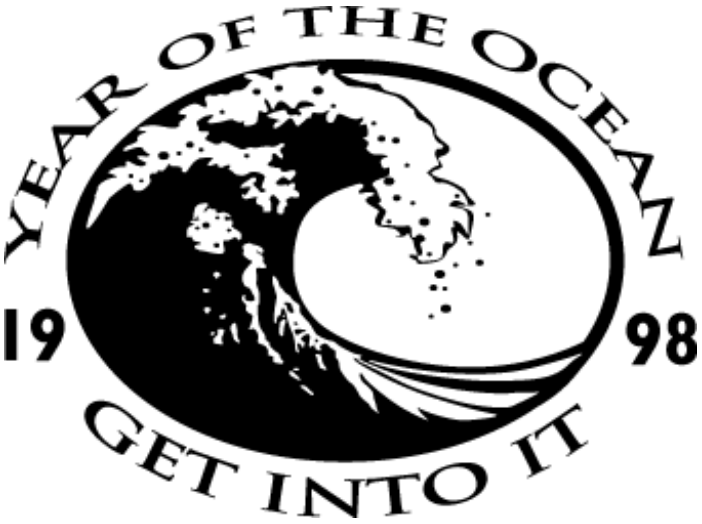

An Educator's Guide to Year of the Ocean

YEAR OF THE OCEAN 1998 PUBLICATIONS

To receive the publications on this form, please mail the form to:
NOAA Outreach Unit, 1305 East West Highway, Silver Spring, MD 20910
(These publications will be available until December 31, 1998)
Please limit your request on this form to 10 or fewer items-
Check the brochures and publications you wish to receive

ESPECIALLY FOR KIDS

_____ Marine Debris Coloring Book
_____ Sea Turtles Coloring Book
_____ Pacific Coral Reef Coloring Book
_____ Adopt the Coast Activity Book
_____ Adopt a Buoy - An Activity & Coloring Book
_____ The Whale and the Plover Coloring Book
_____ Fisheries Activity Book

OUR COASTS AND CORAL REEFS

_____ 25 Things You Can Do to Save Coral Reefs
_____ Common Questions on Coastal Management
_____ Habitat Protection Activity Report 1991-1993
_____ NOAA Fisheries National Habitat Plan - 1997 and Beyond
_____ Keep It Clean! A Citizen's Guide to Protecting Our Coasts
_____ Sample Nautical Chart (Not on website)
_____ Habitat Restoration Booklet

SEA CREATURES

_____ Northwest Salmon
_____ Endangered Whales
_____ Sea Turtles
_____ Threatened, Endangered, and Depleted Seals and Sea Lions

OCEAN ISSUE FACT SHEETS

_____ General Information about the Ocean
_____ Oceans: Our Weather and Climate
_____ Coastal Tourism
_____ Runoff Pollution
_____ Marine Protected Areas
_____ Ocean Products
_____ Coastal Development
_____ Ocean Science Careers
_____ Sustaining Marine Resources
_____ Habitat Restoration
_____ Ocean Mineral Resources
_____ Marine Mammals
_____ Safe Navigation

REPORTS TO THE NATION ON OUR CHANGING PLANET

_____ Our Changing Climate
_____ El Nino

ESPECIALLY FOR TEACHERS

_____ Coastal Awareness Guide
_____ Marine Resources Reference List
_____ Tour of the National Marine Sanctuaries
_____ National Estuarine Research Reserve System Web Addresses
_____ Sea Grant: Classroom Information/References
_____ NOAA Website Addresses for Teachers
_____ Sanctuary Web Addresses

These publications can be found at *http://www.yoto98.noaa.gov* in the Kid's and Teacher's Corner

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PLEASE SEND ME THE PUBLICATIONS CHECKED ABOVE:
NAME_____
ADDRESS_____
CITY/STATE/ZIP_____

International Year Of The Ocean: An Educator's Guide

In recognition of the importance of the marine environment, the United Nations has declared 1998 the International Year of the Ocean (YOTO). The International Year Of The Ocean can provide teachers with an important opportunity to incorporate the ocean into their classroom activities.

Why study the ocean? There are many reasons. The ocean is truly one of the planet's most fascinating ecosystems. So many unique and unusual life forms live in it or depend upon it. Many are hidden in the deepest ocean floor and are therefore especially interesting.

Some people have called the oceans the "last frontier" on planet Earth. We are only now beginning to study the ocean floor and all that it holds. The oceans also are an extremely important economic resource. Many peoples' livelihoods are dependent on the ocean, and thus it plays a major role in the global economy. In recent years, we also have learned more about the important role the oceans play in controlling our global climate. The El Niño effect that has been featured in the news recently, is one example.

With so much to learn, where can you start? The National Oceanic and Atmospheric Administration (NOAA) has produced a series of 14 Year Of The Ocean "Fact Sheets" which will point you in the right direction and get you started. They will help you understand some of the major issues, and help you find additional information.

"The study of marine science is necessarily a multi-disciplinary endeavor, encompassing the efforts of many workers in the biological, chemical, geological, and physical sciences. The field concerned with research on the oceans—oceanography—has united biology, ecology, chemistry, geochemistry, geology, geophysics, physics, and meteorology as well as other disciplines in investigations of the marine environment." [1]

[1] Practical Handbook of Marine Science, edited by Michael J. Kennish, CRC Press, Inc. Boca Raton, FL, 1989.

