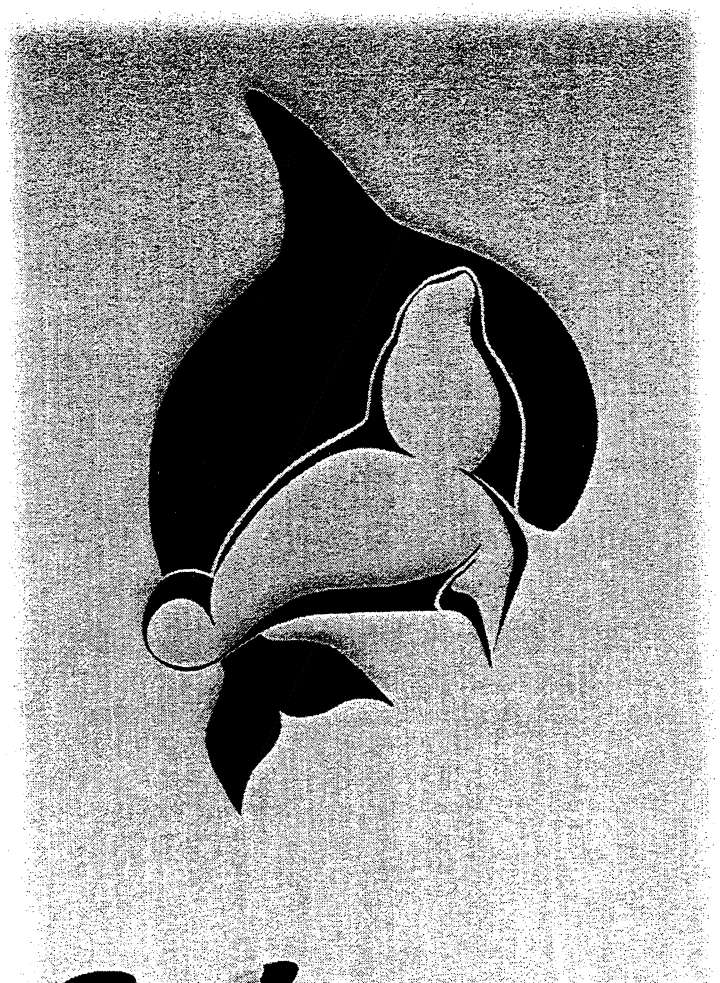


Science Resource Guide

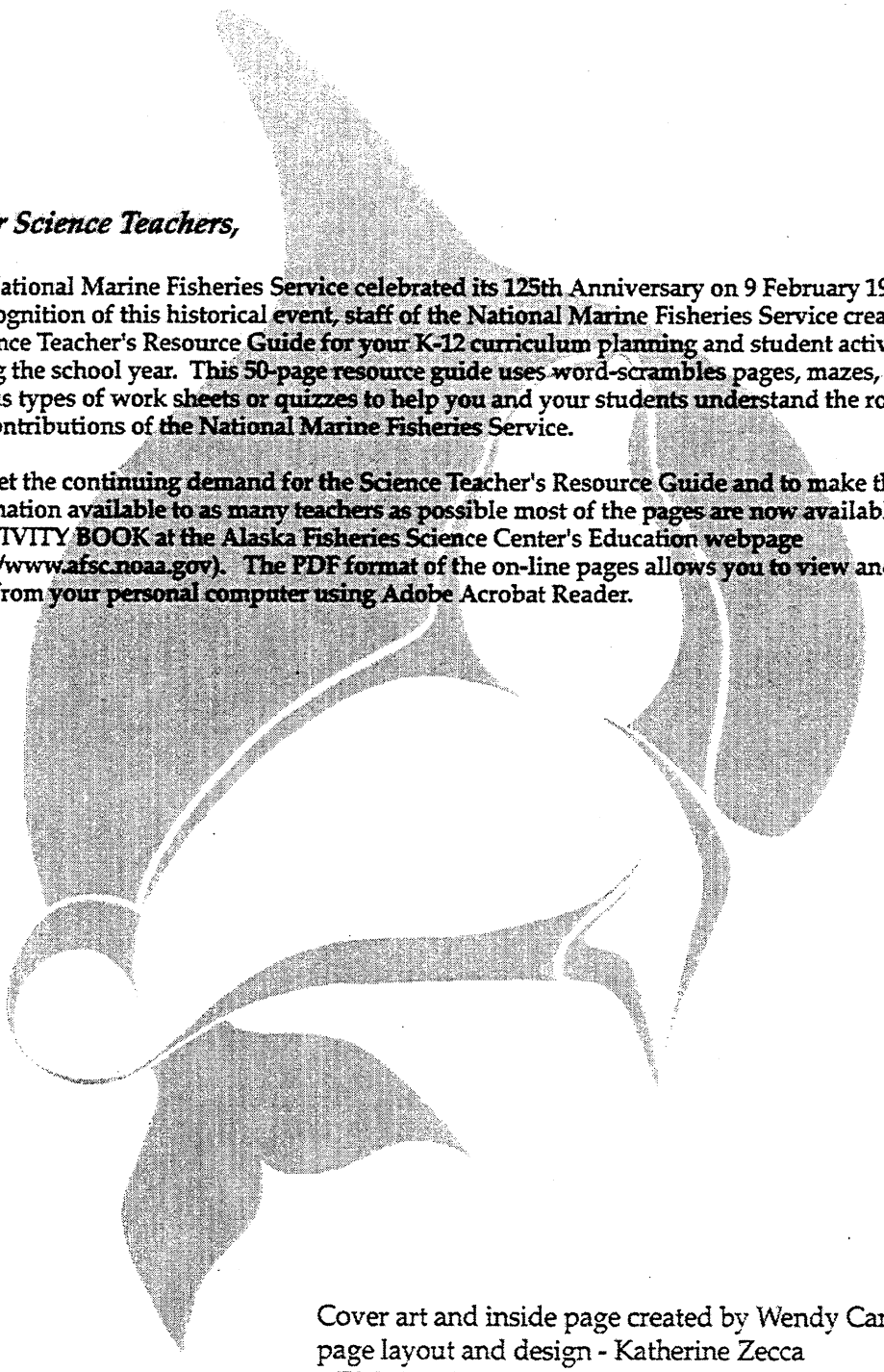
K-12 activity and curriculum guide
Developed for the National Marine Fisheries Service 125th Anniversary
Alaska Fisheries Science Center

