs and grass.
- Eggs, clutch of 2-7 are laid from April to July.
- Incubation performed by both sexes 24-25 days.
- First flight 35-42 days after hatching.

Feeding:

- Dives from the surface and swims about in pursuit of prey, generally depths of 25 ft. below the surface.
- Catches mainly fish such as, sculpins, eels, herring, tomcod, flounder, butterfish along with small invertebrates.

GREAT EGRET

Casmerodius albus



Identification:

- A large, stately, slender white bird within the heron family, with a yellow bill.
- Legs and feet black.
- Straight plumes on back extend beyond tail when breeding.

Size:

A mature adult will grow to approximately 38 in. (95 cm).

Range:

Continental United States to South America.

Local Distribution:

The Great Egret arrives in New York Bight region sometime in spring and remains abundant throughout the summer and fall. When temperatures drop in late fall they will fly south to find a more suitable temperature and are rarely seen in the New York Bight during the winter.

Habitat:

Marshes, ponds, shores and mud flats.

Breeding:

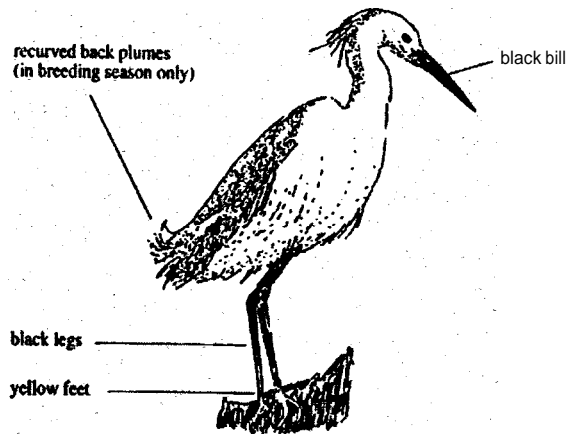
- Nest either singly or in colonies, Usually with other herons in woods of swamps, mangroves, cypresses and willows near water.
- Nest is usually 20-40 feet above ground in medium sized trees.
- 1-6 eggs are laid from January into June depending on location of nest.
- Incubation lasts 23-24 days.
- First flights of young occur about 42 days after hatching.

Feeding:

- Feeds commonly in salt-marshes and freshwater ponds and marshes.
- Feeds on fishes, frogs, salamanders, snakes, crayfishes, mice, cotton rats, aquatic insects, moths, grasshoppers, etc.

SNOWY EGRET

Egretta thula



Identification:

- A small white heron, with a black bill, black legs and yellow feet.
- Recurved plumes on the back during breeding season.
- A yellow loreal spot before the eye.

Size:

A mature adult will grow to approximately 20-27 in. (50-68 cm).

Range:

United States to Argentina.

Local Distribution and Movement:

The Snowy Egret is abundant from spring to fall in the New York Bight and is an uncommon resident in the winter months.

Habitat:

Lives around fresh, brackish and saltwater.

Breeding:

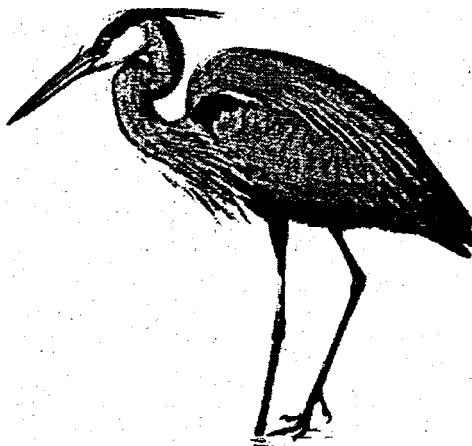
- Builds nest on ground or to 30 feet high in trees.
- A social nester often found in colonies with pairs numbering in the thousands.
- Eggs are laid from January to July depending in Latitude.
- Anywhere from 1-6 blue-green eggs are laid..
- Incubation is by both parents and lasts approximately 18 days.
- Young are reported to leave the nest in 20-25 days after hatching.

Feeding:

- Eats small fishes, frogs, lizards, snakes, shrimps, fiddler crabs, crayfish and various insects.
- Uses feet to stir up prey, will hover, then drop to catch prey in bill and chase prey in shallows.

GREAT BLUE HERON

Ardea herodias



Identification:

- A tall blue-grey heron.
- Long legs, long neck and dagger-like bill.
- White and black on head.

Size:

A mature adult will grow to approximately 42-52 in. (105-130 cm).

Range;

Canada to Mexico.

Local Distribution:

The Great Blue Heron remains common throughout the year in the New York Bight region.

Habitat:

The Great Blue Heron inhabits marshes, swamps, shores and tidal flats of both fresh and saltwater. They spend equal time on land and in shallow water and can often be seen perching in trees.

Breeding:

- Nests can be built on the ground, rock ledges, sea cliffs and on top of tall trees.
- Nest in small groups to hundreds of pairs.
- May nest with other herons or by themselves.
- Eggs are laid from March to May.

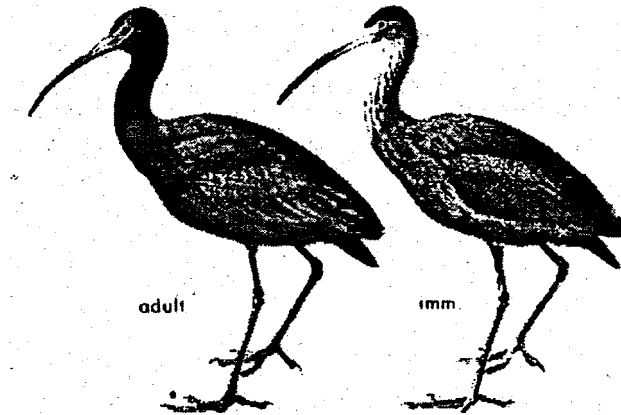
- 3-7 blue-green to pale olive eggs are laid.
- Incubation is by both sexes and lasts approximately 25-29 days.
- Young leave the nest after 64-91 days.

Feeding:

- Fishes at night and during the day.
- Waits motionless in shallow water for prey to come into striking distance.
- Will usually catch fish crosswise in bill, turn and swallow whole.
- Feeds on fishes, frogs, shrimps, salamanders, snakes, insects and occasionally small rodents.

GLOSSY IBIS

Plegadis falcinellus



Identification:

- Medium marsh wader with long down curved bill.
- Deep glossy purplish chestnut plumage color.
- Legs gray or green-black.
- Bare skin at base of bill.

Size:

Mature adults will grow to approximately 22-25 in. (55-63 cm).

Range:

Maine To Florida.

Local Distribution:

The Glossy Ibis is common in the New York Bight region from spring until fall and is rarely seen in the winter.

Habitat:

Fresh and saltwater marshes, and swamps.

Breeding:

- Eggs are laid in March to late May.
- Usually 3-4 blue-green eggs are laid.
- Incubation is done mostly by the female at night and by the male during part of the day.

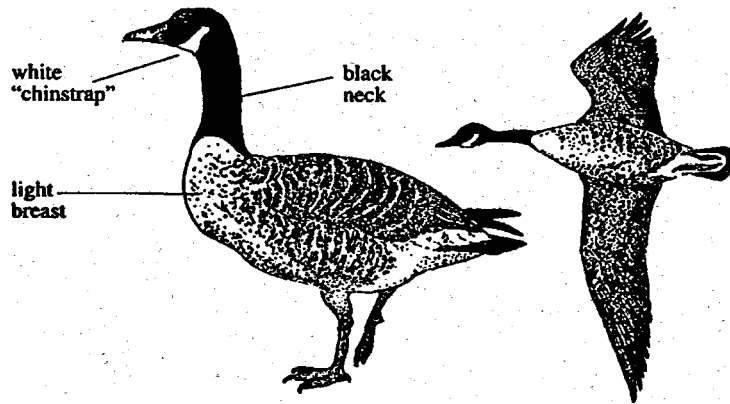
- Incubation lasts approximately 21 days and young feed on regurgitated food from the parents.
- Young are on their own after 42 days.

Feeding:

- Feeds .by probing into crayfish holes, a major part of their diet in some areas.
- Also eats snakes, grasshoppers, cut worms and other insects.

CANADA GOOSE

Branta canadensis



Identification:

- Light brown breast and body, darker brown wings.
- Black neck and head with white chin strap.
- Black bill and legs.

Size:

A mature adult will grow to approximately 43 in. (108 cm).

Range:

All of North America

Local Distribution:

The Canada Goose is a year round resident in the New York Bight region.

Habitat:

Lakes, ponds, bays, marshes, fields.

Breeding:

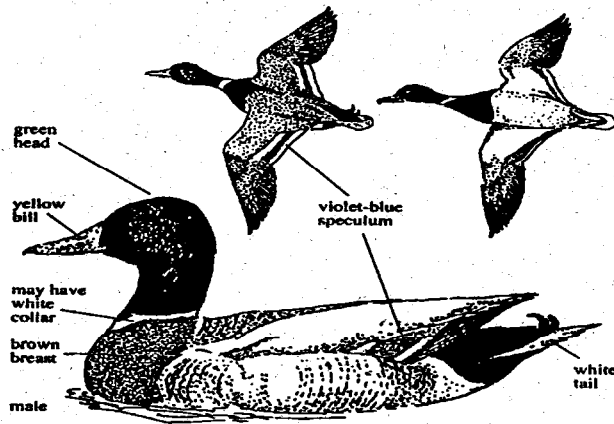
- Nests can be built on the ground near water or on ridges.
- Nest is lined with down.
- Eggs, clutch of 2-12 can be laid usually 5-6 are laid in early March.
- Incubation usually lasts 25-28 days.
- Young first fly 63-86 days after hatching.

Feeding:

- Feed mostly in early morning and late afternoon.
- Essentially grazers.

MALLARD

Anas platyrhynchos



Identification:

- Male has shiny green head a brown breast and may have a white neck ring.
- Female is mottled brown overall.
- Both sexes have violet blue speculum, yellow bill and whitish tail.

Size:

A mature adult will grow to approximately 28 in. (70 cm.)

Range:

Found in temperate regions around the world. Most of the Northern hemisphere.

Local Distribution:

The Mallard is a year round resident throughout the New York Bight Region.

Habitat:

Marshes, wooded swamps, grainfields, ponds, rivers, lakes, and bays.

Breeding:

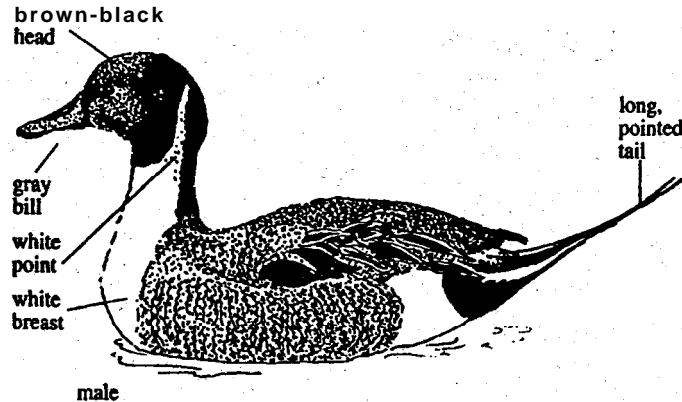
- Nests usually built on ground among dead grasses, reeds, sometimes in cavities of trees.
- Nests lined in down.
- Eggs, clutch from 5-14 usually 8-10 are laid between March and July.
- Incubation lasts 26-30 days.
- Once young dry off from hatching, they are led to the nearest water.
- Young first fly 49-60 days after hatching.

Feeding:

- Feeds by tipping up and reaching below the water surface with bill in shallow waters.
- Can dive for food if necessary.
- Feeds on marsh grasses, seeds, and sedges.

PINTAIL

Anas acuta



Identification:

- Male has brown-black head, white breast, gray body and wings with a long needle-pointed tail.
- Female is mottled brown overall.
- Both sexes have a gray bill and a brown speculum, bordered by a white line on trailing edge.

Size:

Mature adults grow to approximately 26-30 in. (65-75 cm.).

Range:

Northern parts of the Northern Hemisphere.

Local Distribution:

Pintails arrive in the New York Bight region during the winter months and travels north to the Tundra when spring comes.

Habitat:

Marshes, prairies, fresh ponds, lakes, and salt bays.

Breeding:

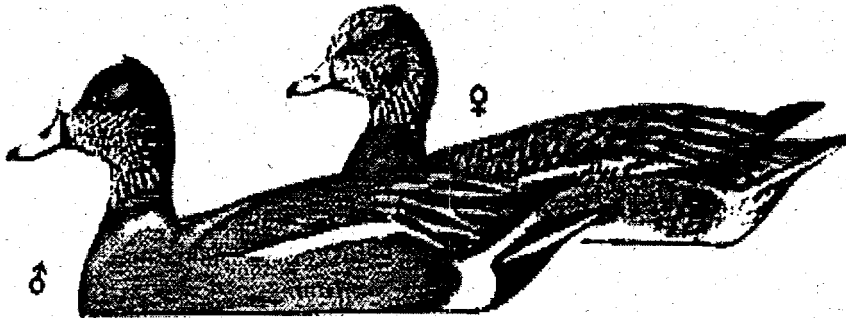
- Nests in sedges and hay meadows often far from the water.
- Nest built of sticks, leaves grasses and mosses. Lined with females down.
- Eggs, clutches between 6-12, usually 6-9 are laid during May through July.
- Incubation is performed by the female and lasts 23-25 days.
- First flies 38-52 days after hatching.