The purpose of this guide is to stimulate your thinking on ways to involve your students in the study of the ocean. It suggests a wide variety of study topics and projects for your students. Reading these may stimulate more ideas. The possibilities are really limitless.

Today, issues related to ocean pollution and management are especially important. The oceans have been used as dumping grounds for garbage and many polluting materials, and their living resources are being exploited as never before. How people all over the world can work together to better manage and preserve our ocean resources is certainly a topic for discussion. All of these topics are worthy of in-depth study.

You are encouraged to use the Year of the Ocean poster as well as the Species List in this booklet to help your students gain an interest and understanding of the ocean and its creatures. The poster is an artistic interpretation of more than 70 organisms living in tropical and temperate waters, in the open ocean, in polar waters and in the deep sea.

The many NOAA Offices and the World Wide Web sites mentioned on the "fact sheets" are excellent sources of information. If you do not have access to the web but have telnet, take a look at the gopher site at gopher://esdim1.esdim.noaa.gov/11/NOAA_systems/education/. At this site NOAA has a text version of its brochures and publications. Additionally, your local and school libraries have a wide range of books and information about the ocean, its creatures and the people who make their living on and in the ocean.

Many of the NOAA Sea Grant College Programs have curriculum materials you can order. All of our coastal states have Sea Grant programs. For a list of them contact the National Sea Grant College Program, NOAA, R/OR1, 1315 East West Highway, 11th Floor, Silver Spring, MD 20910, telephone 301-713-2448. This information can be found on the web at http://www.mdsg.umd.edu/#SG.

STUDENT STUDY AND PROJECT IDEAS FOR THE YEAR OF THE OCEAN

Have your students explore these questions and issues in your classroom. Assistance has been provided in most cases to find the general answers to these questions. Look at the websites listed, but remember that other information on the project ideas can be found in your local school library and on the Year of the Ocean Fact Sheets. The web addresses for Year of the Ocean information is *http://www.yoto98.noaa.gov* and *http://www.yoto98.com*.

Weather

What is a hurricane? Where do hurricanes begin, and why? What is the minimum wind speed for a hurricane? What is the fastest wind speed recorded for a hurricane? Make a map of the path of a hurricane. Begin your search for hurricane information at *http://www.aoml.noaa.gov/general/lib* and *http://www.nhc.noaa.gov*

Are you and your family prepared for bad weather? Do you know what to do if a hurricane or tornado is heading your way? How can you stay safe where lightning or floods threaten? Take a look at the weather section of *gopher://esdim1.esdim.noaa.gov/11/NOAA_systems/education/* and at *http://www.crh.noaa.gov/mkx/owlie/owlie.htm*

Borrow a weather radio and record its message one morning, during the afternoon and that night. Were there weather watches or warnings in your area? Did the forecast change during the day? Information about NOAA Weather Radio and NOAA Weather Radio frequencies can be found at *http://www.nws.noaa.gov/nwr/nwrbro.htm*

What causes our seasons? What is air pressure? Are air temperatures the same over land and water? Does water temperature differ between near-shore and offshore sites? How are ocean waves described? What causes ocean surface waves? Are wind speeds the same over land as they are over the ocean? The answer to these and other related questions can be found at *http://seaboard.ndbc.noaa.gov/educate/educate.shtml*

Climate

What is the difference between weather and climate? Look at the weather information above. To learn about climate check out *http://www.ogp.noaa.gov/OGPFront/Edoutrch.html*. Look on pages 9-10 of Our Changing Climate.

What is El Niño? How does it affect our climate? What is La Niña? What happens when the earth experiences either of an El Niño or La Niña? What role do ocean currents play in climate control? Begin your search at *http://www.elnino.noaa.gov*

Is our global climate changing, and, if so, why? What are some of the predicted impacts of global climate change on the oceans and the land? Some of the questions are answered, and some others are posed, at *http://www.ogp.noaa.gov/OGPFront/mono1.html.* See the section entitled: The Oceans.

Our Oceans and Coasts

In what year did the president ask that the U.S. coast be charted? Who was that president? What percentage of Americans live in counties that border our coast? What areas of our country are growing the fastest? See *http://www.nos.noaa.gov/bro*

What's the difference between a nautical chart and a map? What is bathymetry? How do scientists map the ocean floor? What do the ocean floors look like? See *www.chartmaker.ncd.noaa.gov/ocs/text/map-cht.htm.* The National Ocean Service's MapFinder is a one-stop web service that provides direct Internet access to imagery and data holdings for coastal photography, nautical charts, coastal survey maps, environmental sensitivity index maps, hydrographic surveys, water level stations, and geodetic control points. This can be found at *http://mapindex.nos.noaa.gov/.*

What are our country's biggest ports? What are the characteristics of a good port? You will find this information most easily in an almanac in your local library.

Can the coast be developed and protected at the same time? What are some of the environmental costs of development? Pick a coastal state and see how far the coastal management program has developed.
Begin at *http://www.nos.noaa.gov/ocrm/czm/welcome.html* and *http://www-orca.nos.noaa.gov/projects/population/population.html* Contact the state government for more information.