National Oceanic Atmospheric Adminstration

Dear Science Teachers,

The National Marine Fisheries Service celebrated its 125th Anniversary on 9 February 1996. In recognition of this historical event, staff of the National Marine Fisheries Service created a Science Teacher's Resource Guide for your K-12 curriculum planning and student activities during the school year. This 50-page resource guide uses word-scrambles pages, mazes, and various types of work sheets or quizzes to help you and your students understand the role and contributions of the National Marine Fisheries Service.

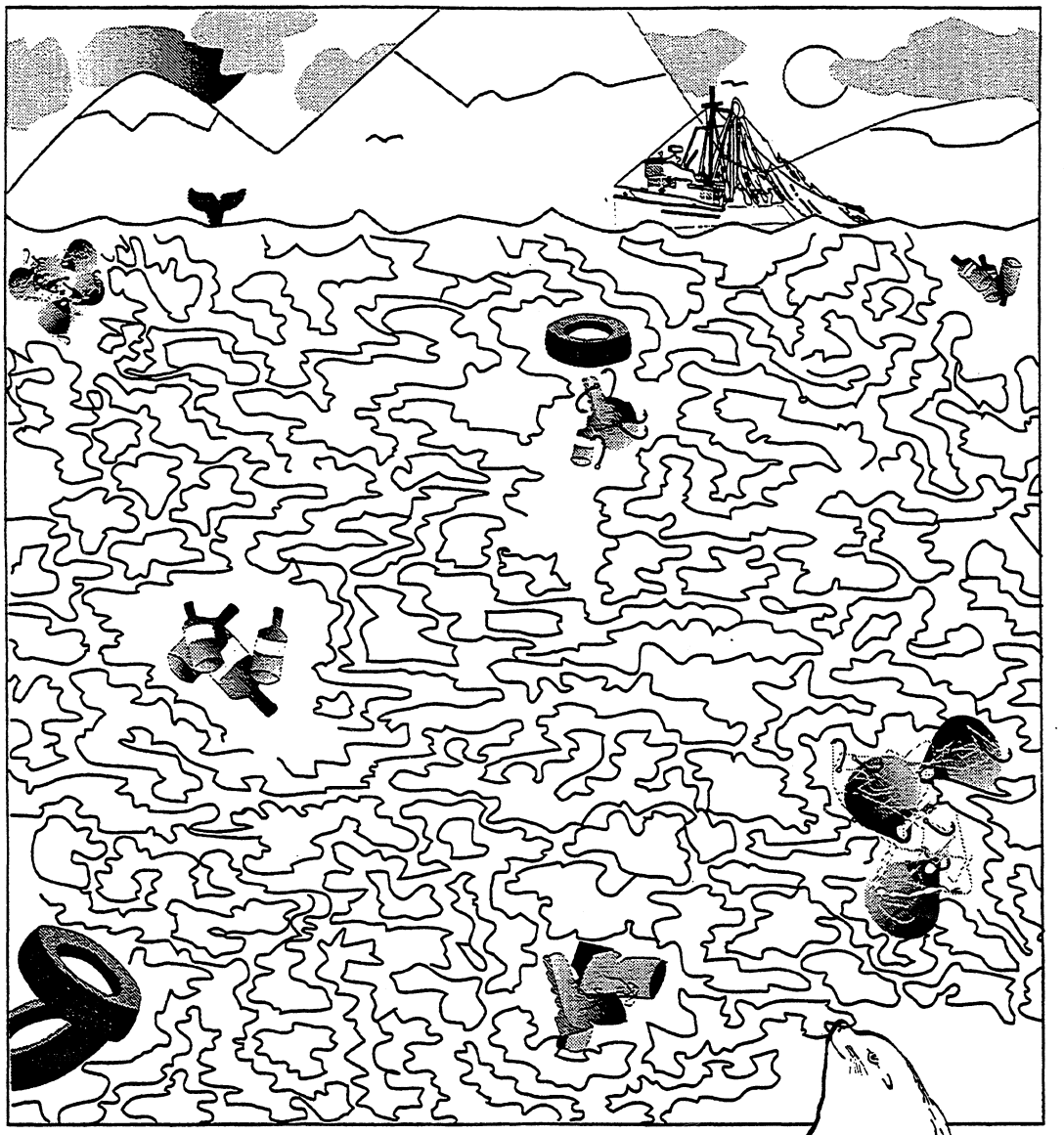
To meet the continuing demand for the Science Teacher's Resource Guide and to make this information available to as many teachers as possible most of the pages are now available as a ACTIVITY BOOK at the Alaska Fisheries Science Center's Education webpage (http://www.afsc.noaa.gov). The PDF format of the on-line pages allows you to view and print from your personal computer using Adobe Acrobat Reader.