Feeding:

- Feeds like other dabbling ducks.
- 90% of diet is vegetal, chiefly of seeds.
- The other 10% is of small invertebrates.

AMERICAN WIDGEON

Anas americana



Identification:

- A medium sized dabbling duck.
- Male has gray head with bright white crown.
- Female is ruddy brown with gray head and neck.
- Both have a white patch on forepart of the wing and a pale blue bill that has a black tip.
- They are strong swift flyers.

Size:

Mature adults grow to approximately 18-23 in. (45-58 cm).

Range:

Breeding range includes Alaska, western Canada and the United States. Winters to Central America and the West Indies.

Local Distribution: .

The American Widgeon is common during the spring and fall in the New York Bight region when they are on their way to wintering and summer grounds. At other times of the year they are an uncommon resident in the New York Bight.

Habitat:

Marshes, bays, lakes and fields.

Breeding:

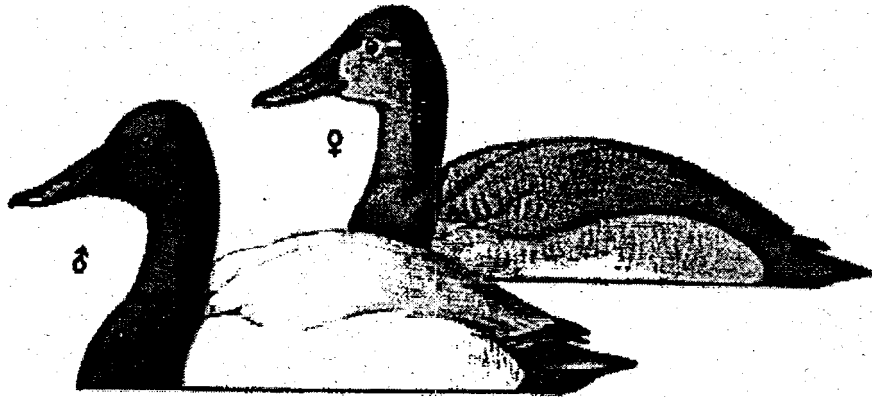
- Eggs are laid from May to July.
- Commonly 9-11 cream white eggs are laid.
- Incubation is by the female and lasts 22-24 days, Young leave the nest at 45-58 days.

Feeding:

- Dabbles with bill in mud or tips up in shallow water to reach bottom.
- When feeding in water they eat mostly seeds, leaves, stems, buds, widgeon grass, and other grasses that are found in the water.
- Will also graze in fields feeding on snails; beetles, insects and young grass and grain plants.

CANVASBACK

Aythya valisineria



Identification:

- A common diving duck.
- Pale gray back, white sides and rust red neck.

Size:

Mature adults grow to approximately 20-24 in. (50-60 cm).

Range:

Breeding range includes Alaska, west Canada and northwest United States. Winters to Mexico, Atlantic and Gulf coasts.

Local Distribution:

The Canvasback is common in the New York Bight region during the late fall and winter months but becomes uncommon in the spring and summer.

Habitat:

Freshwater marshes, lakes and saltwater bays and estuaries.

Breeding:

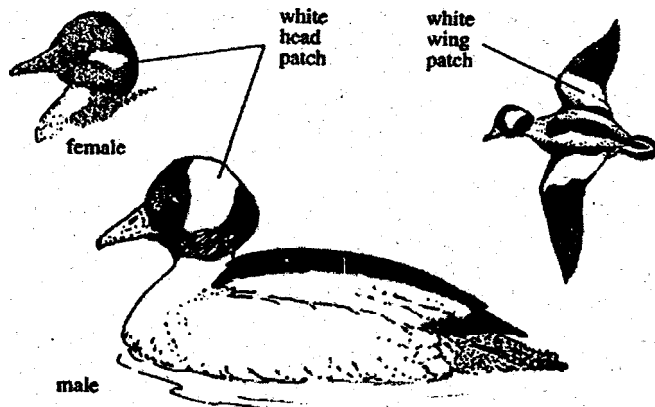
- Nests are built within 20 yards of water.
- Eggs are laid from May to June.
- 7-12 gray-green or gray-olive eggs are laid.
- Incubation is by the female and lasts 23-29 days.
- Young leave the nest after 63-77 days.

Feeding:

- Feeds by diving in water that varies from 3-30 feet deep.
- Eats primarily roots, tubers, grasses and basal parts of bottoms plants.
- Will also eat some mollusks, aquatic insects and small fishes.

BUFFLEHEAD

Bucephala albeola



Identification:

- One of the smallest diving ducks.
- Tiny bill with large puffy head.
- Body of male mostly white with black back and white patch on head.
- Female is gray-brown with small white cheek patch.

Size:

Mature adults grow to approximately 13-15 in. (33-38 cm).

Range:

Breeding range includes Alaska and Canada. Winters to Mexico and Gulf coast.

Local Distribution:

The Bufflehead is abundant in the New York Bight region throughout the fall, winter and spring months but becomes scarce in the summer.

Habitat:

Fresh and saltwater lakes, ponds, rivers, bays, and estuaries.

Breeding:

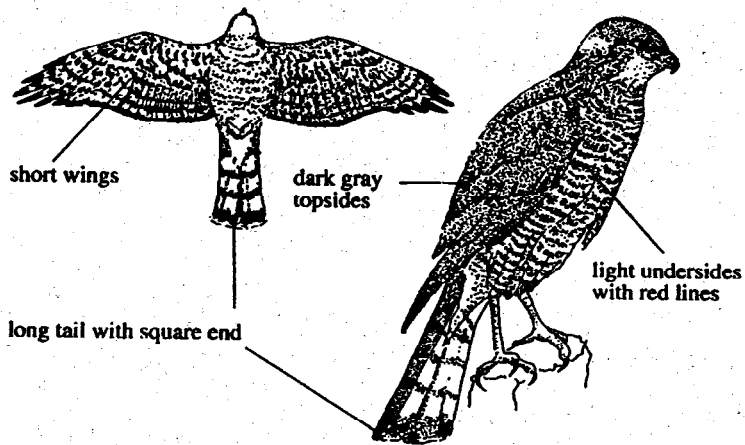
- Nests in flicker holes adding no nesting material.
- Eggs are laid from mid April to May.
- Commonly 9 ivory yellow to pale olive buff eggs are laid.
- Incubation is by the female and lasts 28-33 days.
- Young leave nest at 24-36 hours after hatching and fly at approximately 50-55 days after hatching.

Feeding:

- Dives for food often having a companion on the surface to watch for danger.
- Eats primarily small aquatic insects, snails, small fishes, shrimp and some water plants.

SHARP-SHINNED HAWK

Accipiter striatus



Identification:

- A small slimmed bodied hawk.
- Slim tail and squared at the end, cross barred with three or four narrow bands of black.
- Adults upper-parts blue-gray.
- Underparts whitish, heavily cross barred with red-brown.
- Legs yellow.

Size:

Mature adults grow to approximately 10 -14 in. (25-35 cm.).

Range:

Tree limit in Canada to Gulf states.

Local Distribution:

Year round resident of the New York Bight region. Mainly in wooded area's. Most commonly seen during migratory seasons.

Habitat:

Woods and Thickets.

Breeding:

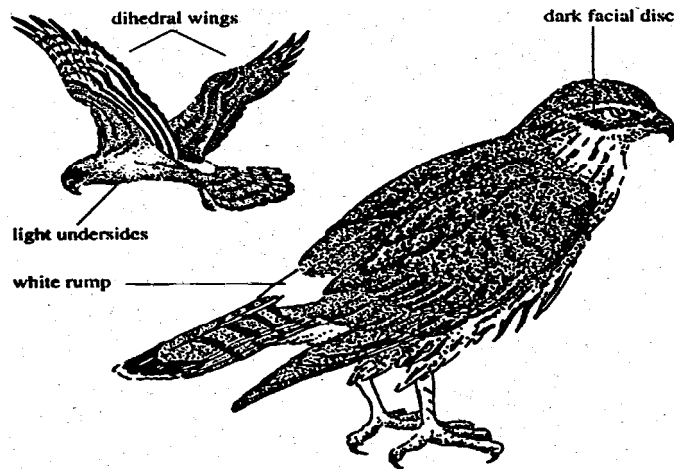
- Nest built of sticks and twigs lined with strips of bark. About 2 ft. across in a crotch of a tree or a branch close to the trunk of a tree.
- Usually found in a coniferous tree, between 10- 60 ft. up.
- Eggs, clutches of 3-8 are laid between March and July.
- Incubation is performed by both adults 34-35 days.
- First fly about 23 days after hatching.

Feeding:

- Feeds on small birds, starlings, mourning doves, and pigeons.
- * Hunts by dashing through woods in a low swift flight, around trees, through brush and reaches out in air or on the ground to catch in talons; surprised birds and other prey.

MARSH HAWK

Circus cyaneus



Identification:

- Males are light gray with dark wing tips.
- Females are dark brown.
- Both sexes have a white rump and dark facial discs.

Size:

Mature adults grow to approximately 17-24 in. (44-60 cm).

Range:

Alaska, Canada to southern United States, winters in South America.

Local Distribution:

Most common from spring through fall. Majority migrate south during winter.

Habitat:

Marshes and fields.

Breeding:

- Nests built on ground by female commonly near low shrubs, in tall weeds or reeds usually near a swamp or meadow.
- Eggs, clutches of 3-9 are laid in March and July.
- Incubation lasts 31-32 days.
- First flight occurs 30-35 days after hatching

Feeding:

- Glides and tilts buoyantly low over the ground with wings slightly above horizontal.
- Eat mainly mice, rats, frogs, small snakes, crayfish, insects, and small birds.

OSPREY

Pandion haliaetus



Identification:

- Only raptor that will plunge into water.
- Dark brown above with purplish gloss and white below.
- Breast streaked with brown.
- Bill and claws black.

Size:

Mature adults grow to approximately 21-24 in. (53-61 cm).

Range:

Almost cosmopolitan always near fresh or saltwater.

Local Distribution:

The Osprey is common in the New York Bight region from the spring through the fall but will head to wintering grounds in the winter months.

Habitat:

Rivers, lakes and coasts.

Breeding:

- Nests in trees and other high objects near or above water.
- Nests can weigh up to half a ton and are built with sticks, seaweeds, bones, driftwood and other trash.
- A nesting pair will often use the same nest for decades.

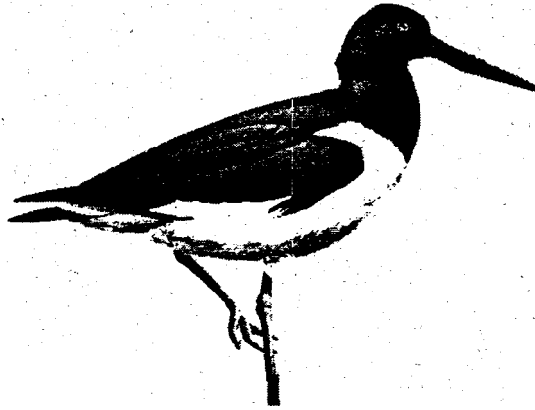
- Incubation is by the female and lasts 35-38 days.
- First flight takes place 48-59 days after hatching and return to nest afterwards.
- Young do not breed until three years old.
- Osprey will go to great measures to protect nest.

Feeding:

- Spends most of time perched near water and flies out over water to hunt.
- When a fish is sighted they will hover with wings beating, legs trailing under body and strike with a great splash.
- Holds fish gripped in both feet and head pointed forward to reduce resistance from wind.
- Feeds almost exclusively on fish, such as herring, bluefish, flounders, catfish, pickerel and most any fish it can capture.
- The outer toe of the talons, rotate forward and, backward, which permits them to hold two toes forward and two toes backwards or three toes forward and one backwards, this adaptation allows the osprey to grasp strong-swimming, slippery fish.

AMERICAN OYSTERCATCHER

Haematopus palliatus



Identification:

- Dark back, white belly, large white wing and tail patches.
- Large straight red bill, legs pale flesh color.
- Shy bird that is often spotted as it flies away.

Size:

Mature adults grow to approximately 17-21 in. (43-53).

Range:

Shores of Cape Cod South to Chile and Argentina.

Local Distribution:

The American Oystercatcher is common in the New York Bight region from spring until fall and becomes a rare sight in the winter.

Habitat:

Coastal beaches and tidal flats.