Navigation

What is the Gulf Stream? Where is it located? What do the numbers on the side of the map signify? Take a look at *http://www.erols.com/gulfstrm* to see the differences in temperature.

Find out what are the five largest cities in the world. How many of these are ports? Take a look at an atlas in your library. Check the populations of Beijing, Mexico City, London, New York. What other cities have large populations? How many of these cities are located on water?

Draw a sailing ship and label the different kinds of sails. You will need to use your librarian's guidance on this project.

How deep is the ocean floor? What does it look like from a satellite in outer space? Why do we study water depths of lakes and the ocean floor? You can start your search at *http://www.ngdc.noaa.gov/ngdc/news/lakemich.htm* and at *http://www.ngdc.noaa.gov/ngdc/news/gravity.htm*

Sustaining Marine Resources

Who do the fish in the ocean belong to? Who should have a say in how many fish are caught each year? Who makes the decisions now on how many fish can be caught? Are we catching too many, just the right number, or can we catch more? Who should be involved in making these decisions? What does the word sustainable mean? Why is it important to manage our fisheries sustainably? To start to answer these questions, take a look at *http://www.noaa.gov/nmfs/sustain.html*

How many fish species are there in the sea? Look at Fishes of the World, Third Edition, by Joseph S. Nelson

How does the U.S. work to keep all the fish in the sea from disappearing? You can start here - *http://www.noaa.gov/nmfs/law.html*

Maritime History

Most of the projects here may require assistance from a librarian.

Read a book about an ocean voyage, pirates, fishermen, sailors or ships or whaling. When did wind-powered ships give way to steam-powered ones?

Find three poems about the ocean (or sea).

During the Civil War, the Monitor and Merrimac (or C.S.S. Virginia) fought a battle in Hampton Roads, Virginia. One ship sank later in a storm off North Carolina. What can you discover about the sunken ship? Look at *http://www.nos.noaa.gov/ocrm/nmsp/nmsmonitor.html*

If the RMS Titanic sailed today, it would probably not be sunk by hitting an iceberg. Why not? Take a look at the photo of the iceberg that probably sunk the ship at *http://www.rdc.uscg.mil/iippages/home.html*

Runoff Pollution

All land drains eventually to the sea. Where does the rainwater that falls on your school ground end up? Will it ever reach the ocean? If so, which one, and how? What pollutants might it carry with it? Watersheds are nature's way of dividing up the landscape. Rivers, lakes, estuaries, wetlands, streams, even the oceans can serve as catch basins for the land adjacent to them. Ground water aquifers serve the same purpose for the land above them. The actions of people who live within a watershed affect the health of the waters that drain into it. To get your students involved in your local watershed, check out *http://www.epa.gov/surf//locate.html.*

Plastics and other floatable items are a major source of ocean pollution. What are their impacts on sea life? What can be done to keep them out of the ocean? How do they get there in the first place? How do each of us contribute to ocean pollution? Might we contribute to the problem, even

if we live miles away from the ocean? Look at *http://www.epa.gov/OWOW/OCPD/Marine/contents.html*

Each year, millions of gallons of oil and other chemicals spill into U.S. waters. Scientists work closely to respond to about 100 accidental oil and chemical spills and to investigate the consequences of releases from about 400 hazardous waste sites each year. What do these scientists do and who do they work with? Begin your search with *http://www-orca.nos.noaa.gov/projects/hazmat/intro/hazmat.html*

Ocean Life

Have students pick a marine organism and learn about its life. Consider one of the following: flounder, sea cucumber, jellyfish, crab, conch, skate, coral, sponge, oyster, octopus, whale, shark, nori, electric eel, blowfish, seahorse, squid. Much of this information can be found by students in an encyclopedia. An interesting site for tropical fish is *http://www.tropicalfish.com/html/primer.html*

-what special adaptations does it have?
-how does it reproduce?
-where does it fit into the marine food web? What does it eat, and what eats it?
-what are its special habitat needs?
-how well is this species surviving? Is it endangered or threatened? If so, why?
-is this life form important to people? If so, how?
-how do scientists study it?
How old is a 1 lb. lobster? How long can lobsters get? What is the cost of a lobster dinner compared to a steak dinner at a local restaurant?
How are lobsters caught?
Look at *http://www.yoto98.noaa.gov/books/fishfaq*

What fish is used to make fish sandwiches at your local fast food restaurant? Find recipes that use (1) a fish (2) a shellfish (3) squid and (4) seaweed. Try them!

Visit a local seafood market. Draw one fish and one shellfish that you see there. Learn how they keep fish fresh. Make a fish mobile with three or more different species of fish. Make a jellyfish mobile.

What types of fish and shellfish do your students like to eat? How did they get to your area?

Protected Areas

Find out about a National Park along the coast. What special habitats does it have? When and why was it set aside and protected? What marine life is found there? Start at *http://www.nps.gov/parklists/pickstates.html*

Find out about a NOAA National Marine Sanctuary or National Estuarine Research Reserve. What does estuarine mean? What is an estuary? Do you live near an estuary? What marine life is found there? Begin your search at *http://www.nos.noaa.gov/ocrm/nmsp|* and *http://www.nos.noaa.gov/ocrm/nmsp/*

Coastal Tourism

These questions are included to elicit information from the students about what they like to do at the coast and in coastal areas. Have they visited National Parks, National Marine Sanctuaries or National Estuarine Research Reserves?