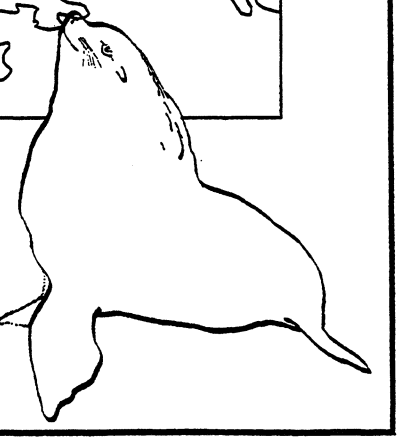
Cover art and inside page created by Wendy Carlson
page layout and design - Katherine Zecca
AFSC Graphics Unit, Seattle Washington

Name _____

NMFS encourages everyone to reduce trash in the oceans and waterways. Please remember, stow your trash until you can dispose of it properly.



Help Sammy the Sea Lion reach the open clean seas, and while you are at it please help pick up the garbage.



Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

Marine Trivia

1. The teeth of sharks are actually modified
(a) bones (b) fins (c) scales? _____

2. What corporate symbol was chosen because the company founder was a shell collector? _____

3. What capitol of an island country in the South Atlantic has a grouper named after it **(a) Dublin (b) Havana (c) Nassau?** _____

4. Sharks lack which of the following:
(a) fins (b) bones (c) gills _____

5. The fish used in England's famous "fish and chips" is
(a) dogfish shark (b) blue marlin (c) haddock? _____

6. The most valuable product per pound harvested by Gulf of Mexico fishermen is **(a) wool sponge (b) pompano (c) spiny lobster?** _____

7. Does the statement "he drinks like a fish" have any basis in nature; ie: do fish need to drink water **(a) yes (b) no (c) yes and no?** _____

8. What crab, by law, must be returned to the water alive after its claws are removed by fishermen **(a) blue crab (b) stone crab (c) fiddler crab?**
_____

9. The prime cause of fatal food poisoning in Japan is from consumption of
(a) pesticide laden water (b) fugu (puffer fish) (c) bad saki? _____

10. Scallops can **(a) swim (b) molt (c) change color?** _____

11. Scallops are often made from skate wings. **True or False?**

Southeast Regional Center
St. Petersburg, Florida 9/96

Name _____

Marine Trivia

12. Sea turtle is a gourmet item in American seafood restaurants. **True or False?**

13. Eels are marine reptiles. **True or False?**

14. Do fish sleep? **True or False?**

15. Red tide toxins sometimes contaminate filter-feeding mollusks such as _____, _____, and _____?

16. Red tide contaminated clams, mussels, and oysters become safe to eat when cooked. **True or False?**

17. A mechanical device which allows marine turtles to escape from shrimp nets is called a **(a) FED (b) TED (c) NED ?**

18. The fish most frequently caught by anglers in the Gulf of Mexico is **(a) redfish (b) speckled trout (c) croaker?**

19. A famous Key West breakfast is
(a) grits and grunts (b) tarpon and taters (c) mullet and margaritas?

20. A fish that has an edible gizzard is **(a) swordfish (b) flounder (c) mullet?** _____

21. How many "arms" does a squid have?_____

22. How many "arms" does an octopus have? _____

Name _____

Marine Trivia

23. What group of people that subsist on a diet high in fish was studied for 25 years and was found to be among the healthiest on earth **(a) Amazon Indians (b) Greenland Eskimos(c) African pygmies?**

_____

24. Studies indicate that a diet which includes seafood containing omega- 3 may
(a) prevent scurvy (b) counteract heart disease (c) cause infertility? _____

25. A good source of omega-3 is
(a) sardines (b) tuna (c) salmon (d) all three ? _____

26. Rock shrimp boil to doneness in **(a) 1/3 the time as regular shrimp (b) the same time as regular shrimp (c) twice the time as regular shrimp?**

_____

27. Canned fish such as sardines, mackerel, or salmon is a good source of **(a) iron (b) potassium (c) calcium ?** _____

28. In dockside value, our most valuable domestic fishery is
(a) shrimp (b) tuna (c) sea urchin?

29. The state bird of Utah is the
(a) robin (b) quail (c) sea gull?

30. Which three states have the longest shorelines (list in order)? _____

Name _____

Water World

Water is the most common substance on Earth.
It covers more than 70% of the Earth's surface.
Water is everywhere, but how much do you know about water?
Test your knowledge by trying to answer the following questions.

Multiple Choice

1. Most of the water on Earth is salt water; what percentage of the Earth's water is fresh? **a) 3%, b) 5%, c) 7%.** _____

2. Which continent has the most fresh water?
a) Asia, b) Antarctica, d) North America.

3. What is the name of the waterfall between Lake Erie and Lake Ontario?
a) Victoria Falls , b) Iquazu, c) Niagara Falls, d) Bridal Veil Falls. _____

4. In what state is the source of the Mississippi River?
a) Wisconsin, b) Mississippi, c) Minnesota, d) Louisiana. _____

5. The Welland Canal connects what two lakes?
a) Ontario and Erie, b) Superior and Michigan, c) Huron and Ontario, d) Erie and Huron. _____

6. The Mariana Trench, the deepest spot in all the oceans, is
a) 26,578, b) 42113, c) c) 36,198, d) 37,689 feet deep. _____

7. A tributary of the Missouri River is the only river longer than 600 miles in the contiguous United States that remains undammed or undiverted. What is the river?
a) Snake River, b) Yellowstone River, c) Salmon River, d) Little Bighorn. _____

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Graphics Unit

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Water World

8. Which U.S. state is the only one that borders the St. Lawrence River?
a) New York, b) Pennsylvania, c) Ohio, d) Vermont? _____

9. The mouth of the Irrawaddy, in Southeast Asia, forms one of the largest river deltas in Asia. In what country is the delta?
a) Vietnam, b) Thailand, c) Burma (Myanmar), d) Laos. _____