Breeding:

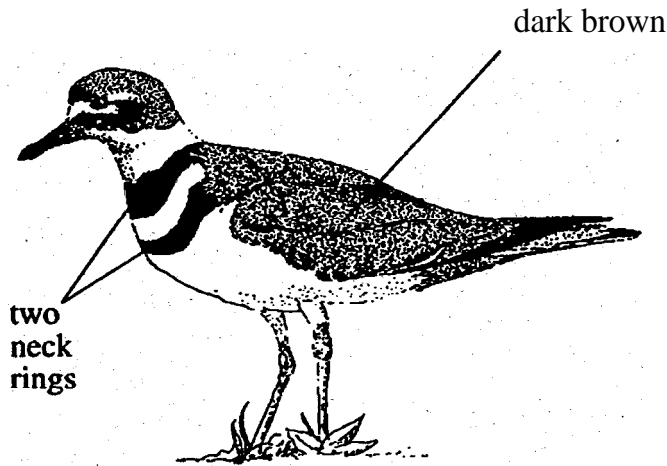
- Nest consists of a hollow in the sand of dry flat beaches, above high water mark.
- Eggs are laid from April to May.
- Usually 24 eggs of the color green-brown or buff, marked with brown blotches are laid.
- Incubation is done by both parents and lasts approximately 27 days.
- Young fly at approximately 35 days after hatching but are not able to get food for themselves until at least 60 days after hatching:

Feeding:

- Feeds primarily by prying bivalves open with the use of their long bill.
- Will also eat sea urchins, starfish, crabs, and marine worms.

KILLDEER

Charadrius vociferus



Identification:

- Top of head, wings, and back are dark brown.
- Rump is tan.
- Undersides are white with two black neck rings.
- Voice makes a loud, “kill-deeah”

Size:

Mature adults grow to approximately 11 in. (28 cm).

Range:

Canada to central Mexico.

Local Distribution:

Some are year round residents of the New York Bight region.

Habitat:

Fields, airports, lawns, river banks, shores.

Breeding:

- Nests are built in open areas.
- Nest is usually a slight depression in the ground, lined with pebbles, grasses, and weed stalks.
- Eggs, clutches of 3-5 are usually laid between April and July.
- Incubation lasts approximately 24 days.

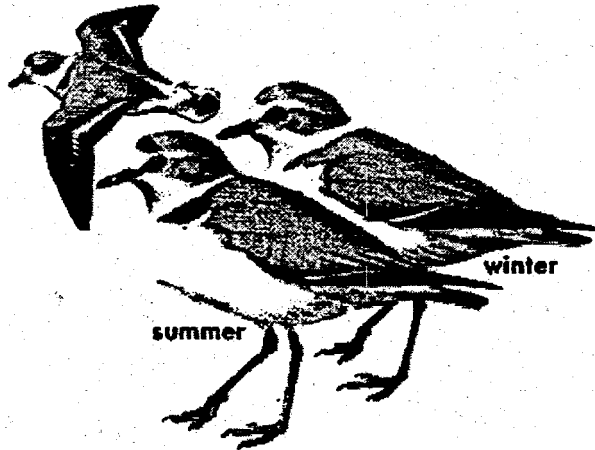
- Young fly around 25 days after hatching.

Feeding:

- 98% of food are insects gleaned from fields and river banks etc.
- Also feeds off of small marine invertebrates.

PIPING PLOVER

Charadrius melodus



Identification:

- Color of dry sand on top and white below.
- A complete or incomplete ring around neck.
- Legs yellow, bill yellow with black tip in summer and all black in winter.

Size:

Mature adults grow to approximately 6-7 1/2 in. (15-19 cm).

Range:

South Canada to northeast and central United States.

Local Distribution:

The Piping Plover is an uncommon sight in the New York Bight region, however they utilize lower portions of the Hudson-Raritan Estuary as a nesting site.

Habitat:

Sand beaches and tidal flats.

Breeding:

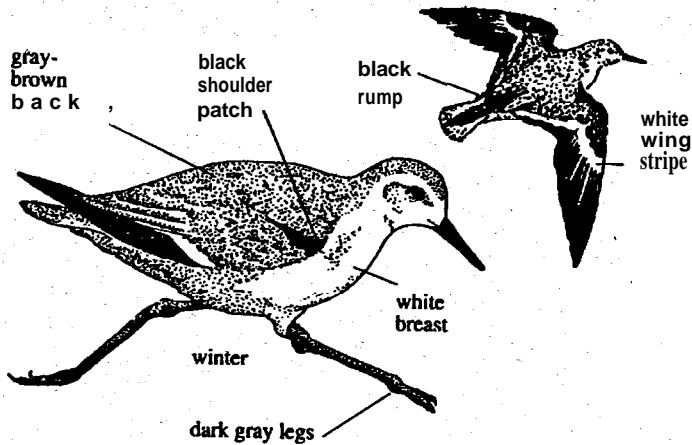
- Nests are built on sand bordering a water body and consist of a hollow in the sand that is sometimes lined with shells or driftwood.
- 3-4 eggs are laid in April to May.
- Eggs are a sand color, spotted with purple and black.
- Incubation is done by both parents and lasts approximately 27 days.
- Young fly 30-35 days after hatching.

Feeding:

- The Piping Plover when feeding will run a short distance, stop, stare at the sand and then pick up something.
- Feeds on marine worms, fly larvae, beetles, crustaceans, mollusks and small eggs of other animals.

SANDERLING

Calidris alba



Identification:

- In summer has reddish brown head, back, and breast.
- In winter pale gray back, white underside, black shoulder patches.
- Legs are dark gray.

Size:

Mature adults can grow to approximately 8 in. (20 cm).

Range:

Arctic and circumpolar.

Local Distribution:

Common in the New York Bight region during migration periods and winter.

Habitat:

Outer beaches, tide flats, lake shores, strong tundra.

Breeding:

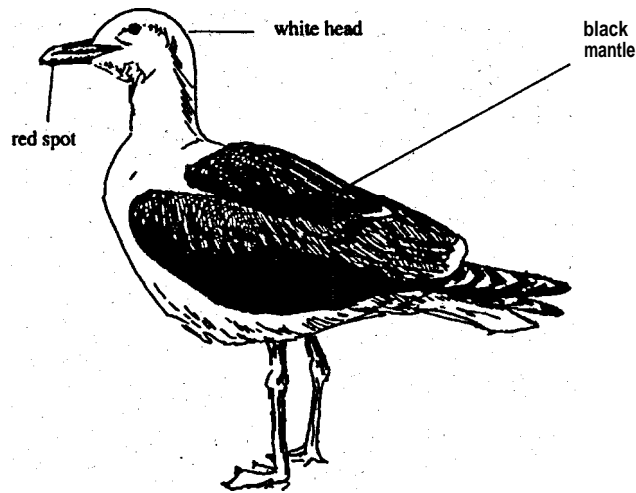
- Nest in the high Arctic.
- Nest on dry often strong tundra or on well-drained ridges.
- Eggs, a clutch usually of four eggs are usually laid between June and July.
- Incubation lasts 24-31 days only by one of the two adults.
- First flight occurs about 17 days after hatching.

Feeding:

- Eats flies and their larvae along with other insects and minute crustaceans.
- On wet beaches of coasts, the Sanderling probes vigorously with partly open bill.

GREATER BLACK-BACKED GULL

Larus marinus



Identification:

- Black mantle.
- White head, body, and tail.
- Pinkish-beige legs.
- Yellow bill with red spot.

Size:

Mature adults can grow to approximately 31 in. (78 cm).

Range:

Mainly coasts of North Atlantic, wintering to Mid-Atlantic states.

Local Distribution:

Year round resident of the New York Bight region.

Habitat:

Mainly coastal waters, estuaries, a few on large lakes.

Breeding:

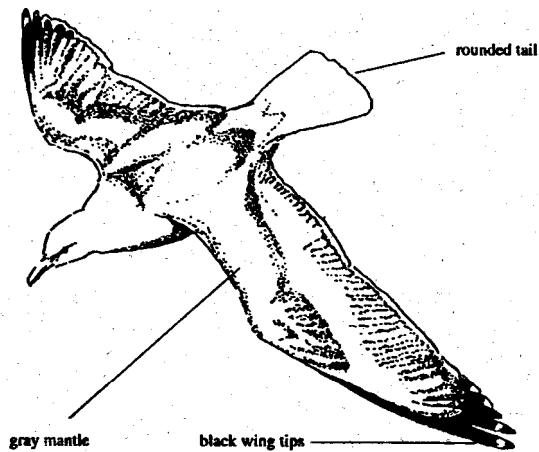
- Nests usually built solitary or in small colonies on ground or on ledges.
- Seaweed grasses, mosses in a hollow depression.
- Eggs, a clutch of usually 2-3 eggs are laid between May to June.
- Incubation lasts for 26-28 days.
- Young first fly 42-56 days after hatching.

Feeding:

- Omnivorous and voracious feeder.
- Feeds on eggs and young.
- Takes fish from other seabirds.
- Scavengers on garbage.
- Hunts for fishes.

HERRING GULL

Larus argentatus



Identification:

- Gray mantle with gray wing tips.
- White head, body, and tail.
- Pinkish-beige legs.
- Yellow bill with red spot.

Size:

A mature adult will grow to approximately 26 in. (65 cm).

Range:

The North American coast line.

Local Distribution:

Year-round resident of the New York bight region.

Habitat:

Oceans, coast bays, beaches, lakes, piers, farmlands, dumps.

Breeding:

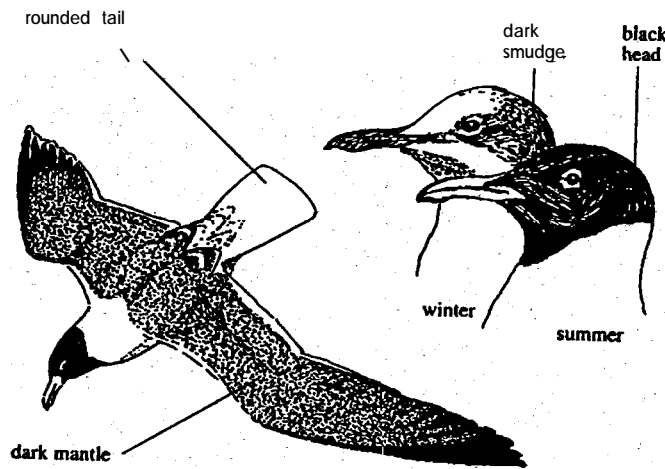
- Nest generally in colonies, on ground, near sea, lake or river.
- Associated with nesting Cormorants on rocky or grassy coastal islands.
- Eggs, a clutch of 2-3 eggs are laid between May and June.
- Incubation lasts for 25 to 27 days.
- First flight occurs 42-49 days after hatching.

Feeding:

- Feeds on small fish.
- Forages through wastes and sewage along water fronts of towns, cities, or dumps.
- Hunts animal carrion, dead fishes, mollusks, crustaceans, marine worms, starfish and sea urchins.

LAUGHING GULL

Larus Atricilla



Identification:

- Dark gray mantle with black wing tips.
- White body and tail.
- Dark red legs.
- In summer head is all black, in winter head is white with dark smudge.

Size:

Mature adults will grow to approximately 16-17 in. (40-43 cm).

Range:

Nova Scotia to Venezuela.

Local Distribution:

The Laughing gull is most common during the summer in the New York Bight region.

Habitat:

Salt marshes, coastal bays, piers, beaches, oceans.

Breeding;

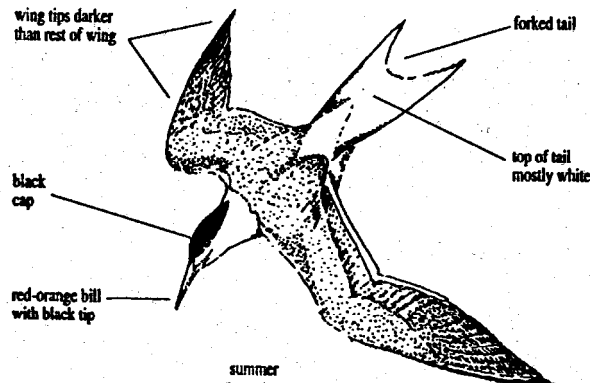
- Nests in colonies.
- Nest is usually built on ground of coastal islands or on tufts of grass or reeds in saltwater marshes.
- Eggs, a clutch of 3-4 are usually laid between May and July.
- Incubation lasts about 20 days.

Feeding:

- Catches small fish at the surface.
- Seeks scraps thrown from boats.

COMMON TERN

Sterna hirundo



Identification:

- Light gray mantle.
- White body and tail.
- Orange-red feet.
- In summer, black cap on head and black tip on bill,
- In winter black cap is incomplete and bill is blackish.

Size:

A mature adult can grow to approximately 16 in. (40 cm).

Range:

Temperate zone of the Northern Hemisphere.

Local Distribution:

The Common Tern migrates into the New York Bight region in early May and leaves in mid September.

Habitat:

Lakes, oceans, bays, beaches.