What are the enjoyable activities you can do at the beach or on the ocean?
Do a survey in your school of the most popular coastal recreation activities and vacation destinations.
What percentage of the students in your class have seen personally an ocean?

Protected Marine Mammals

Some marine mammals require protection under the laws of the U.S. Why are these mammals endangered? What is being done to protect them? Pick an animal and investigate its habitat, its life cycle, its natural predator, and how it reproduces. Does this animal have any contact with humans? To get a complete list of the protected marine mammals, like some species of dolphins, whales, sea lions, and seals check out *http://www.nos.noaa.gov/ocrm/nmsp/*

Science and Technology

How are deep-sea submersible vehicles used in studying the ocean? Start your search for this information at *http://www.jasonproject.org/jason.html*

How do we measure the salinity of the ocean? How do conductivity and density of sea water relate to salinity? These questions are most easily answered in your library.

What is remote sensing? What role do satellites play in remote sensing? Have students find a remote sensing image on the web. One place to start is at the NOAA/NESDIS Satellite Active Archive (SAA) WWW Interface at *http://www.saa.noaa.gov/*

Careers

Marine Science Careers: A Sea Grant Guide to Ocean Opportunities, produced for the National Sea Grant College Program (1996). Single copies ($5) may be ordered from: WHOI Sea Grant, 193 Oyster Pond Rd.,MS #2, Woods Hole, MA 02543-1525 (checks payable to WHOI), or Sea Grant Communications, Kingman Farm/UNH, Durham, NH 03824-3512 (checks payable to UNH). Please be sure to include payment with order. Discounts for large orders are available. An interactive and informational marine science careers web site, based on the Sea Grant publication, will debut this fall. For more details, contact WHOI Sea Grant, (508) 289-2665, or by email at seagrant@whoi.edu

SPECIES LIST

Tropical or Reef Habitat: In warm tropical or subtropical waters, coral reefs provide habitat for thousands of different species. Many of these are brightly colored and adapted to very specific ways of life. Like terrestrial rain forests, reefs are disappearing rapidly as a result of human activities, including pollution and overfishing.

1 Reef lobster - *Enoplometopus occidentalis* - Living in crevices and caves, these nocturnal marine crustaceans that live on the sea bottom scavenge for dead animals but also eat live fish, seaweed, small mollusks and other bottom-dwelling invertebrates.

2 Star coral - *Montastrea cavernosa* - One of many marine invertebrates in the class Anthozoa, it is has stinging cells and internal or external skeletons of a stonelike, horny, or leathery consistency. The term "coral" is also applied to the skeletons alone, particularly the stonelike ones. See 6, 7, 8, 9, 28, and 67.

3 Tube sponge - Phylum Porifera - A tube sponge may be 3 to 6.5 feet tall. Size within a species may vary with age, environmental conditions, and food supply. See 26, 27, and 38.

4 Gorgonian - *Gorgonia* species- A "soft coral" composed of polyps that grow together to form a flat structure instead of a rocky reef, it has a central internal skeleton, composed of a flexible, horny substance supporting the colony. See 21.

5 Butterflyfish - Family Chaetodontidae - Most often found on reefs and in warm waters, the precise number of species in this family is unknown, but exceeds 150. Their bright colors are usually patterned to provide protection from predators - frequently the tail appears to be the head. See also 12 and 17.

6 Long-tentacled anemone - *Heteractis magnifica* - A member of the invertebrate order Actiniaria, made up of sedentary marine animals resembling flowers but closely related to jellyfish, anemones occur in all oceans from the intertidal zone to depths of more than 33,000 feet. See 2, 7, 8, 9, 28 and 67.

7 Brain coral - *Diploria strigosa* - This species of coral forms boulders that are ridged and shaped like the surface of the brain. See 2, 6, 8, 9, 28, and 67 .

8 Boulder coral - *Porites* species - Another of the many forms taken by corals. Corals are closely related to anemones. See 2, 6, 7, 9, 28, and 67.

9 Plate coral - *Agaricia tenuifolia* - Stony corals form reefs that can extend only a few feet or thousands of miles. See 2, 6, 7, 8, 28, and 67.

10 Sea grass - One of the relatively few non-algal plants living in salt water, sea grasses are most common in very shallow waters near shore. They provide food and shelter for the larvae and juveniles of many species of fishes and invertebrates.

11 Spotted moray - *Gymnothorax moringua* - Morays generally live in tropical and subtropical waters. Most have large flattened bodies and often anchor their rear half in coral and rocks, extending the head in the current, ready to grab prey that comes close. They are dangerous when provoked, with ferocious teeth producing deep wounds that usually become infected.

12 Butterflyfish - Family Chaetodontidae - Butterflyfish are most often found in reefs and in warm waters. See 5 and 17.

13 Rock beauty - *Holacanthus tricolor* - This angelfish of warm Atlantic and Caribbean waters reaches a length of 12 inches. As is common in tropical reef fishes, juveniles have a different color pattern from adults. In most angelfish, the lips are a different color from the body, appearing to be painted on.