10. What is the longest river on Earth?
a) Amazon River, b) Yangtze River, c) Mississippi River, d) Nile River _____

11. What is the longest river in the United States?
a) Columbia River, b) Mississippi River, or c) Missouri River. _____

12. What is the largest northward flowing river in the United States?
a) Red River, b) Sacramento River, or c) St. Johns River _____

13. What is the largest freshwater lake (based on surface area) on Earth? **a) Lake Victoria, b) Lake Tanganyika, or, c) Lake Superior.** _____

14. What is the deepest freshwater lake on Earth?
a) Lake Tanganyika, b) Crater Lake, or c) Lake Baikal. _____

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Fisheries Service
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Alaska Fisheries Science Center 6/96
Graphics Unit

Name _____

Water World

Fill in the blank

15. Name the Great Lakes (from largest to smallest).

_____

16. Only one of the five Great Lakes does not border Canada. Name the lake. _____

17. The Mississippi River flows through Louisiana before it empties into what large body of water? _____

18. Which continent is mostly desert? _____

19. What U.S. state is surrounded by an ocean? _____

20. What river flows through the Grand Canyon in Arizona?

_____

21. The Allegheny River and Monongahela River converge in Pittsburg to form what river? _____

22. What sea borders Saudi Arabia on the west? _____

23. There are four oceans on Earth. Name them. _____

_____

24. Which five U.S. states touch the Pacific Ocean? _____

_____

25. What ocean lies west of Australia? _____

26. Which two oceans are connected by the Strait of Magellan?

_____

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Graphics Unit

Name _____

Water World

Fill in the blank

27. Which U.S. state borders on four of the five Great Lakes?

_____

28. The Orinoco River forms a natural boundary between Colombia and which other country? _____

29. Which one of the Great Lakes has the highest elevation above sea level? _____

30. Pierre, the capital of South Dakota, is located on the banks of which major river? _____

31. The Churchill, Peace, and Slave Rivers are in what country?

_____

32. Name the deepest (at 1,962 feet) lake in the United States.

_____

33. The Snake, Willamette, and Yakima Rivers are tributaries of which major U.S. river? _____

34. Big Bend National Park, in Texas, takes its name from a meander in a river that serves as an international boundary. Name this river. _____

35. The Gulfs of Finland, Bothnia, and Riga are part of what sea?

_____

36. Which five U.S states border on the Gulf of Mexico.

_____

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Name _____

Water World

True or False

37. Angel Falls in Venezuela is the highest waterfall in South America. _____

38. The Suez Canal connects the Red Sea and the Mediterranean Sea. _____

39. The delta of the Mississippi River is in Texas. _____

40. The Bering Sea borders the United States. _____

41. The Silver Strand waterfall in California is the highest waterfall in the United States. _____

42. The Mackenzie River is the longest river in Canada.

43. If all the polar ice caps were to melt, the sea level of all oceans would rise about 200 feet. _____

44. The Pacific Ocean is twice the size (based on surface area) of the Atlantic Ocean. _____

45. The average depth (14,000 feet) of the Atlantic and Pacific Oceans are the same. _____

46. The Atlantic Ocean is the deepest ocean on Earth. _____

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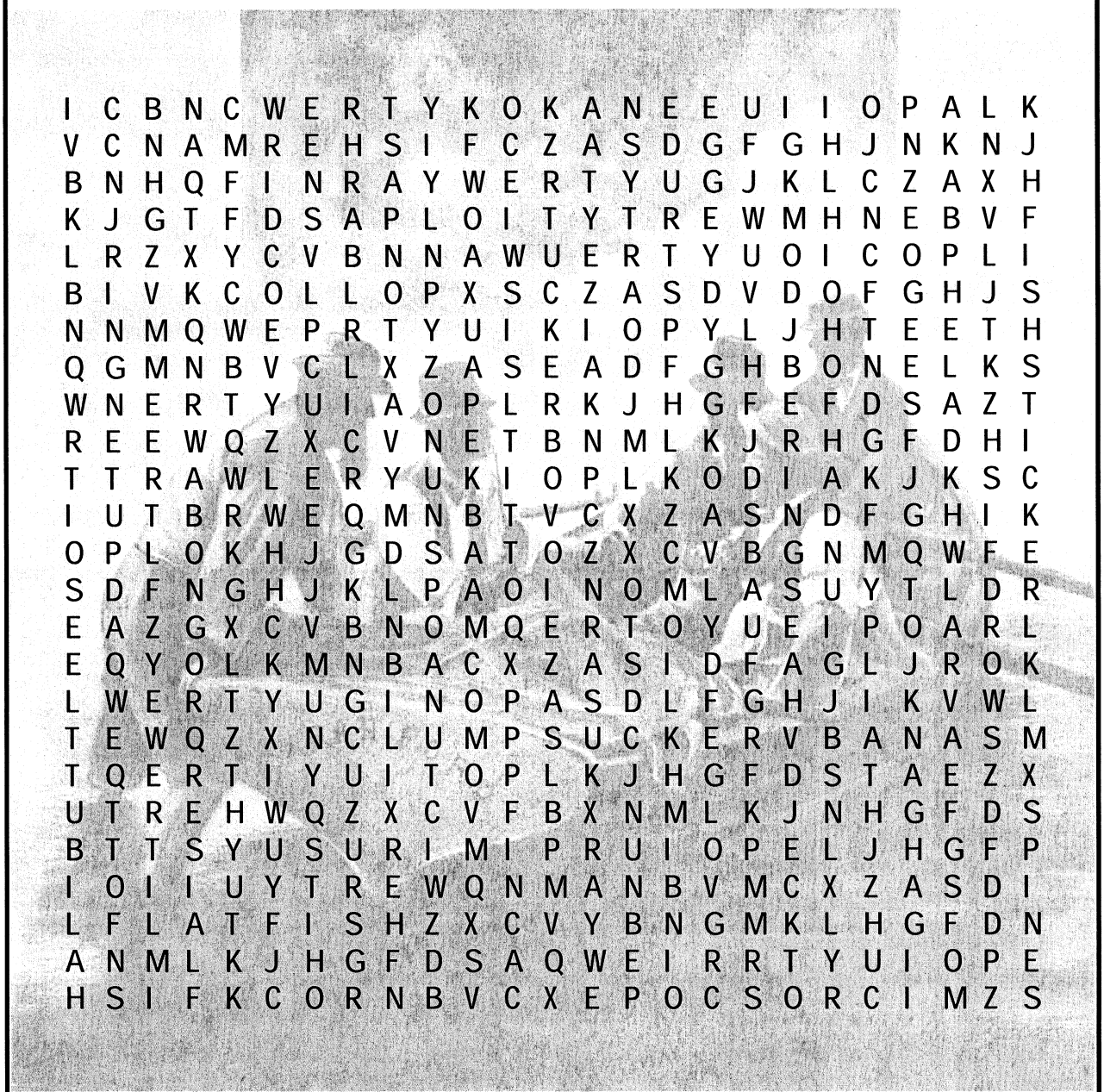
Fish Word Search