Breeding:

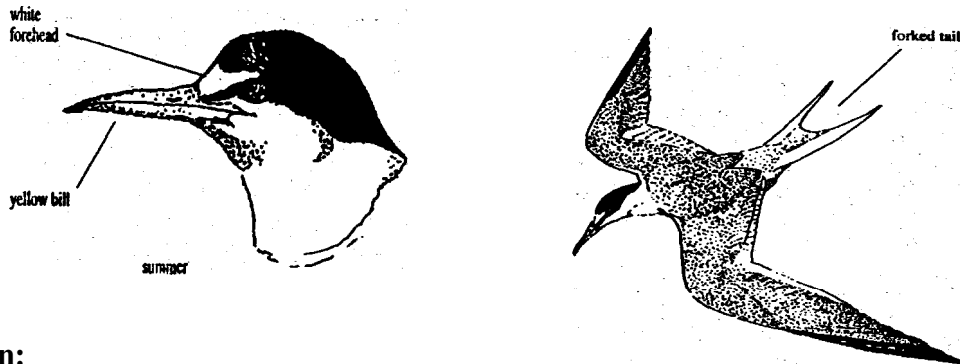
- Nests in colonies, several hundred or up to many thousands assemble in breeding season.
- Nest is made in a slight depression in soil usually lined with grasses, seashells, or bits of seaweeds.
- Eggs, a clutch usually of 2-3 are laid between May and August.

- Incubation lasts 21-26 days.
- Young first fly after 28 days after hatching.

Feeding:

- Hover in flocks over schools of small fish that have been driven to the surface by bluefish and plunging head first into the water to feed.

LEAST TERN *Sterna albifrons*



Identification:

- A very small pale tern, black capped with white forehead.
- Yellow bill and feet.
- In winter bill may be dark.

Size:

Mature adults can grow to approximately 9 in. (23 cm).

Range:

Temperate and tropical oceans. Winters south of the United States.

Local Distribution:

The Least Tern is common in the New York Bight region during the spring and the summer but heads for wintering grounds in the fall.

Habitat:

Ocean beaches, bays and large rivers.

Breeding:

- Builds nest in unlined scrape on open beach above high tide line.
- Does not always require islands or isolated places like other terns.
- Will nest in small colonies occasionally.
- Nests May to July.
- Usually 2 eggs are laid that are buff to pale olive and spotted or blotched with dark brown in color.
- Incubation lasts 20-22 days and young fly 28 days after hatching.

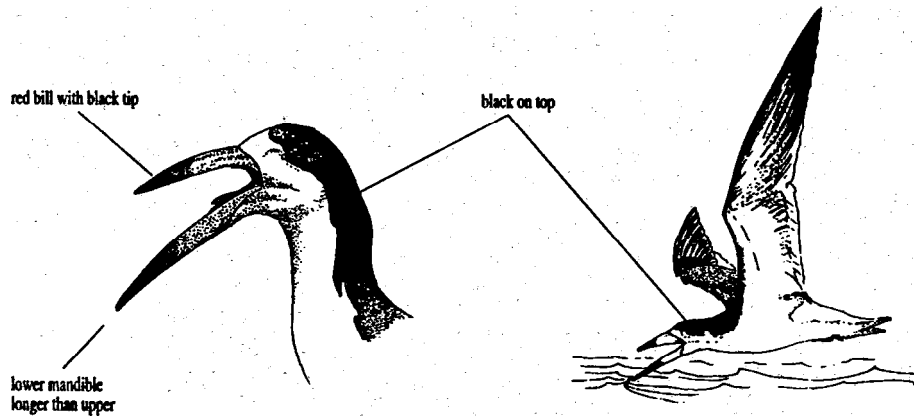
- Adults will defend eggs by flying above and dropping excrement on intruder.

Feeding:

- Feeds by hovering or skimming above the surface of water and then diving water; catches prey in its bill. Usually swallows prey while in flight.
- Eats small fishes and shrimps.

BLACK SKIMMER

Rhychops niger



Identification:

- Black above and white below.
- Exceptionally long wings.
- Long scissor like bright red bill with black tip, lower mandible is longer than upper.

Size:

Mature adults grow to approximately 16-20 in. (40-50 cm).

Range:

Cape Cod to Gulf of Mexico. Winters from Gulf of Mexico to South America.

Local Distribution:

The Black Skimmer is common in the New York Bight region from spring until fall but becomes rare in the winter when they head for their wintering grounds.

Habitat:

Ocean, beaches, salt bays and tidal waters.

Breeding:

- Nests in colonies of 100-200 pairs.
- Nest consists of a shallow hollow above high-water mark.
- Eggs are laid in May to July.

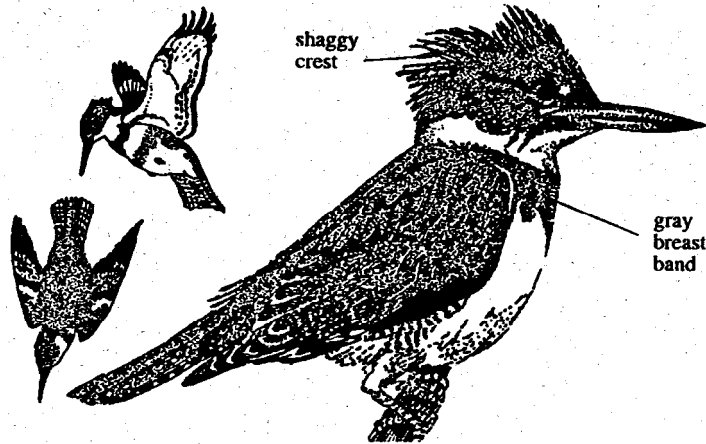
- Usually a clutch of 4-5 eggs, heavily marked with brown, lilac and grey colors.
- Eggs are often destroyed by dogs and people walking on the beach.
- Incubation is by female.
- Length of incubation and first flight are unknown.

Feeding:

- Feeding takes place mostly at night when waters are calm and fish and crustaceans are near the surface.

BELTED KINGFISHER

Megaceryle alcyon



Identification:

- Big headed and big billed.
- Larger than a robin.
- Blue-gray above, with a ragged bushy crest and a broad gray breast band.
- The female has an additional rusty breast band.

Size:

Mature adult will grow to approximately 13 in. (33 cm).

Range:

Alaska, Canada, to the southern United States, winters to Panama.

Local Distribution:

The Belted Kingfisher is most common in early spring through late fall.

Habitat:

Streams, lakes, bays, and coasts.

Breeding:

- Nest in a horizontal or slightly up slanting burrow, about 3-7 feet, dug by pair in sand, clay or gravel bank. Usually along river banks.
- Eggs, a clutch usually of 6-7 are laid between April and July.
- Young leave the nest at least 23 days after hatching.

Feeding:

- Mainly small fish.
- May dive from perch obliquely into water to seize fish in its powerful bill or hover in the air 20 to 40 feet above the water, then make a straight dive into the water.

BENTHIC INVERTEBRATE SPECIES OF THE HUDSON-RARITAN ESTUARY

SCIENTIFIC NAME

COMMON NAME

Phylum: Rhynchocoela (Unsegmented Worms)

Cerebratulus lacteus

Milky Ribbon Worm

Phylum: Annelida (Segmented Worms)

Class Polychaeta

Glycera spp.

* Blood Worms

Clymenella torquata

* Bamboo Worm

Nereis spp.

Clam worms

Pectinaria gouldii

Trumpet Worm

Sabella microphthalma

Fan Worm

Saebellaria vulgaris

Sand Builder Worm

Capitella capitata

Capitellid Thread Worm

Nephtys spp.

Red Lined Worms

Heteromastus filiformis

Asabellides oculata

Ampharete Worms

Phylum: Mollusca (Snails, Clams, Oysters, Mussels and Scallops)

Class Gastropoda (univalves)

Littorina littorea

Common Periwinkle

Melampus bidentatus

* Common Marsh Snail

Class Gastropoda cont.

<i>Busycon carica</i>	Knobbed Welk
<i>Busycon canaliculatum</i>	Channeled Welk
<i>Urosalpinx cinerea</i>	Atlantic Oyster Drill
<i>Eupleura caudata</i>	Thick-lipped Oyster Drill
<i>Nassarius obsoleta</i>	* Mud Snail
<i>Nassarius trivittatus</i>	Three-Lined Basket Shell
<i>Lunatia heros</i>	* Northern Moon Snail
<i>Polinices duplicatus</i>	* Lobed Moon Snail.
<i>Anomia simplex</i>	Jingle Shell
<i>Crepidula fornicata</i>	* Common Slipper Shell
<i>Crepidula plana</i>	Eastern White Slipper Shell

Class Bivalvia (bivalves)

<i>Anadara ovalis</i>	Blood Ark
<i>Anadara transversa</i>	Transverse Ark
<i>Astarte castanea</i>	Chestnut Astarte
<i>Mulinia lateralis</i>	Dwarf Surf Clam
<i>Spisula solidissima</i>	Atlantic Surf Clam
<i>Mya arenaria</i>	* Soft Shelled Clam
<i>Modiolus demissus</i>	* Ribbed Mussel
<i>Mytilus edulis</i>	* Blue Mussel
<i>Crassostrea virginica</i>	Eastern Oyster
<i>Aequipecten irradians</i>	Bay Scallop

Class Bivalvia cont.

<i>Placopecten magellanicus</i>	Sea Scallop
<i>Petricola pholadiformis</i>	False Angel Wing
<i>Ensis directus</i>	Common Razor Clam
<i>Mercenaria mercenaria</i>	* Hard Clam
<i>Gemma gemma</i>	Gem Shell

Phylum: Arthropoda (Shrimps, Crabs and Lobsters)

Class Merostomata

<i>Limulus polyphemus</i>	* Horseshoe Crab
---------------------------	------------------

Class Crustacea

<i>Cancer irroratus</i>	* Rock Crab
<i>Callinectes sapidus</i>	* Blue-Claw Crab
<i>Carcinus maenas</i>	* Green Crab
<i>Ovalipes ocellatus</i>	Lady Crab
<i>Eurypanopeus depressus</i>	Black-Fingered Mud Crab
<i>Rhithropanopeus harrissii</i>	White-Fingered Mud Crab
<i>Emerita talpoida</i>	Mole Crab
<i>Libinia emarginata</i>	Common Spider Crab
<i>Ocypode quadrata</i>	Ghost Crab
<i>Uca pugnax</i>	Mud Fiddler Crab
<i>Pagurus longicarpus</i>	Long-Clawed Hermit Crab
<i>Pagurus pollicaris</i>	Flat-Clawed Hermit Crab
<i>Homarus americanus</i>	* Northern Lobster

Class Crustacea cont.,

<i>Palaemonetes</i> spp..	* Common Shore Shrimps
<i>Crangon septemspinosa</i>	* Sand Shrimp
<i>Ampelisca abdita</i>	Four-Eyed Amphipods
<i>Corophium</i> spp.	Slender Tube Makers
<i>Cyathura polita</i>	Slender Isopod
<i>Edotea triloba</i>	Isopod
<i>Balanus amphitrite</i>	Striped Barnacle
<i>Balanus balanus</i>	Rough Barnacle
<i>Balanus improvisus</i>	Bay Barnacle
<i>Balanus balanoides</i>	Northern Rock Barnacle

Phylum: Echinodermata (Sand Dollar and Starfish)

Class Stellerioidea

<i>Asterias forbesi</i>	* Eastern Common Sea Star
-------------------------	---------------------------

Class Echinoidea

<i>Echinarachnius parma</i>	Sand Dollar
<i>Arbacia punctulata</i>	Purple Sea Urchin

Pelagic Invertebrate Species of the Hudson River Estuary

Phylum: Cnidaria (Anemones and Jellyfish)

Class Anthozoa

Haliplanella luciae

Striped Anemone

Diadumene leucolena

Ghost Anemone

Metridium senile

Frilled Anemone.

Class Scyphozoa

Cyanea capillata

Red Jellyfish

Aurelia aurita

Moon Jelly

Phylum: Ctenophora (Comb jellies)

Mnemiopsis leidyi

Leidys Comb jelly

Pleurobrachia pileus

Sea Gooseberry

Phylum Mollusca:

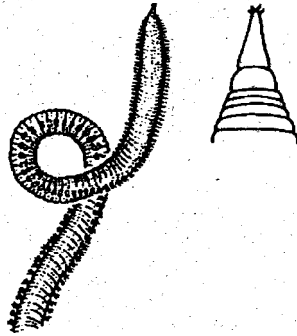
Class Cephalopods

Loligo spp.

Squids

BLOOD WORMS

Glycera sp.



Identification:

- Pale translucent skin with red body fluid visible.
- Tapered head region with a cone-like head.
- Large bulbous proboscis with four black fangs.
- Four tiny antennae.

Size:

Up to 15 in. long and 3/8 in. thick (375 x 9 mm).

Range:

Arctic to Argentina.

Local Distribution:

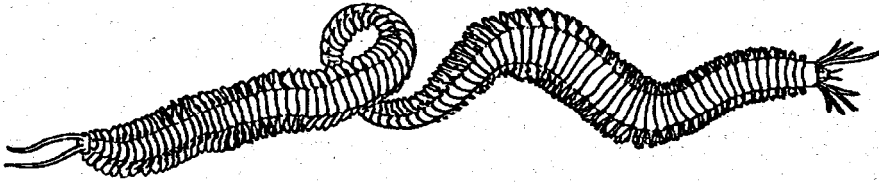
Blood Worms are abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Mud or sandy substrates below the surface.
- Intertidal to depths of 1000 ft. (300 m).