14 Blue spotted ray - *Taeniura lymma* - Sharks, skates, and rays are closely related; skates and rays can be thought of as flattened sharks with very large pectoral fins. Stingrays are noted for the long, sharp spines at the base of the tail. Each spine has a venom sac at its base, and stings are extremely painful. Wounds are frequently the result of a swimmer stepping on a ray.

15 Spotted wobbegong - *Orectolobus ornatus* - Carpet sharks are bottom dwellers with the lower lobe of the tail absent. This Australian species blends into the sea bottom, where it ambushes bottom-dwelling prey at night. It has a fringe of fleshy barbels around its broad snout.

16 Common octopus - *Octopus vulgaris* - Distributed from the North Atlantic as far South as Guiana, this species reaches a length of three feet and a weight of ten pounds. The Giant Pacific Octopus span can extend 30 feet across and it can reach a maximum weight of nearly 600 pounds. Stories of octopus attacks on divers are false; octopus are generally shy and avoid confrontations with humans if possible.

17 Butterflyfish - Family Chaetodontidae - These are "picker" feeders: they use their long snout with the mouth at the end to pick small organisms and food particles from crevices and holes. See also 5 and 12.

18 Nassau grouper - *Epinephelus striatus* - A member of the sea bass family, this species lives in warm waters along rocky shores and coral reefs in the western North Atlantic. A valuable commercial species, it is in such demand that populations have been seriously damaged by overfishing.

19 Marine iguana - *Amblyrhynchus cristatus* - The only sea-going lizard in the world, the marine iguana is found throughout the Galapagos Islands in densities of 4,500 per mile of coastline. Marine iguanas eat marine algae, crustaceans, and grasshoppers. Most feed on exposed reefs close to shore. Larger males, however, are famous for their offshore swimming and diving abilities. They can reach forty feet underwater and usually dive five to ten minutes, although the longest observed was about sixty minutes.

20 Potato grouper - *Epinephelus tukula* - An Indo-Pacific member of a warm-water family that includes some of the largest of all reef fishes, groupers are disruptively colored so they can blend with the coral reef or rocky bottom. Some are able to change color to match their surroundings.

21 Purple sea fan - *Gorgonia ventalina* - The living tissues form a layer over the entire surface, often in bright colors. See 4.

22 Common clownfish - *Amphiprion ocellaris* - Living among anemone tentacles, and producing a skin secretion inhibiting anemone tentacles from stinging, clownfishes can shelter amid the tentacles safe from harm, taking advantage of the anemone's own formidable defenses. They can also steal food from the anemone, which provides an easy living for them.

23 Cortez garden eel - *Taenioconger digueti* - These eels from the Gulf of California live in colonies at a depth of 12 to 132 feet; each individual has a burrow well-separated from the others. Because they feed by extending the upper half of the body up into the water to catch small animals that drift or swim by, they look like a garden that was planted.

Temperate Waters: Warm and cool temperate waters extend between the subtropical and subpolar regions in each hemisphere. They are highly productive, but support relatively fewer species than tropical regions. However, populations of individual species may be extremely high owing to the rapid growth of plankton that provides food for them.

24 Giant Kelp - *Macrocystis* spp.- Giant kelp are very large seaweeds found in colder seas and belonging to the order Laminariales (about 30 genera) of brown algae. Giant kelp is rich in minerals and produces algin, a complex carbohydrate useful in various industrial processes, including ice cream and tire manufacture.

25 Leopard shark - *Triakis semifasciata* - Living in the northeastern Pacific Ocean near the bottom, females may reach a length of about 7 feet, but males only grow to 5 feet. The markings are distinctive: black crossbars and blotches on a pale brown or gray background. This shark is frequently on display in public aquaria.

26 Velvety red sponge - *Ophlitaspongia pennata* - There are more than 5,000 species of sponges in the Phylum Porifera, occurring in many forms including tubes, balls, vases, incrustations, and shapeless masses. See 3, 27, and 68.

27 Vase sponge - *Phylum Porifera* - A vase sponge may be 3 to 6.5 feet tall. They live in colonies or as solitary animals attached to the sea bottom or to other solid objects. See 3, 26, and 68.

28 Northern red anemone - *Tealia crassicornis* - Occurring in the northeastern Pacific Ocean; they can be thought of as an upside-down attached jellyfish. They are largest, most numerous, and most colorful in warmer seas. See 2, 6, 7, 8, 9, and 67.

29 Ochre sea star - *Pisaster ochraceus* - Sea stars are in the Phylum Echinodermata, which is generally characterized by five-rayed symmetry, a hard, spiny covering, and tube feet. Others include sea lilies, sea urchins, sea cucumbers, basket stars and brittle stars, and the recently discovered sea daisies. Ochre sea stars are very common in the intertidal and shallow waters of the northeastern Pacific Ocean. See 37 and 53.

30 Serpent star - Ophiuroidea - An echinoderm, serpent stars can climb and some are capable of coiling their arms vertically. They are predominantly carnivores and feed by capturing food and bringing it to the mouth by arm looping or by moving the mouth to the food. See 50.