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V	C	N	A	M	R	E	H	S	I	F	C	Z	A	S	D	G	F	G	H	J	N	K	N	J
B	N	H	Q	F	I	N	R	A	Y	W	E	R	T	Y	U	G	J	K	L	C	Z	A	X	H
K	J	G	T	F	D	S	A	P	L	O	I	T	Y	T	R	E	W	M	H	N	E	B	V	F
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N	N	M	Q	W	E	P	R	T	Y	U	I	K	I	O	P	Y	L	J	H	T	E	E	T	H
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I	O	I	I	U	Y	T	R	E	W	Q	N	M	A	N	B	V	M	C	X	Z	A	S	D	I
L	F	L	A	T	F	I	S	H	Z	X	C	V	Y	B	N	G	M	K	L	H	G	F	D	N
A	N	M	L	K	J	H	G	F	D	S	A	Q	W	E	I	R	R	T	Y	U	I	O	P	E
H	S	I	F	K	C	O	R	N	B	V	C	X	E	P	O	C	S	O	R	C	I	M	Z	S

egg	salmon	bone	teeth	rockfish	anchovy	alaska	flatfish
larvae	bongo	finray	kodiak	lumpsucker	ringnet	bering sea	tucker
fish	net	pigment	tail	eel	fishing boat	plankton	ocean
pollock	yolk	surimi	trawler	tuna	spines	ichthyoplankton	fisherman
microscope	oil	fishstick	fin	kokanee	teeth	halibut	xray

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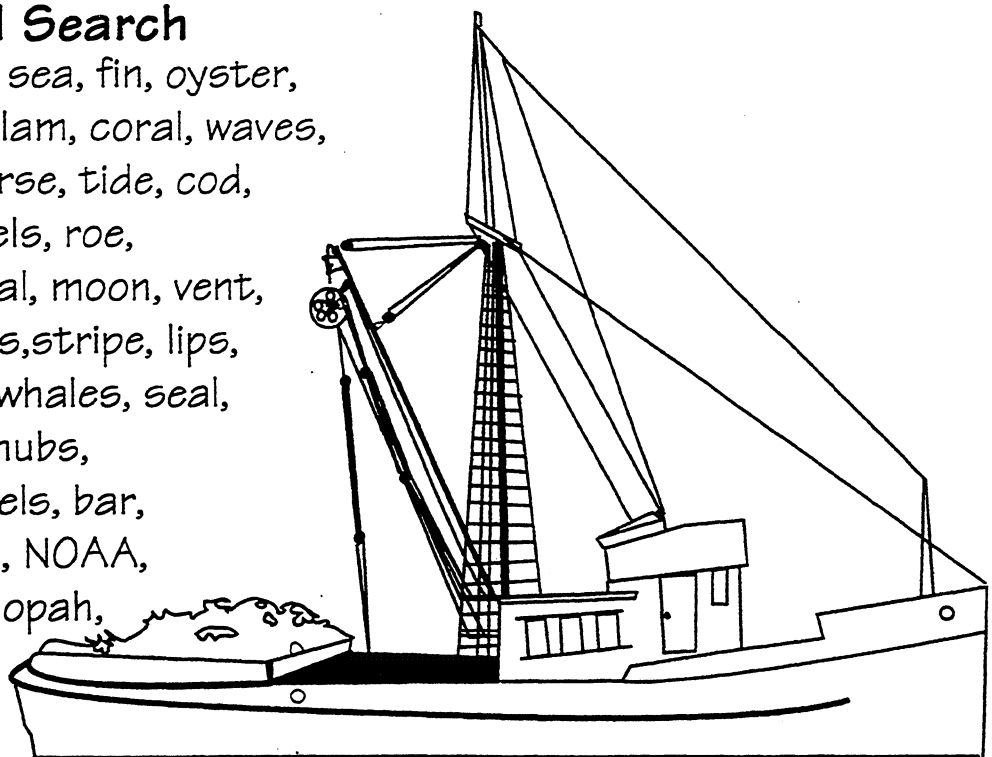
Name _____

Word Search

otter, sea, fin, oyster,
gills, clam, coral, waves,
seahorse, tide, cod,
tail, eels, roe,
abyssal, moon, vent,
barbels,stripe, lips,
toad, whales, seal,
net, chubs,
kelp, eels, bar,
NMFS, NOAA,
drum, opah,
oars,
boat.