CLAM WORMS

Nereis sp.



Identification:

- Body color ranges from brown to pink.
- Robust elongated body.
- Well developed parapodia and head appendages.
- 2 ringed proboscis with sickle like jaws.
- Four tiny antennae.

Size:

Ranges from 5- 36 in. long (125-900 mm).

Range:

Arctic to Florida.

Local Distribution:

Clam Worms are abundant in lower reaches of the Hudson-Raritan Estuary. Five out of seven species are reported to be found in the Hudson-Raritan Estuary.

Habitat:

- Burrow in a variety of bottom types.
- Shallow waters in or near clam beds.
- Intertidal to depths of 1000 ft. (300 m).

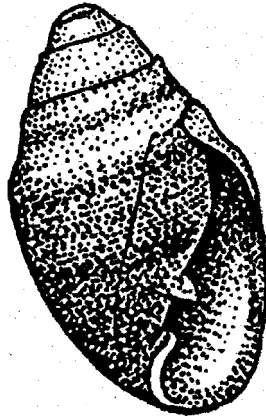
Spawning:

- During breeding seasons they metamorphose into special sexual forms called heteroneises, which have enlarged parapodia especially adapted for swimming.
- Heteroneises swarm to the surface in frenzied mating dances in spring and summer.
- They appear for several successive nights and eventually they release their eggs and sperm and die.
- Planktonic larvae develop and become recognizable clam worms.
- They settle to the bottom and resume the benthic existence of their parents.
- Some species spawn in their burrows.

Feeding:

- Strong predators.
- Feed on other clam worms, algae and scavenge.

COMMON MARSH SNAIL
Melanpus bidentatus



Identification:

- Gastropod
- Thin oval shaped shell.
- Shell opening is the widest opposite the tip and contains two thin-lipped tooth folds.
- Color is light brown.

Size:

To 1/2 in. (12 mm).

Range:

Gulf of St. Lawrence to Gulf of Mexico.

Local Distribution:

The common Marsh Snail is abundant in intertidal areas of the Hudson-Raritan Estuary.

Habitat:

- Intertidal.
- Found among grasses and under debris.
- Cannot tolerate immersion because it has an air-breathing lung.

Spawning:

- Reproduces as a marine snail.
- Adults lay eggs among salt-meadow hay and salt grass meadow in synchrony with the spring tides.
- Lays approximately eight hundred eggs that are encased in a gelatinous covering.
- The eggs are timed to hatch in about 13 days with the arrival of the next spring tide.

- Eggs develop into free swimming larvae called veligers.
- The veligers are part of the plankton for about fourteen days.
- At the end of their planktonic life cycle they are returned back to the marsh by the next spring tide.
- They then develop into air breathing adults and move up grass stems to avoid the water.

Feeding:

- Herbivorous.

MUD SNAIL
Illyanassa obsoletus



Identification:

- Blunt tipped shell with approximately six body spirals.
- Lattice-like surface.
- Smooth edged operculum.
- Color varies from brown to black with a glazed inner lip.

Size:

To 1 in. (25mm).

Range:

Cape Cod to Gulf of Mexico.

Local Distribution:

Mud Snails are common in intertidal areas of the Hudson-Raritan Estuary.

Habitat:

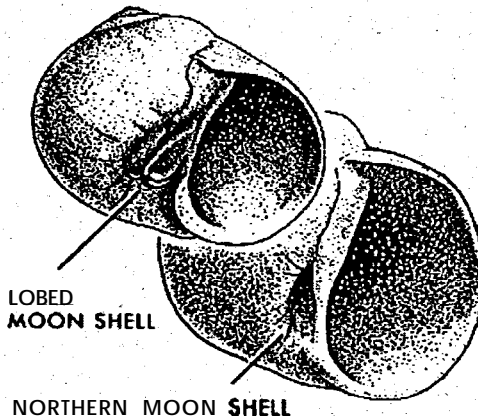
- Intertidal to subtidal.
- Prefers muddy substrates.

Feeding:

- Feeds primarily on bottom sediments rich in algae.
- Can detect dead organisms such as clams, crabs, and fish.
- Hundreds of Mud Snails can be found feeding on these dead animals.

NORTHERN MOON SNAIL

Lunatia heros



Identification:

- Thin, globular shell.
- Deep open umbilicus distinguishes this snail from the Lobed Moon Snail.
- Color is brown occasionally with bluish spots.

Size:

To 4 in. (100 mm).

Range:

Labrador to North Carolina.

Local Distribution:

The Northern Moon Snail is abundant in the lower reaches of the Hudson-Raritan Estuary.

Habitat:

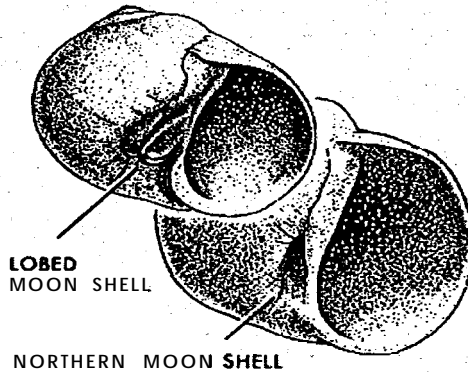
- Intertidal mud flats, salt marsh banks and near algae covered bottom.

Feeding:

- Prey on other mollusks.
- Drill a beveled hole in the shell and extract the flesh.

LOBED MOON SNAIL

Polinices duplicatus



Identification:

- Solid, rounded, glossy shell.
- Umbilicus almost completely covered by a dark callus.
- Color gray to tan.

Size:

To 3 in. (75 mm).

Range:

Massachusetts Bay to Gulf of Mexico.

Local Distribution:

The Lobed Moon Snail is abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Sandy beaches, intertidal zone to subtidal in shallow water.
- Prefers high salinity waters.

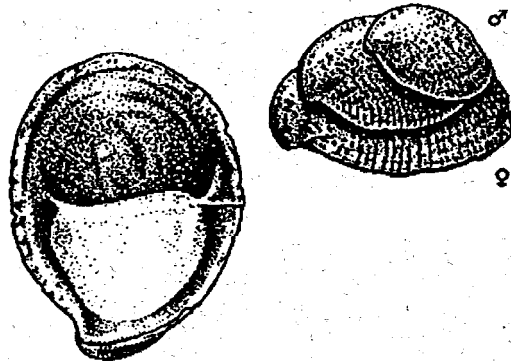
Spawning:

- Lay distinctive eggs cases called sand collars up to 6 inches in diameter.

Feeding:

- A predaceous hunter.
- Prey on other mollusks primarily clams.
- Drills a beveled hole in the shell and extract the flesh using their proboscis.

COMMON SLIPPER SNAIL *Crepidula fornicata*



Identification:

- Smooth or lumpy surface depending on substrate attached to.
- Bottom of shell has a platform extending about half the length of the shell..
- Color off-white or beige with wavy pinkish-brown lines.

Size:

To 1 1/2 in. (38 mm).

Range:

Massachusetts Bay to Gulf of Mexico.

Local Distribution:

The Common Slipper Snail is common in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Found attached to almost any hard object.
- Often found growing in stacks with larger females on the bottom and smaller males on top.

Spawning:

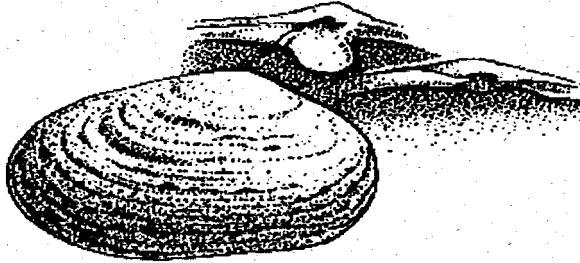
- Slipper Snails begin life as males and change into females as they grow and age.
- Eggs are laid in thin walled capsules and are brooded by the females.

Feeding:

- Algal feeders.

SOFT SHELLED CLAM

Mya arenaria



Identification:

- Elongate, brittle, thin shell.
- Large siphons that often squirt water in exposed flats.
- Chalky white color.

Size:

Length to 4 in. (10 cm).

Range:

Subarctic to Cape Hatteras.

Local Distribution:

The Soft Clam is abundant in intertidal areas of the Hudson-Raritan Estuary.

Habitat:

- Found in bays, sounds, intertidal, and subtidal areas to 30 ft. (9 m).
- Prefer muddy substrates.
- Live deep in burrows with siphons extruded above the bottom.

Spawning:

- Spawning occurs from June to September.
- An average female will produce 3 million eggs, the average male produces 1 billion sperm.
- Eggs and sperm are not produced all at once but throughout the spawning cycle.
- The presence of eggs or sperm in the water will cause the hard clam to spawn.
- Eggs and larvae are pelagic.

Growth:

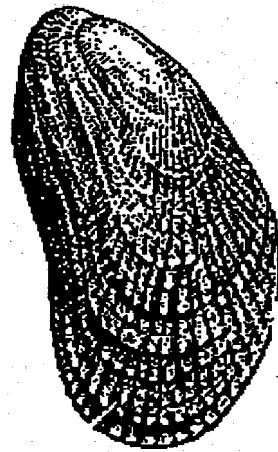
- Eggs develop into ciliated larvae, a period that lasts anywhere from 12 days to a month or more.
- After this period they go through a change and develop a foot and two shells. They are called spat.
- The spat settle to the bottom and attach themselves by byssal threads. They are microscopic.
- At approximately 1 in. (25 mm) they lose their byssal threads and burrow into the bottom. Growth is rapid.
Young Soft Shelled Clams can move about to search for suitable habitat, eventually they become non-motile and remain in their burrows for the duration of their life.

Feeding:

- Soft Shelled Clams have an in current and excurrent siphon.
- Water enters the in current siphon, passing over the gills. Food sticks to the mucus, and cilia passes it to the mouth.
- Unwanted food and wastes are passed out the excurrent siphon.
- Food consists of small plants, clumps of bacteria, decomposing fragments of organic material, and animals.

RIBBED MUSSEL

Guekensia demissa



Identification:

- Bivalve.
- Numerous radial ridges.
- Color varies from brown to greenish-yellowish.

Size:

To 4 in. (100 mm).

Range:

Florida to Cape Cod.

Local Distribution:

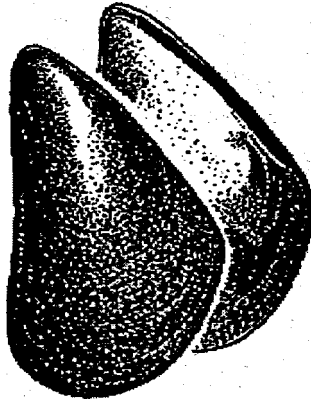
The Ribbed Mussel is abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Common along salt marsh banks and submerged rocks.
- Mussels use byssal threads to attach themselves to rocks, pilings, mud flats, etc.
- Often half buried in peat or muck.

BLUE MUSSEL

Mytilus edulis



Identification:

- Bivalve.
- Smooth, elongated, triangular shell with pointed umbo.
- Four small teeth near the umbo.
- Violet blue inside, with a shiny bluish black outer covering.
- Smooth shell.

Size:

Shell lengths to 3 in. long.

Range:

Circumpolar, south in West Atlantic to South Carolina.

Local Distribution:

Blue Mussels are abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Attach to any hard surface, singly or in clumps.
- Mussels use byssal threads to attach themselves to rocks, pilings; mud flats, etc.
- Slightly brackish waters to depths of several hundred feet.

Spawning:

- Eggs and sperm are broadcast into water column.

Growth:

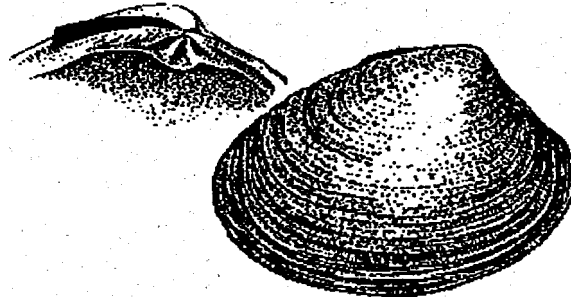
- Full growth can take place in one year in prime habitats, otherwise it may take 2-5 years.

Feeding:

- Feeds primarily on organic detritus.
- Feeds by siphoning of water.
- The current is caused by cilia.
- Selective feeder, secretes a mucous containing unwanted food particles.

HARD CLAM

Mercenaria mercenaria



Identification:

- Strong thick shell.
- Violet interior border.
- Short siphons.

Size:

Length to 5 in. (13 cm).

Range:

Gulf of St. Lawrence to Texas.

Local Distribution:

Hard Clams are abundant in lower portions of the Hudson-Raritan Estuary.

Habitat:

- Inhabit intertidal and subtidal waters to depths as great as 50 ft. (15 m).
- Prefer areas with higher salinity.
- Found in sand or muddy-sand bottom.

Spawning:

- Spawning occurs from June through August in the New York bight.
- Males release semen, containing pheromones, into the water.
- Females are stimulated into releasing eggs.
- Spawning is most intense during the first few days after peak temperatures are reached.
- A 2.5 in. (6 cm) female will release up to 2 million eggs.
- Eggs are pelagic and distributed by local currents.