31 Garibaldi - *Hypsypops rubicundus* - The official California state fish, Garibaldi occur in shallow warm waters. Adults are easily recognized by their uniformly reddish gold color, and reach a maximum length of about 12 inches. Young are reddish with iridescent blue spots.

32 Striped jack - *Caranx dentex* - Fast swimmers, striped jack eat smaller fishes, squids, and shrimps. Most species have rows of large heavy scales along the side near the tail fin, with small scales elsewhere, reducing drag and increasing swimming efficiency.

33 California sheepshead - *Semicossyphus pulcher* - This fish can reach a length of 3 feet and weight of 36 pounds, though most are much smaller. They range from Monterey Bay to the Gulf of California and are found most abundantly in kelp beds or along rocky shores.

34 Red sea urchin - *Strongylocentrotus franciscanus* - Urchins are echinoderms having a globular body, movable spines, radially arranged internal organs, and tube feet extending from pores arranged in bands extending from top to bottom over the skeleton. The mouth is on the underside of the body and teeth are extruded to scrape algae and other food from rocks. Sea urchins live on the ocean floor, usually on hard surfaces, and use the tube feet or spines to move about. This species lives in cool North Pacific waters near shore.

35 Sea lion - *Zalophus californianus* - Sea lions differ from seals in having external ears, a coat of short, coarse hair that lacks a distinct undercoat, and can rotate their hind flippers forward to use all four limbs in moving about on land. Sea lions eat mostly fish, squid, and octopus. Breeding in large herds, the males establish harems of 3 to 20 females. See 48 and 49.

36 Port Jackson shark - *Heterodontus portusjacksoni* - This is a relatively small Australian shark with teeth in both the upper and lower jaws—small and pointed in the front, but large and flat-surfaced in the back, allowing it to eat both soft and hard-shelled prey such as snails, oysters, sea urchins, and crustaceans.

37 Troschel's seastar - *Evasterias troscheli* - Seastars are in the class Asteroidea, having rays or arms surrounding an indistinct

disk. The 1,800 living species of starfishes occur in all oceans, although the North Pacific has the greatest variety. This species lives in rocky, shallow subtidal areas. See 29 and 53.

Open Ocean: Animals of the open waters have boundaries defined only by water temperature and salinity. Some species are fast-moving and wide ranging, making feeding or reproductive migrations over thousands of miles. Because nutrients are more abundant nearer shore, productivity is higher closer to continents than in the central regions. Thus, there are relatively fewer organisms of all kinds (especially phytoplankton, microscopic plants) in the center. This results in much clearer water.

38 Ocean sunfish - *Mola mola* - Molas grow very large, reaching to 10 feet in depth and weighing as much as 600 pounds. They eat jellyfish. The young swim with the body in a vertical position like other fishes, but adults spend most of their time on their sides, floating as though they were dead.

39 Atlantic manta - *Manta birostris* - The few species of mantas range in size from ocean giants of over 20 feet to species of only a few feet across the pectoral fins. The two flexible head protrusions, called cephalic fins, help direct small pelagic food organisms into the wide mouth. The Atlantic manta can have a wing span at least 22 feet and weigh well over 3,000 pounds.

40 Billfish - Family Xiphiidae - Billfishes live in the open ocean and can swim almost 70 miles per hour. Their most important identifying feature is the long upper jaw forming a bill, or spear, which may be used to stun prey as they speed through schools of fish.

41 Great white shark - *Carcharodon carcharias* - The white shark, or man-eater, roams all warm and temperate seas, but appears most abundantly in waters off Australia. They average 12 feet long, but can reach over 30 feet. They are so large and powerful that it is very difficult to study them. Great whites are credited with many attacks on humans, probably mistaking them for seals or sea lions. However, as a top predator, they are an essential part of marine ecosystems and should be protected.

42 Sperm whale - *Physeter macrocephalus* - Sperm whales occur in all seas, are the largest of the toothed whales, and can dive to depths below 6,600 feet. They have the largest brains that have ever existed on earth, but it is ratio of brain to body weight that is important in intelligence, not just brain weight. They eat squid and fish; battles with giant squid often result in clear sucker marks on the skin of the whale. See 70.

43 Yellowfin tuna - *Thunnus albacares* - Tunas are fast swimmers; this species can reach speeds over 40 miles per hour. They average 15 to 25 pounds weight, but can reach 300. The long pectoral fins, pelvic fins, and finlets are bright yellow, but the brightness fades soon after death.

44 Arrow worm - *Sagitta macrocephala* - These planktonic (drifting) animals are well-adapted pelagic predators, even though they are an inch long or shorter. They are streamlined, have transparent bodies, and possess heavy grasping spines or hooks near the mouth.

45 Blue shark - *Prionace glauca* - Named for their deep metallic blue color and living in the open ocean in subtropical and cool-temperate seas., blue sharks have very large pectoral fins that help provide lift to keep them from sinking. Often seen at the surface swimming slowly with the first dorsal fin and the tip of the tail out of water, their food is mostly fish.

Polar Waters: Some of the coldest marine waters, the Arctic and Antarctic regions are highly productive, especially in the spring and fall. Their biological diversity is lower than other regions, probably because many species cannot survive the extreme conditions. Those that are successful tend to be very abundant. Whales make feeding migrations into polar regions in the spring, and leave for warmer waters before winter.