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L	S	T	F	E	E	X	S	I	A	N	L	I
T	I	D	E	I	E	T	E	P	R	R	P	P
C	H	U	B	S	N	V	A	S	Y	C	O	E
M	O	O	N	S	U	C	K	E	R	S	I	C
C	O	D	D	R	U	M	O	Y	S	T	E	R
B	A	R	B	E	L	S	I	N	O	A	A	N
O	R	O	T	T	E	R	H	D	P	E	Y	M
A	S	E	M	O	E	R	S	I	A	M	S	F
T	L	W	H	A	L	E	S	U	H	A	I	S
C	L	A	M	D	S	E	A	H	O	R	S	E

Alaska Fisheries Science Center
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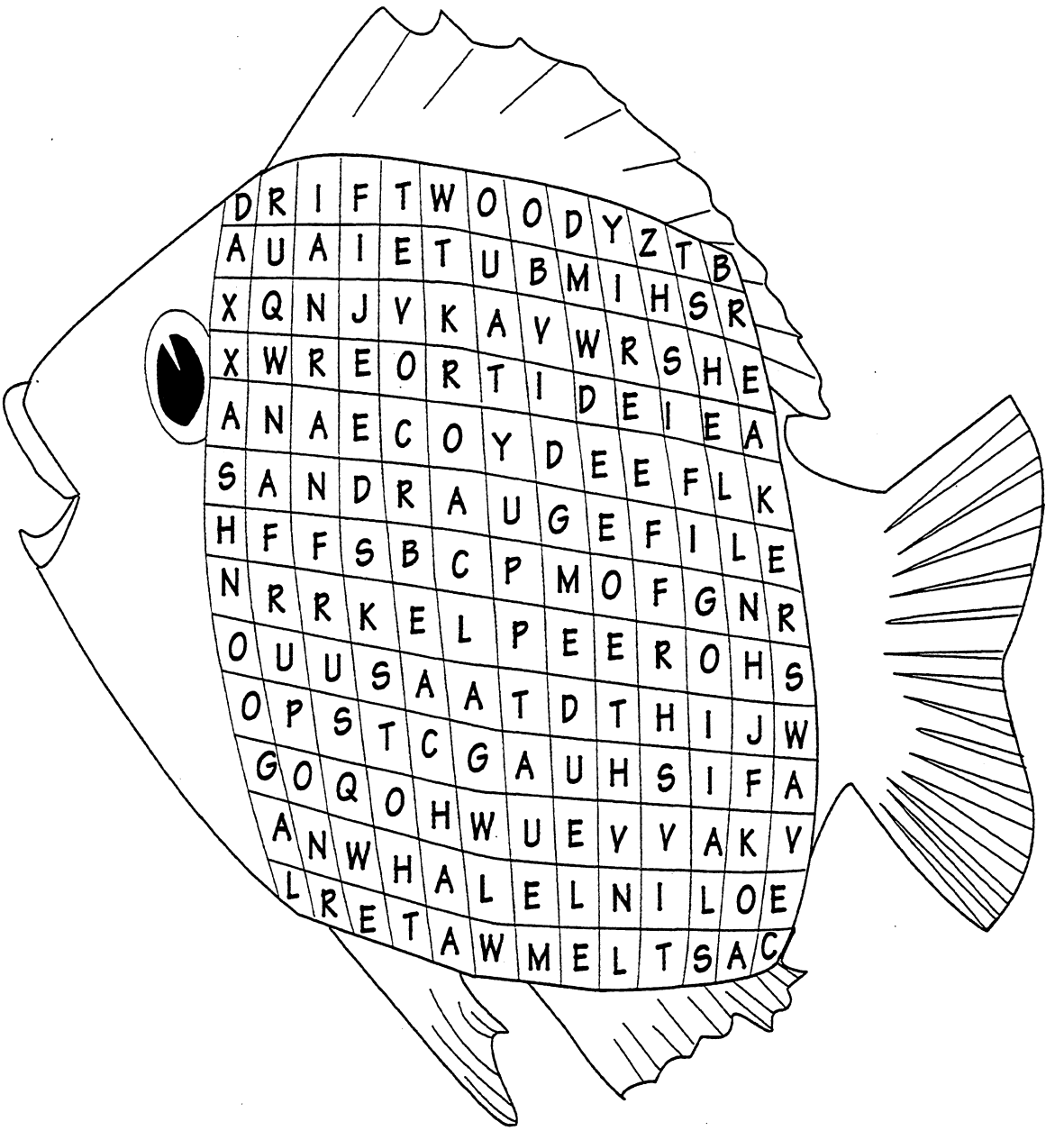
Name _____

Word Search

bay, beach, breakers, cape,
castle, cove, driftwood, dune,
fish, gull, lagoon, lifeguard, sea,
whale, kelp, ocean, reef, sand,
shell, shore, sun, surf, tide,
wade, water, wave



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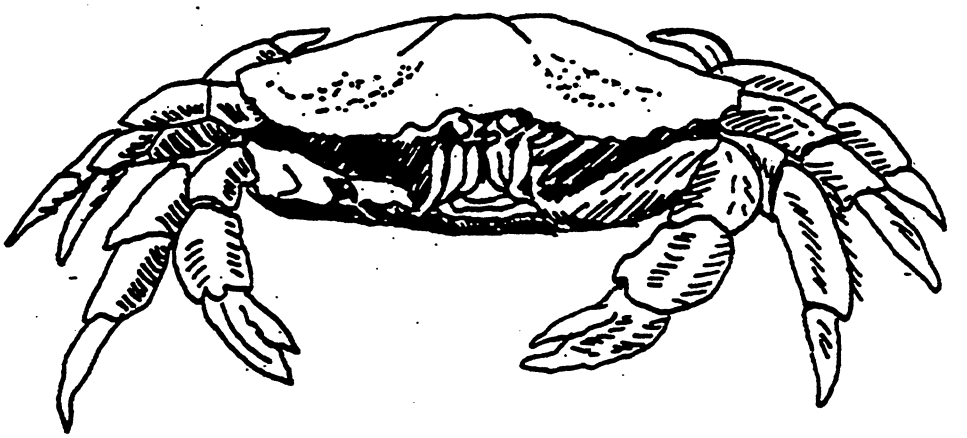
Name _____

Crab

A crab has a hard outside shell.
Its shell protects its soft body.