Growth:

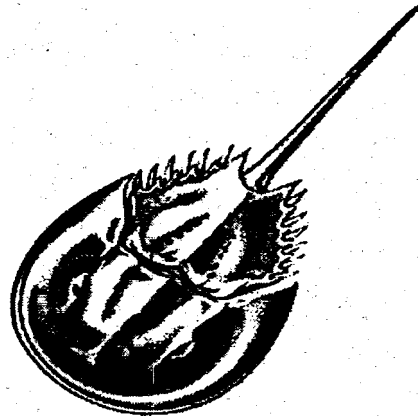
- Eggs hatch into larvae in about 10 hours and go through a complex development period before they become seed clams.
- Larvae settle on sand bottom.
- Hide under rocks and shells until they reach a size of 7/16 in. (10 mm).
- Go through a metamorphosis, become adults, and burrow into the bottom.
- Hard clams grow quickly and measure 3/16-1/4 in. (5-7 mm) by the end of their first summer.
- Growth ranges from 7/16 -1 in. (1-2 cm) in a season.
- Growth is temperature dependent.

Feeding:

- Filter feeders having an incurrent and excurrent siphon.
- Filter out plankton and other microorganisms.
- Water is brought in by the incurrent siphon and passed over the gills, mantle and visceral mass which secretes mucus,
- Particles caught in the mucus are passed onto the mouth.
- Palps at the entrance of the mouth either reject or accept the particles.
- If accepted it is passed into the mouth and ingested.
- If rejected it is ejected as pseudo feces.

HORSESHOE CRAB

Limulus polyphemus



Identification:

- Hard domed shell.
- Tail spike.
- Five pairs of legs.
- Leaf like gills.

Size:

Adults grow to approximately 2 ft. (60 cm) (including tail spike).

Range:

Maine to Gulf of Mexico.

Local Distribution:

Horseshoe Crabs are found in local bays and estuaries including the Hudson-Raritan Estuary. As waters warm in the spring, they reach peak abundance in shallow water. When waters cool they seek deeper waters to winter over.

Habitat:

- Inhabit intertidal to subtidal waters, preferring depths 75 ft. (22 m) or less.
- Live in muddy substrates in the ocean, hibernating during winter months.

Spawning:

- As the days lengthen in early spring horseshoe crabs migrate towards shore.
- Males arrive first, followed by the females.
- Gather on protected sand beaches in back bays and sounds.
- Spawning is correlated with the spring and neap tides.
- Females produce pheromones that attract males.

- As the females crawl ashore males attach themselves and are dragged to the edge of the shore.
- Eggs are laid at the high tide line.
- Eggs laid, number in the thousands.
- The female drags the male over the eggs. The eggs are fertilized as he passes over them.
- Males and female move back into the water, wait 12 hours till the next high tide, and repeat the process.
- Females can lay over 80,000 eggs during the mating season.
- Eggs are left to incubate under the sand for about two weeks.
- Hatching occurs at high tides.
- Juvenile Horseshoe Crabs emerge as miniature adults.

Growth:

- Growth takes place slowly and occurs by molting.
- The shell splits along the front edge and the soft crab protrudes from the front edge.
- The new shell hardens in a few days.
- Molting occurs once a year except when they are young.
- Maturity is not reached until they are ten years old, or have molted 16 times for males and 17 for females.

Feeding:

- Feed by pushing their way along the bottom in a way similar to that of a plow.
- Use their chelicerae as feelers to find food.
- When food is located they use their claws to push it towards their mouth.
- Since Horseshoe Crabs have no jaws, they use their claws to grind the food, then push it into their mouth.
- Feed primarily on worms, clams, and dead fish.

ROCK CRAB

Cancer irroratus



Identification:

- Rounded body.
- Nine wide, smooth-edged marginal teeth.
- : Color yellow-orange with red or purple speckles.

Size:

To 5 1/4 in. (131 mm).

Range:

Labrador to South Carolina.

Local Distribution:

Rock Crabs are abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Found in shallow subtidal waters to depths of 2600 ft. (780 m).
- Common on all types of bottom.

Spawning:

- Spawning occurs from spring until fall and is temperature dependent.
- Larvae are present in surface waters from late spring to September.

Growth:

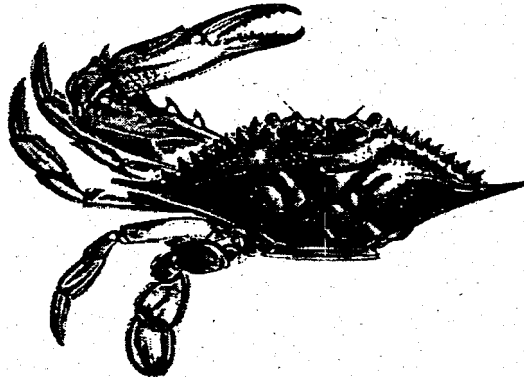
- Active molting takes place in April and June and growth ceases in winter.

Feeding:

- Known to be a scavenger and a carnivore.
- Feed on small clams, polychaetes, mussels, starfish and sea urchins.

BLUE CLAW CRAB

Callinectes sapidus



Identification:

- Males abdomen is shaped like a golf tee; virgin females have a triangular abdomen, gravid females have a rounded abdomen.
- Last pair of legs are paddled shape.
- Generally olive or bluish-green above, white below.
- Adults have bright blue claws.

Size:

Shell lengths to 9 in. (225 mm). Live for 2-3 years.

Range:

Cape Cod to Uruguay.

Local Distribution:

Blue Claw Crabs are year-round residents in the Hudson-Raritan Estuary. They exhibit seasonal migrations in relation to spawning. Blue Claws inhabit shallow waters in spring and summer and move into deeper waters during autumn, where they spend the winter.

Habitat:

- Found in depths as great 120 ft. (36 m).
- Common in bays and estuaries where they often extend into freshwater.
- Prefer muddy or clay bottoms and eel grass beds.

Spawning:

- Occurs in late fall in the upper bay areas.
- Females are inseminated in the fall, but fertilization is not complete.

- In the spring females extrude the eggs and fertilize them, with the stored sperm.
- Eggs stay attached enmasse to the females abdomen.
- Larvae go through an extensive period of development.
- Young migrate into rivers and bays.

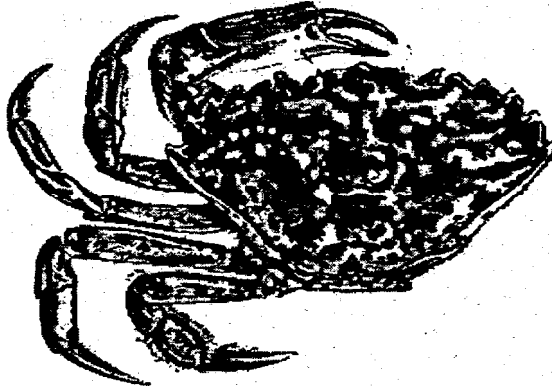
Growth:

- Blue Claw Crabs have a short life span and grow by molting.
- Molting occurs 18-22 times during their life.
- When molting approaches they seek shelter in vegetated areas.
- Molt by backing out of their shells.
- Now they are completely soft and vulnerable to predators.
- Within hours the new shell begins to harden and they can again protect themselves.
- The soft shell crab supports a large industry.

Feeding:

- Feed by ripping apart food with their front claws and passing it into their mouth.
- Use their large first claws to capture prey.
- Feed on plants, soft clams, young hard clams, soft shelled juvenile blue claw crabs and fishes.

GREEN CRAB
Carcinus maenas



Identification:

- Oval body.
- Five marginal and three frontal teeth.
- Color green on top, males yellow underneath and females reddish-orange underneath.

Size:

To 3 in. (75 mm).

Range:

New Jersey to Nova Scotia.

Local Distribution:

Green Crabs are abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

- Found in intertidal to subtidal at shallow depths.
- Common on rocky substrates.

NORTHERN LOBSTER

Homarus americanus.



Identification:

- First claws consist of a pincer and a crusher.
- Dark brown with orange edges and spots.

Size:

Length to 36 in. (90 cm) and weighs up to 40 lbs. (18 kg).

Range:

Labrador to Virginia.

Local Distribution:

Lobsters migrate in a more or less east-west direction. When Hudson-Raritan Estuary waters are warm they move to shallow waters, as the waters cool they move back into deep waters. Peak abundance in the waters of the New York Bight is reached by July or early August.

Habitat:

- Inhabit shallow coastal waters out to the edge of the continental shelf.
- Nocturnal, and prefer a place to hide during daylight hours.
- Rocky areas are favored.

Spawning:

- Spawning occurs once every other year.
- Mating occurs after the female has molted and is soft.
- Sperm is stored for up to 15 months.
- When the eggs are laid they pass the sperm and are fertilized.
- They attach to the swimmerets and remain there until hatching occurs.

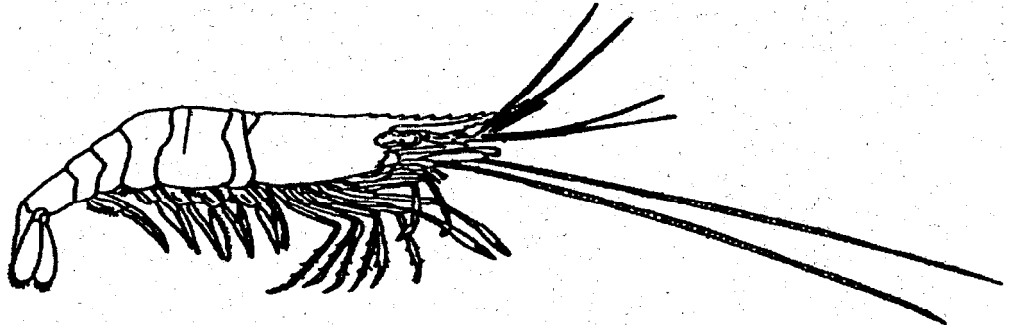
- The female is now a berried female.
- Eggs are carried for a period of 10 to 11 months.
- Large females can carry up to 80,000 eggs.
- Hatching occurs about mid May and the larvae go through a free swimming stage.
- Larvae are dispersed by prevailing water currents.
- Larvae go through three molts, at which point they resemble adults, and seek the bottom in order to complete their life cycle.

Feeding:

- Lobsters are not the scavengers they are believed to be.
- Feed primarily on algae, hydroids, mollusks, crustaceans, echinoderms, and fish.
- Feeding does not take place immediately before molting.

COMMON SHORE SHRIMPS

Palaemonetes spp.



Identification:

- Sharply pointed and dagger-like rostrum.
- Number of teeth on the crest behind the eye vary from 1 to 2.
- Distinct claws on first and second pairs of legs.
- Color varies from light tan to mottled brown.

Size:

To 2 in. (50 mm).

Range:

Cape Cod to Gulf of Mexico.

Local Distribution:

Common Shore Shrimps are abundant in intertidal areas of the Hudson-Raritan Estuary.

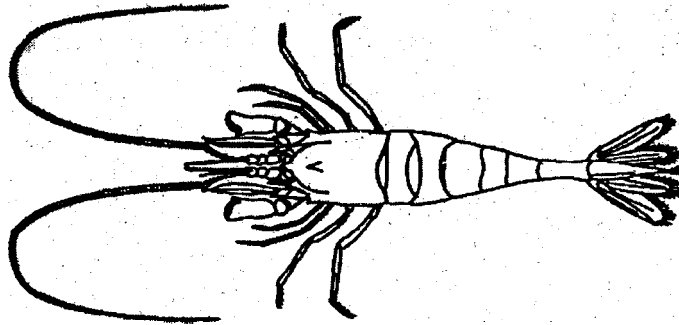
Habitat:

- Intertidal zone near pilings, rocky substrates and aquatic plants.

Spawning:

- Spawns in summer.
- Carries eggs within its swimmeretes until hatching.
- Upon hatching they are released as the larval zoeal stage.

SAND SHRIMP
Crangon septemspinosa



Identification:

- Short rostrum.
- Subchelate claws on first pair of walking legs.
- Color varies from almost colorless to mottled brownish or black.

Size:

To 2 3/4 in. (69 mm).

Range:

Arctic to Florida; also North Pacific.

Local Distribution:

Sand Shrimp are common in intertidal areas of the Hudson-Raritan Estuary.

Habitat:

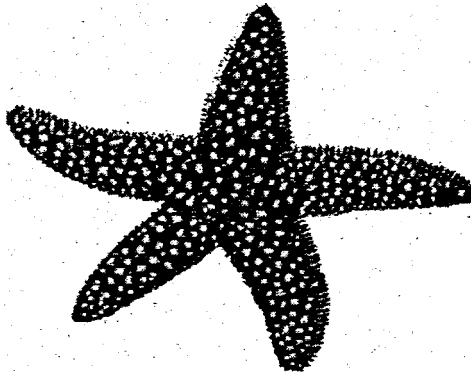
- Lower intertidal down to subtidal down to 300 ft. (90 m).
- Common on sandy bottoms and in eel grass beds.
- Often burrow into the sand.

Feeding:

- Feed on small decapods, invertebrate eggs and organic debris.