46 Lion's mane jellyfish - *Cyanea capillata* - The largest jelly known, this species grows up to 8 feet wide and 1000 feet long, and has up to 12,000 stinging tentacles. When an animal comes in contact with these tentacles, it is stung and injected with a neurotoxin (nerve poison).

47 Icefish - Family Channichthyidae - Members of this Antarctic family have a kind of antifreeze that allows them to survive in the coldest water, even that below freezing. They have no hemoglobin (the oxygen-carrying blood pigment) but in the low temperatures at which they live, their blood carries enough dissolved oxygen for life.

48 Weddell seal - *Leptonychotes weddelli* - Seals survive extremely cold temperatures by having a thick layer of blubber which insulates them. True seals lack external ears and must drag their hind flippers. This Antarctic seal weighing 900 to 1,000 pounds, searches around sea ice for prey, usually fish and squid. Its main predator is the killer whale. See 35 and 49.

49 Ringed seal - *Phoca hispida* - Ringed seals usually live in ice-covered waters. They live on both seasonal and permanent ice, where they give birth in late winter or early spring. They can be found in all seas of the Arctic ocean and in some northern Finnish and Russian lakes. The world population is estimated at 5 million, with 1 to 1.5 million in Alaskan waters. There is no evidence that population levels are declining. See 35 and 48.

50 Serpent star - Class Ophiuroidea - Serpent stars occur in warm, cold, deep, and shallow waters. Like most echinoderms, they cannot tolerate marked changes in salinity, temperature, or light intensity. They use their spines and tube feet in locomotion, may move forward with any part of the body and reverse direction without turning around. See 30.

51 Antarctic cod - Family Nototheniidae - The Antarctic cods are a large, diverse family, dominating the Antarctic fish fauna. Most are bottom dwellers feeding on invertebrates and occasionally algae; some live associated with sea ice, but others live in midwater. They are a very important food for most penguins, seals and cetaceans.

52 Arctic sea spider - Class Pycnogonida - Related to spiders but not one, the Arctic sea spider lives in very cold waters. They walk on the ocean bottom on slender legs, or crawl among plants and animals; some may tread water. They have a very small body; the internal organs extend out into the legs.

53 Bat Star - *Patiria miniata*- Starfish can digest food outside of the body by extruding their stomach around prey. They move by walking with their tube feet. See 29 and 37.

54 Long tentacle comb jelly - Phylum Ctenophora - Transparent, gelatinous planktonic animals, ctenophores have cells which, instead of stinging, have a sticky tentacle to which food particles adhere to be drawn into the mouth.

55 Antarctic octopus - Class Cephalopoda - The cephalopods are a small group of highly advanced, exclusively salt water molluscs, to which octopus, squid, cuttlefish, and chambered nautilus belong. Extinct forms outnumber the living, the class having attained great diversity in late Paleozoic and Mesozoic times. The best-known cephalopod features are the possession of arms and tentacles, eight (octopus) or ten (squid) in most forms, and the use of ink for protection.

56 Gurney's sea pen - *Ptilosarcus gurneyi* - Sea pens are colonial coelenterates that stick up from the mud like a feather, feeding by filtering water through the branches. When threatened, they pull themselves down into the mud. When disturbed they may also display startling flashes of brilliant orange bioluminescence.

Deep Sea: The deep sea is cold, dark, and relatively deserted. Because there is no sunlight, food comes from the surface waters where plants can live; below the photic (lighted) zone, there are no plants. The animals are all predators; they have evolved many bizarre and unique structures and behaviors to survive. The discovery 20 years ago of communities of specialized animals and bacteria living around hydrothermal (hot water) vents in volcanically active areas provides the best-known example of organisms that do not depend upon energy derived from sunlight for life.

57 Sablefish - *Anoplopoma fimbria* - Living in cold North Pacific waters at moderate to great depths near the bottom, sablefish are a valuable commercially-fished species, caught by trawling, trapping, or bottom-fishing with baited longlines. They reach a length of three feet and average 20 pounds in weight.

58 Gulper eel - *Saccopharynx harrisoni* - This truly deep-sea fish has a huge mouth and sharp teeth. It can swallow animals at least as large as itself. Despite its capacity for food, it is very fragile, with small, weak bones. It reaches a length of at least four feet and has a whip-like tail with a light at the tip. It is collected very rarely.

59 Deep sea squid - *Heteroteuthis dispar* - This three-inch long deep sea squid is one of just a few animals (in addition to some shrimp and fish) that can expel a bioluminescent ink to confuse predators.

60 Vampire squid - *Vampyroteuthis infernalis* - Neither a squid nor an octopus, this deep-water species has ten arms like a squid. Instead of having two long prey-catching arms, two of its arms are sensory filaments that withdraw into pockets. Vampire squid have large globular eyes an inch across and, unlike octopods, many luminescent organs on the body.

61 Oarfish - *Regalecus glesne* - The only representative of this family, the oarfish has pelvic fins reduced to one ray but extremely long and often expanded to a paddle tip, thus its common name. It is a huge fish, reaching a length of at least 35 feet. The body is silver, with a bright red dorsal fin and very small tail fin.