A crab has legs with joints.
It has strong claws.

Some crabs can run fast.
Some crabs are good to eat.



Circle the words that are true about crabs.

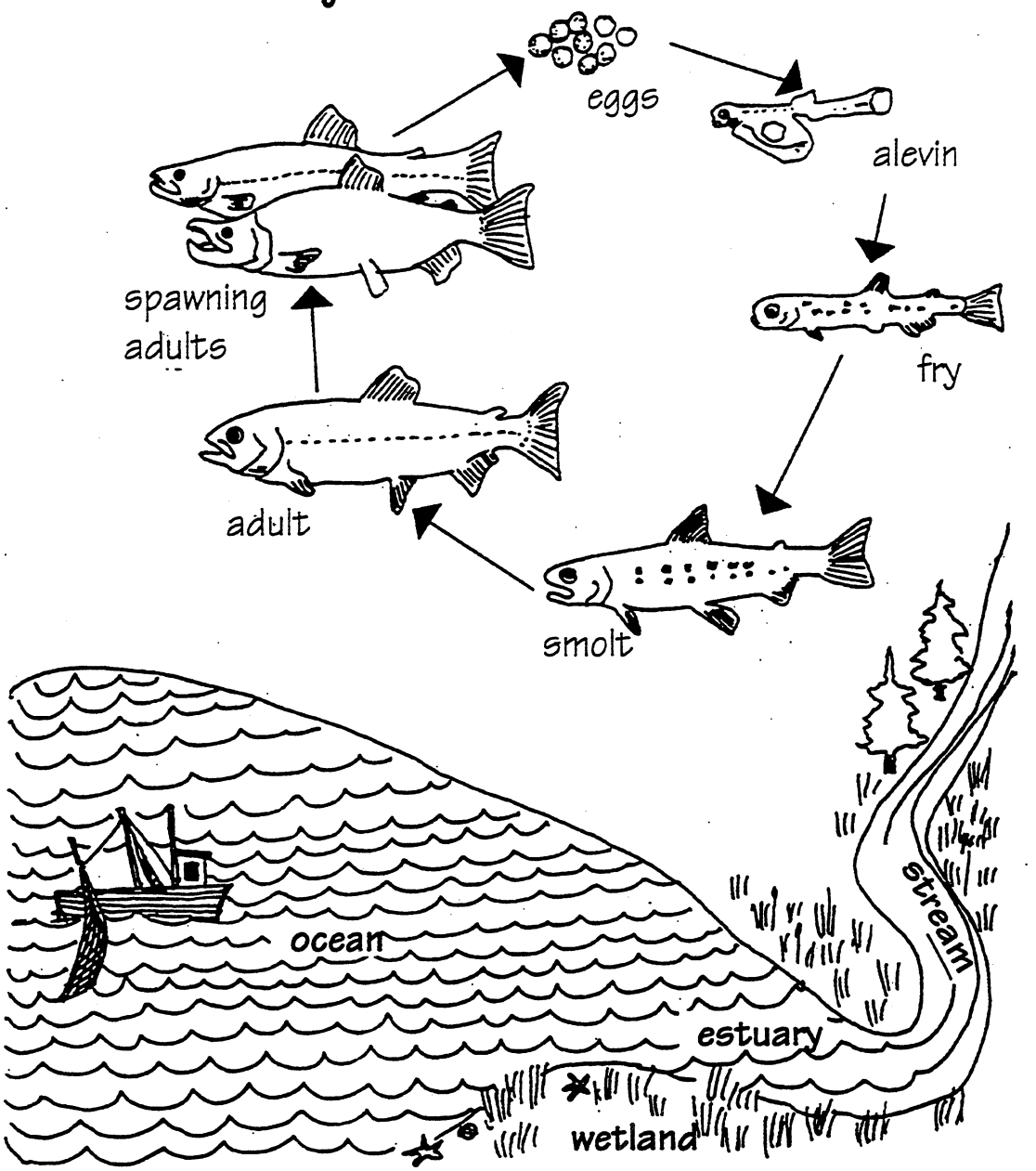
hard shell	soft body
legs with joints	good to eat
inside shell	all taste awful
outside shell	hard body
legs without joints	can run fast
strong claws	has five toes

Adapted from Alaska Sea Grant Program

Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

Salmon Life Cycle



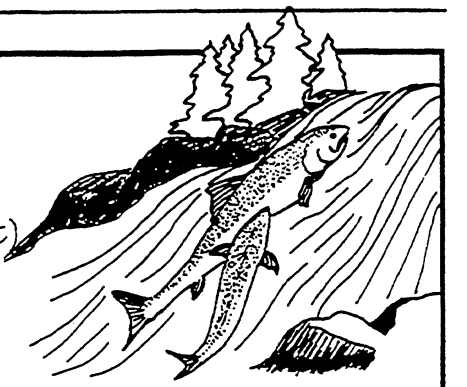
Color, cut and paste.
Place the alevin, smolt, fry and eggs in the stream.
Put the adult in the ocean.
Place the spawning adults in the estuary.

Adapted from the Alaska Sea Grant Progam

Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

Only the Strong Survive



(Adapted from the Alaska State Museum's Salmon Kit)

Use the numbers below to find out how many salmon are left. Use this page for your work.