EASTERN COMMON SEASTAR

Asterias forbesi



Identification:

- Radially-symmetrical.
- Typically five arms project outward from the center.
- Tube feet grow in four rows on the underside of the arms.
- Mouth is located in the center on the underside.
- An orange “eye” or madreporite is located near the center.
- Color varies from olive; brown, yellow, orange, purple or red.

Size:

To 5 in. (125 mm).

Range:

Penobscot Bay to Gulf of Mexico.

Local Distribution:

Seastars are abundant in lower reaches of the Hudson-Raritan Estuary.

Habitat:

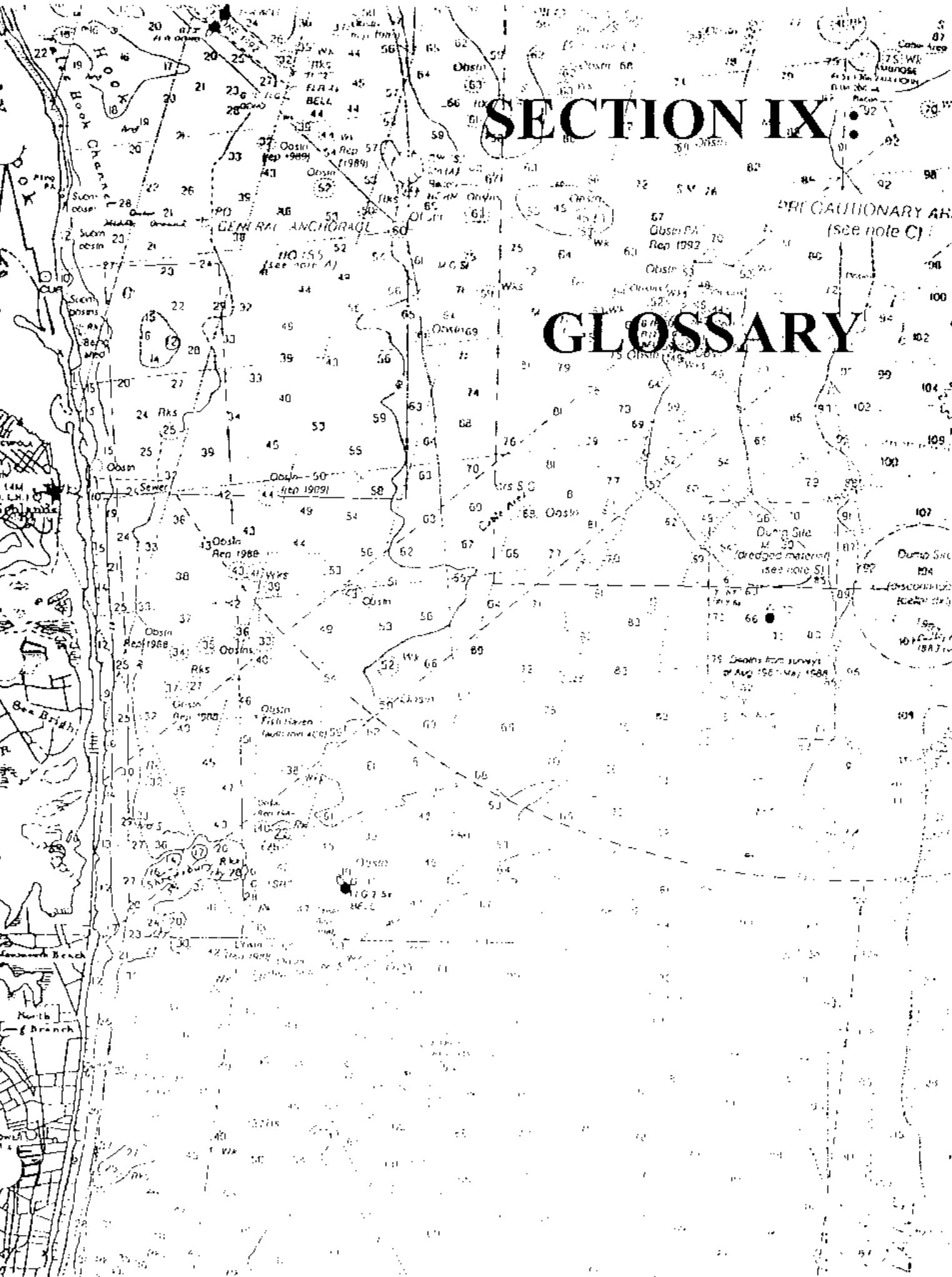
- Intertidal to subtidal zone.
- To depths of 150 ft. (45 m).

Feeding:

- Carnivorous: Feeds on snails, clams, mussels and barnacles.
- Feeds by attaching its arms around shelled invertebrates, forcing valves or shells open.
- Valves are pried open just far enough for the seastar to evert its stomach into the animal to devour it.

SECTION IX

GLOSSARY



BE CAUTIONARY AREA
(see note C)

Dredged material
(see note S)

Dredged material
(see note S)

Swath from survey
of Aug. 1987, May, 1988

GENERAL ANCHORAGE

NO. 55
(see note A)

Hook Channel

Bea Bridge

Linn Beach

North Branch

14M L.M.I.C.

Islands

Islands

Islands

Islands

Islands

Islands

Islands

Islands

Islands

Islands

Islands

GLOSSARY

Abiotic environment - the non-living components of an ecosystem.

Absorb - to take in and make part of an existing whole.

Adaptations - changes by an organism or its parts that make it more fit to the conditions of its environment.

Adhesive Disc (Oral) - a modification of the dorsal, pelvic or pectoral fin to form a mechanism by which the fish can attach itself to a rocky substrate or to other animals.

Aesthetics - a pleasing appearance or effect: Beauty.

Anadromous - the ability to live part of the time in fresh water and part of the time in salt water.

Anatomical Adaptations - changes in the structure of an organism that make it more fit to the conditions of its environment.

Anal Fin - the median fin on the mid-ventral line behind the anus. May contain only soft rays but in most advanced fishes this fin may have two or three spines at the front.

Anoxic - without oxygen or lacking oxygen for body use.

Anthropogenic effects - relating to, or resulting from the influence of human beings on nature.

Appendages - A subordinate or derivative body part; a limb or analogous part.

Aquifer - a water bearing stratum of permeable rock sand or gravel.

Ascend - in reference to fish that move up river.

Autotroph - plants and other organisms that make their own food from inorganic substances.

Barbel - a fleshy sensory appendage located on the head, snout, chin or around the mouth.

Basin - an enclosed or partly enclosed water area.

Bathymetry - the measurement of depth of water in oceans, seas and lakes.

Bearings - to extend in a direction indicated or implied.

Benthic - living in or on the bottom.

Benthos - the forms of marine life that live on the ocean bottom.

Behavioral Adaptations - changes involving action and response to stimulation that makes an organism more fit to the conditions of its environment.

Berried - bearing eggs.

Binomial Nomenclature - a system of nomenclature in which each species of animal or plant receives a name of two terms of which the first identifies the genus to which it belongs and the second the species itself.

Bioaccumulation - the accumulation of substances in the body of an organism.

Biodegradable - capable of being broken down.

Biomagnification - the accumulation of substances in larger and larger quantities in the bodies of organisms at each higher level of a food chain.

Biomass - the amount of living matter in a volume of habitat.

Biota - the animal and plant life of a region; flora and fauna collectively.

Biotic Community - the living organisms that inhabit an ecosystem.

Blotches - irregularly shaped, colored marks.

Body Cavity - a cavity within the body.

Bony Plates - a bony plate in the throat region of certain primitive fishes.

Brackish Water - water in which salinity ranges from approximately 0.50 to 17.00 parts per thousand.

Broadcast - a type of spawning where eggs and sperm are cast or scattered in all directions in the water.

Brood Pouch - a pouch where eggs or embryos develop.

Buffer - material used as a cushion against shock due to contact.

Carnivore - animals that feed on other animals.

Carrying Capacity - the maximum size of a population that can be supported by an environment.

Carotenoid - any of various yellow to red pigments found widely in plants and animals.

Catadromous- living in fresh water and going to the sea to spawn.

Caudal Fin - the median fin at the rear end of the body.

Caudal Peduncle - the rear, usually slender, part of the body between the caudal fin base and the base of the last dorsal and anal fin rays.

Center for Marine Conservation - an environmental group concerned with marine debris that can be contacted at: 1725 DeSales St. NW, Washington D.C. 20036.

Chart - a map for navigators which displays water depths and land forms.

Chelicerae - the first pair of appendages.

Chlorophyll - green-colored, photosynthetic plant material found in chloroplast.

Cilia - minute, movable, hairlike projections.

Clarity - the quality or state of being clear.

Classification - a systematic arrangement in groups or categories according to established criteria.

Coagulating - to become viscous or thickened.

Coastline - the boundary between the land and the ocean.

Colorimetric - a method of chemical analysis that compares a liquid's color with standard colors.

Commensalism - a type of symbiotic relationship in which one organism benefits from the association and the other is not affected.

Community - the population of various individuals interacting in a common area.

Competition - active demand by two or more organisms or kinds of organisms for an environmental resource in short supply.

Compressed - describes a fish body which is flattened from the side to side.

Concave - bowed or curved inward.

Conical - having the characteristic shape of a cone.

Conservation - a careful preservation and protection of resources.

Conserve - to avoid wasteful or destructive use.

Consumer - an organism that feeds on already formed organic matter or preys on other organisms.

Contaminants - substances that introduce unwholesome or undesirable elements to the environment.

Continental Shelf - that part of the ocean floor from the shoreline to a depth of about 200m (660 ft.).

Contour Interval - the space on a map found between contour lines.

Contour Line - a line on a map connecting land surfaces with equal elevations.

Coring - a sampling method that studies the deposition of sediments.

Current - a part of a fluid body of water moving continuously in a horizontal direction.

Decay - a slow change or breakdown.

Decomposer - an organism that feeds off of decaying matter, in turn speeding up the decomposition of an organism.

Deep Bodied - a fish whose body extends far vertically from the center.

Dehydrate - to remove water from.

Density - mass per unit of volume.

Detritus - organic particles that result directly from disintegration.

Depositional - an act or process of depositing, as in sediments.

Detrimental - obviously harmful, damaging.

Diadromous - diadromous species are fish that either migrate into fresh water from the sea to spawn (these species are also known as anadromous fishes) or into the sea from fresh water to spawn (these species are also known as catadromous fishes).

Dichotomous - dividing into two parts.

Diffusion - a process by which fluids move through other fluids from areas of high concentration to areas of lower concentrations through random molecular movement.

Dinoflagellates - single-celled microscopic organisms that may possess chlorophyll and belong to the plant phylum Pyrrophyta (autotrophic) or may ingest food and belong to the class Mastigophora of the animal phylum Protozoa (heterotrophic).

Dissolved Oxygen - oxygen that is dissolved in water.

Diurnal tide - a tide sequence with one high water and one low water during a tidal day.

Diversity - a function of both the number of species present in a given region or habitat and the relative proportions of their numbers,

Dominant - prevailing over all others.

Dormant - temporarily devoid of external activity.

Dorsal Fin - the median fin located on the back.

Downwelling - surface water set in motion by wind that is carried down beneath the surface.

Dredging - removing material from the ocean bottom to deepen a waterway.

Ecology - the branch of science concerned with the interrelationship of organisms and their environments.

Ecological Balance - the balance between organisms and their environment.

Ecosystem - the entire system of organisms and the physical and chemical aspects of their environments.

Elevation - height above sea level.

Elongate - to make long and narrow.

Environment - the combination of physical, chemical and biotic factors that act upon an organism or an ecological community and ultimately determine its form of survival.

Environmental group - a group of people whose goal is to protect and preserve the environment.

Epibenthic - living on the bottom of the sea floor.

Epifauna - animals that live on the ocean bottom, either attached or moving freely over it.

Estuarine - characteristics of an estuary.

Estuary - a water passage where salt water meets fresh.

Euryhaline - able to live in waters of a wide range of salinity.

Eutrophication - the process by which a body of water becomes, either naturally or by pollution, too rich in dissolved nutrients (as phosphates) causing a seasonal deficiency in dissolved oxygen.

Evolution - a process of change in a certain direction.

Fathom - a unit of length equal to six feet used for measuring the depth of water.

Fauna - the animal life of any particular area or of any particular time.

Family - a group of related plants or animals forming a taxonomic category ranking above a genus and below an order.

Feelers - a sensory extension that look like whiskers found on fish.

Filter Feeder - an animal that obtains food by filtering organic matter or minute organisms from a current of water that passes through some point of its system.

Fin - an external membranous process of an aquatic animal used to propel or guide the body.

Flora - plant life.

Flushing - a sudden flowing of water.

Food chain - the passage of food energy from producers to top consumers.

Food web - all of the food chains that interconnect at various points taken together.

Fresh water - water with little to no salt content usually found in rivers, lakes, ponds and streams.

Fucoxanthin - a brown carotenoid pigment ($C_{40}H_{60}O_6$). Especially found in the ova of brown algae.

Generalist - one whose skills or interests extend to several different fields.

Gill - organs designed to remove oxygen from water enabling the organism to breathe while submerged.