62 Viperfish - *Chauliodus sloani* - A remarkable fish, *Chauliodus* has teeth so long that it must open its mouth to make the jaws vertical before it can swallow prey; when the mouth is closed, the teeth overlap the jaws. It can eat large prey by lowering the internal skeleton of the gills, allowing prey to pass into the throat without interference. Apparently it impales prey on the teeth by swimming at them, and the first vertebra (right behind the head) acts as a shock absorber! It has unusual scales that are large, thin, and hexagonal.

63 Deepsea dragonfish - *Grammatostomias flagellibarba* - A ferocious deep-sea predator, this fish is only six inches long; it has a large head and mouth armed with many sharp teeth. Dragonfishes have a long barbel, attached to the chin, with a luminous lure at the end that attracts prey.

64 Rift clam - *Calyptogena magnifica* - This deep-water clam lives around hydrothermal vents, feeding on sulphur bacteria. Its shell is white and the animal inside is a deep red. This fast-growing, large clam measures almost a foot in length. It lives in a methane-rich environment that would normally be poisonous.

65 Deep sea tube worms - *Riftia pachyptila* - These four to six foot "worms" have no mouth and no gut, and live around deep-sea hydrothermal vents. Blood-red feathery plumes (tentacle groups), where digestion occurs, emerge from white tubes. *Riftia* is so different that it has been placed in a new and distinct phylum: the Vestimentifera.

66 Vent crab - *Cyanograea praedator* - Vent crabs are one of the characteristic animals associated with hydrothermal vents. They are completely white, and occur in high abundance in small areas.

67 Tube anemone - Class Anthozoa (Phylum Cnidaria) - Tube anemones are similar in basic features to other anemones but unlike them, each lives in a slime tube. They are widely distributed in tropical and subtropical waters where the ocean bottom is sand, mud, or silt. See 2, 6, 7, 8, 9, and 28.

68 Tube sponges - Sponges have a porous skeleton of interlocking spicules (bony, needle-like structures), glasslike rods, or horny fibers; they live in colonies or as solitary animals attached to the sea bottom or to other solid objects. Food is obtained by filtering water as it moves through the body of the sponge; organ systems are poorly developed and a nervous system is absent. Sponges can regenerate by restoration of damaged or lost parts or by complete regeneration of an adult from fragments or even single cells. See 3, 26, and 27.

69 Giant deep sea angler - *Ceratias holboelli* - Called an angler because its front dorsal fin ray is modified into a luminescent lure at the tip, this fishreaches about three feet in length. Males attach themselves to a female fish and grow to be a permanent part of her, losing their mouths, digestive systems, and gills.

70 Giant squid - *Architeuthis princeps* - Cephalopods are the largest invertebrates. One giant squid was reported to have been almost 60 feet long, including the 20-foot tentacles. *Architeuthis* swims in the same way as other squids, whether by jet propulsion or by using the fins. This squid may inhabit depths of 300 to 600 meters, and is a favored prey of sperm whales. See 42.

71 Ratfish - *Chimaera phantasma* - Ratfishes appear to be a link between cartilaginous and bony fishes, but in reality they are not. Most chimaeras have bodies that taper toward the rear to a slender tail. The snout is rounded and conical with big eyes located on the sides of the head, and there is only a single gill opening. Ratfishes have teeth fused into large, sharp incisors at the front, giving them the appearance of rodents.

72 Japanese spider crab - *Macrocheira kaempferi* - Probably the biggest living arthropod; this crab lives in the North Pacific near Japan at depths of 150 to 1,000 feet. Reaching over 12 feet from leg tip to leg tip, and weighing as much as 40 pounds, its body is only about 15 inches in diameter.

73 Deep sea jelly - *Periphylla* sp. - The deep bell-shaped body lined by dark pigment probably masks light from the bioluminescent animals it eats. Jellyfish move by rhythmic muscular contractions of the bell, providing a slow jet propulsion. Hanging downward from the center is a stalk-like structure with the mouth at its tip, opening into the main body cavity . Unlike some other jellyfish, *Periphylla* has very short tentacles.

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•To access the commercial Year of the Ocean Homepage:
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Other homepages of interest to Teachers:

•NOAA Library:
www.lib.noaa.gov/docs/windandsea.html

•National Oceanographic Data Center:
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•National Climatic Data Center:
www.ncdc.noaa.gov

•National Geophysical Data Center:
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•Adopt the Coast Action Kit:
www.nos.noaa/gov/ocrm/pcdoutreach.html#anchor45144

•Teacher at Sea Program:
www.tas.noaa.gov

•National Data Buoy Center Adopt a Buoy Education:
www.ndbc.noaa.gov

•National Hurricane Center:
www.hurricanehunters.com/welcome.htm

•El Nino Homepage:
www.elnino.noaa.gov

•Weather Education:
www.nws.noaa.gov/om/edures.htm
www.bristol.wbox.noaa.gov/education.html
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•Endangered & Threatened Marine Mammals:
http://kingfish.ssp.nmfs/gov/tmcintyr/prot_res.html

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This Educator's Guide was developed with assistance from The National Aquarium, the New York Sea Grant Program, the Mid-Atlantic Marine Educators Association, NOAA's Office of Oceanic and Atmospheric Research, and NOAA's National Marine Fisheries Service