Gill Rakers - variously developed structures which project forward from the gill arches, like the teeth of a comb.

Gorge - to eat greedily or feed to capacity.

Gregarious - tending to associate with others of one's kind.

Habitat - the natural life-environment of individuals or organisms.

Herbivore - animals that only feed on plants.

Heterocercal - describes a caudal fin in which the vertebral column turns upward and continues almost to the end of the upper lobe.

Heterotroph - animals and bacteria that depend on the organic compounds produced by other animals and plants for food. Organisms not capable of producing their own food by photosynthesis.

Hierarchical - arranged in hierarchy.

Homeostasis - the process of achieving and maintaining a stable internal environment within a given organism.

Homocercal - describes a caudal fin in which all the principal rays of the fin attach to the modified last vertebrae.

Hydrographic - the measurement of the physical features of the oceans, seas, lakes, rivers and other waters, and their marginal land areas, with special reference to the elements that affect safe navigation, and the publication of such information in a suitable form for the use of navigators.

Hydrologic cycle - the cycle of water exchange among the atmosphere, land and ocean through the processes of evaporation, precipitation, runoff and subsurface percolation.

Hydrology - a science dealing with the properties, distribution and circulation of water on the surface of the land, in the soil, underlying rocks and in the atmosphere.

Hydrometer - a instrument for determining specific gravities of liquids.

Hypothesis - an interpretation of a practical situation or condition taken as the ground for action.

Hypothetical Situation - a circumstance to test logical consequences to see if it is consistent with observed data or previous knowledge.

Hypoxia - detrimental effects caused by lack of oxygen in the body cells or tissues.

Impact - the force or affect of one thing on another.

Incubation - the act of maintaining eggs under conditions favorable for hatching, development, or reaction.

Infauna - animals that live buried in the soft substrate (sand or mud).

Inferior - refers to the placement of a fish's mouth on the underside of its head or distinctly below the snout.

Inshore - area ranging from near the shore to the continental shelf.

Invertebrate - lacking a spinal column.

Juveniles - young of a species; generally a small immature version of the adults.

Key - an arrangement of the descriptive characters of a group of plants or animals or of taxa designed to facilitate identification.

Larvae - newborn, i.e., the development stage of a fish before it becomes a juvenile.

Laterally compressed - compressed side to side.

Lateral Line - a canal along a fish's body. This canal is a rearward extension of a sensory canal system on the head and it contains sense organs which can detect pressure changes. Usually single and located mid-side, but sometimes branched, double or triple and variously placed.

Latitude - location on the earth's surface based on angular distance north and south of the equator.

Litter - an untidy accumulation of objects usually trash, wastepaper, or garbage.

Longitude - location on the earth's surface based on angular distance east and west of the Greenwich Meridian.

Lunate - used in reference to a deeply forked, narrow-bladed caudal fish fin.

Madreporite - a porous plate through which the internal waste vascular system opens to the exterior in echinoderms. Often conspicuous in sea stars and mistaken for an eye.

Mandible - lower jaw.

Mantle - a fold of skin that surrounds the body organs in mollusks and contains glands that secrete the shell of shelled mollusks.

Marsupium - a chamber, or pouch on the underside of the trunk or tail of male seahorses and pipefish for the retention and brooding of eggs.

Mature - relating to a condition of full development.

Maxilla - the rear bone of the two bones that form the upper jaw.

Meniscus - the curved upper surface of a liquid column that is concave when the containing walls are wetted by the liquid and convex when not.

Mercator projection - a conformal map projection in the usual case of which the meridians are drawn parallel to each other and the parallels of latitude are straight lines whose distances from each other increases with their distance from the equator.

Meridian - any great circle which goes through the poles of a spherical body which is rotating.

Metamorphosis - a marked and more or less abrupt developmental change in the form or structure of an organism.

Micro Habitat - a small, distinctly specialized and effectively isolated habitat.

Molecules - the smallest particle of a substance that retains all the properties of the substance and is composed of one or more atoms.

Mollusks - soft unsegmented animals usually protected by a calcareous shell and having a muscular foot for locomotion. Includes snails, clams, chitons and octopuses.

Molting - in arthropods, shedding of the exoskeleton.

Morphology - a branch of biology that deals with the form and structure of animals and plants.

Mottling - marked with blotches, streaks or spots of different colors or shapes.

Mutualism - a symbiotic relationship in which both organisms benefit from their association.

Nape - the part of the back immediately behind the head or, in spiny-rayed fishes, the portion between the head and the point where the first dorsal fin begins.

Natal - in reference to an area where a fish was born.

Nautical Mile - unit of distance applied at sea, equivalent to about 6,076 feet, 1/60 of a degree, or 1852 meters.

Navigation - the method of determining position, course, and distance traveled.

Neap Tides - low tides which occur about every two weeks when the moon is in its quarter position.

Nekton - animals that are able to swim, independent of current action.

Niche - the ecological role of an organism and its position in the ecosystem.

Nocturnal - relating to or occurring in the night.

Non-Biodegradable - unable to be broken down by bacteria and other organisms into simpler substances.

Nomenclature - name, designation; an intentional system of standardized new Latin names used in biology for kinds and groups of animals and plants.

Nonpoint Source Pollution (NPS) - situations where the source of pollution is not known.

Nursery Areas - a place where young fish and other organisms can grow.

Oceanography - science that deals with the oceans and includes the delimitation of their extent and depth, the physics and chemistry of their waters, marine biology and the exploitation of their resources.

Ocellus - an eyespot in which the central color is bordered by a ring of another color, which is also different from the adjacent color of the body.

Offshore - area beyond the continental shelf.

Omnivore - feeds on both plants and animals.

Opercle - the uppermost and largest of the bones that form the gill cover.

Osmoregulator - regulation of osmotic pressure in the body of a living organism.

Osmosis - the passage of water through a semipermeable membrane from a region of high concentration of water to a region of low concentration of water.

Palps - in polychaete worms one of several types of sensory appendages on the head.

Palustrine - pertaining to materials growing or deposited in a marsh.

Parapodia - one of the lateral foot like appendages found on polychaete worms.

Passerine - of or relating to a suborder of (Passers) passerine birds, comprising the true songbird, with specialized vocal apparatus.

Pathogen - a specific causative agent (as a bacterium or virus) of disease.

Pattern - a reliable sample of traits, acts, tendencies, or other observable characteristics.

Pectoral - of, situated in, or on the chest.

Pelagic - of, relating to, or living or occurring in the open sea: oceanic.

Pelvic Fin- also called the ventral fin. A pair of fins on the lower part of the body. These fins can vary in position from on the belly just in front of the anal fin to under the pectoral fin, to below a point in front of the base of the pectoral fins.

Pervasive - to go through every part.

pH - the measure of the alkalinity or acidity of a solution.

Foramens : A hormone that acts upon the olfactory system in animals, usually used by an animal to attract a mate.

Photosynthesis - the process by which plants produce carbohydrate food from carbon dioxide and water in the presence of chlorophyll, using light energy and releasing oxygen.

Phytoplankton - plant plankton. The most important community of primary producers in the oceans.

Pigment - a coloring agent in animals and plants especially in cells or tissue.

Plankton - passively drifting or feebly swimming organisms that are carried by ocean currents. Plankton include microscopic plants, protozoa, and larval forms of higher animals, including jellyfish.

Point Source - situations where the source of pollution is known.

Pollution - the addition of anything to the environment that makes it less fit for living things.

Populations - the whole number of inhabitants in a certain area.

PPT. - parts per thousand.

Predator - carnivores that capture and feed on prey.

Prey - an animal taken as food by a predator.

Primary Productivity - the amount of organic matter synthesized by organisms from inorganic substances within a given volume of water or habitat in a unit of time.

Proboscis - a snout or trunk, with distinct structural peculiarities in different phyla.

Producer - the autotrophic component of an ecosystem, that produces the food that supports the bio-community.

Productive - the power of producing in abundance.

Prehensile - adapted for seizing or grabbing by wrapping around.

Protrude - to jut out from the body.

Pugnacious - having a belligerent nature.

Quadrangle - a tract of country represented by one of a series of map sheets.

Quiescent - marked by inactivity or repose.

Radial Symmetry - spoke-like arrangement of parts around a central axis as in jellyfish, sea stars, etc...

Raptors - birds that capture food by use of talons.

Ray - one of the supporting elements, which may be soft or spiny in a fin.

Reagent - a substance used because of its chemical or biological activity.

Refractometer - a device that measures the index of refraction to determine salinity.

Resource - a source of supply or support.

Respiration - the process by which food is used.

Resuspension - when the particles within the water column become stirred up then settle back down and then become stirred again.

Riverine - relating to, formed by, or resembling a river.

Rostrum - The blade-like projection between the eyes in shrimp.

Runoff - the portion of the precipitation on the land that ultimately reaches streams.

Salinity - a measure of the quantity of dissolved salts in ocean water.

Salt wedge estuary - a very deep river mouth with a very large volume of freshwater flow beneath which a wedge of salt water from the oceans invades.

Scale - a small, flattened, rigid and definitely circumscribed plate forming part of the external body covering.

Scavenger - carnivores that feed on dead animals.

Sea water - water containing dissolved salts, primarily Na^+ and Cl^- .

Sediment - particles of organic or inorganic origin that accumulate in loose form.

Semidiurnal Tide - tide having two high and two low waters per tidal day with small inequalities between successive highs and successive lows.

Serrate - saw-like notches along an edge.

Siltation - the act of being choked, filled, covered, or obstructed with silt or mud.

Sinking - to go to the bottom.

Siphons - a tube that carries water in to the body or out of the body. Bivalves usually have a incurrent and excurrent siphon.

Skimming - glide or skip along, above, or near a surface.

Snout - that portion of the head which projects beyond the eyes.

Sounding - measuring the depth of water beneath a ship.

Soft Rays - a bilaterally paired element or ray in a fin, with cross striations; frequently branched toward the tip, and usually soft or flexible to the touch.

Spat - a young bivalve.

Specialist - one who devotes itself to a special occupation or branch of learning.

Species - a category of biological classification, ranking immediately below the genus or subgenus.

Specific Gravity - the ratio of density of a given substance to that of pure water at 4°C and at atmospheric pressure.

Spine - sharp, pointed, protective outgrowths used for defense and locomotion.

Spring Tides - tide of maximum range occurring every fortnight when the moon is new or full.

Stenohaline - organisms that can withstand only a small range of salinity change.

Storm Surge - a rise above normal water level resulting from wind stress and reduced atmospheric pressure during storms.

Stout Body - physically strong.

Straining Apparatus - a device to retain food or debris as water passes through.

Substrate - a base on which an organism can live and grow.

Sub Terminal - in reference to the placement of a fish's mouth, where the mouth opens just below the tip of the snout.

Superior Mouth - in reference to the placement of the mouth, when the mouth opens, on the upper profile. In these cases the tip of the lower jaw is the foremost part of the body.

Symbiosis - a relationship between two species in which one or both benefit and/or neither one is harmed.

Symbiotic Relationship - relationships in which two different organisms live in close association with each other to the benefit of at least one of them.

Taxonomy - orderly classification of plants and animals according to their presumed natural relationships.

Terminal - in reference to the placement of the mouth, used in those instances when the mouth opens at the front end of the body, the snout and lower jaw being equally far forward.

Theory of Evolution - Charles Darwin's theory of survival of the fittest.

Threshold - the minimum sensitivity level of a nerve cell; impulses below this level do not initiate responses.

Tidal Creeks - water that flows through the marsh moved by tides.

Tides - periodic rise and fall of the surface of the ocean and connected bodies of water resulting from the gravitational attraction of the moon and sun acting unequally on different parts of the earth.

Tide Line - line formed on shore made by the high and low tide water levels.

Tidal Pools - water left in the marsh or on a beach after the tide recedes. Some are permanent and others are temporary.

Tolerant - able to withstand changes in the environment, including fluctuations in salinity, dissolved oxygen and temperature.

Topography - the configuration of a surface.

Translucent - allowing light to pass through, but not transparent or clear.

Transparent - having the property of transmitting light without appreciable scattering so that bodies lying beyond are entirely visible.

Tributaries - small streams that feed into larger streams or rivers.

Trophic level - a nourishment level in a food chain.

Turbidity - a state of reduced clarity in a fluid caused by the presence of suspended matter.

Umbilicus - a sometimes conspicuous dent or hollow at the base of the columella in shelled gastropods .

Umbo - in bivalves, a projection near the hinge.

Unpigmented - lacking coloring matter, especially in cells and tissues.

Upwelling - the process by which deep, cold, nutrient-laden water is brought to the surface.

Valve - in mollusks, one of the parts of the shell, bivalves have two and gastropods have one.

Vegetation Beds - areas where vegetation growth is concentrated and heavy.

Vertebrate - animals with backbones.

Wastewater - water that has been used (sewage).

Watershed - a region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Waterway - a navigable body of water.

Wetlands - land containing much soil moisture.

Zoea - a crustacean larval stage, especially of crabs or crab like forms.

Zonation - distribution of kinds of organisms in biogeographic zones.

Zooplankton - animal plankton.