1. A salmon deposited **5,000** eggs in a redd. _____
2. Five hundred (**500**) eggs were not fertilized. _____
3. Sixty (**60**) were washed out of the gravel when a 3-wheeler crossed the stream. _____
4. Mud from building a new subdivision eroded into the stream and suffocated one thousand (**1,000**). _____
5. Three hundred (**300**) alevins died because they were very weak. _____
6. After the alevins developed into fry, five hundred (**500**) were eaten by other fish in the stream. _____
7. Forty-one (**41**) were eaten by birds. _____
8. As they neared the ocean, (**260**) smolts were caught in a pool where they got too hot and died because of thermal pollution from a coal-fired power plant. _____
9. In the ocean, **1,500** were eaten by bigger fish. _____
10. Seals ate **95.** _____
11. Fisherman caught **556.** _____
12. As the salmon returned to their spawning stream, bears ate **180** of them. _____
13. Three (**3**) were dashed against the rocks trying to jump the waterfall. _____
14. The rest of the salmon spawned. _____
15. HOW MANY SALMON WERE LEFT TO SPAWN? _____

Adapted from Alaska Sea Grant Program

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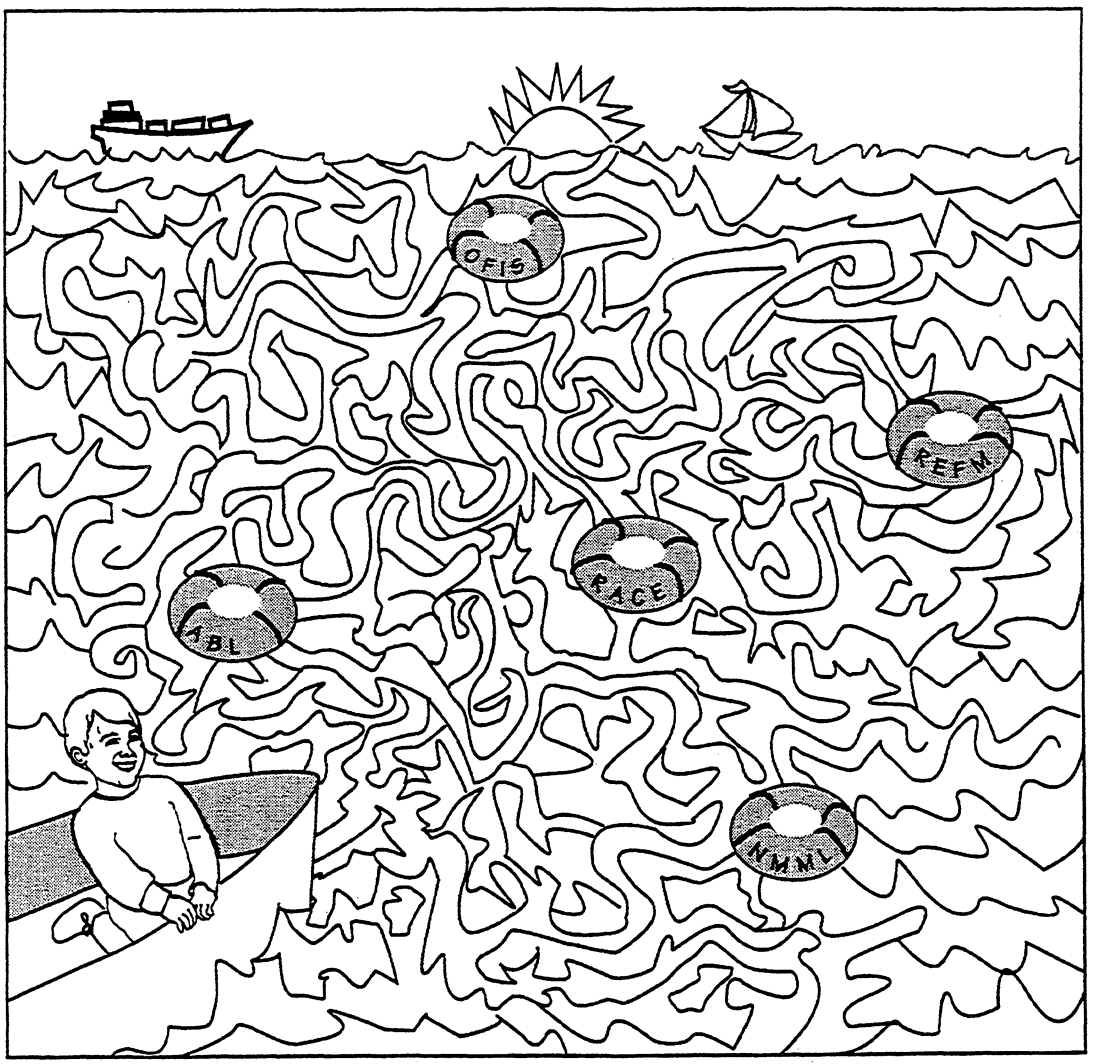
Name _____

Alaska Fisheries Science Center

We are working for you and a better way of life!



Help Joel collect each life saver as he sails out to open sea!

Did you know ?

ABL - scientists study the life histories of all five Pacific salmon species found in Alaska.

NMML - is the principal United States laboratory responsible for research on marine mammals in the Antarctic, Arctic, Bering Sea, Gulf of Alaska and California ecosystems.

RACE - scientists use bottom trawls, longlines, crabpots, and manned submersibles to study the behavior and abundance of fish and crabs.

REFM - scientists train observers to be placed aboard fishing vessels.

OFIS - maintains over 40 billion bytes of information in a database on all Alaska Fisheries Science Center research projects.

* Note: a glossary of names, titles can be found within this packet.

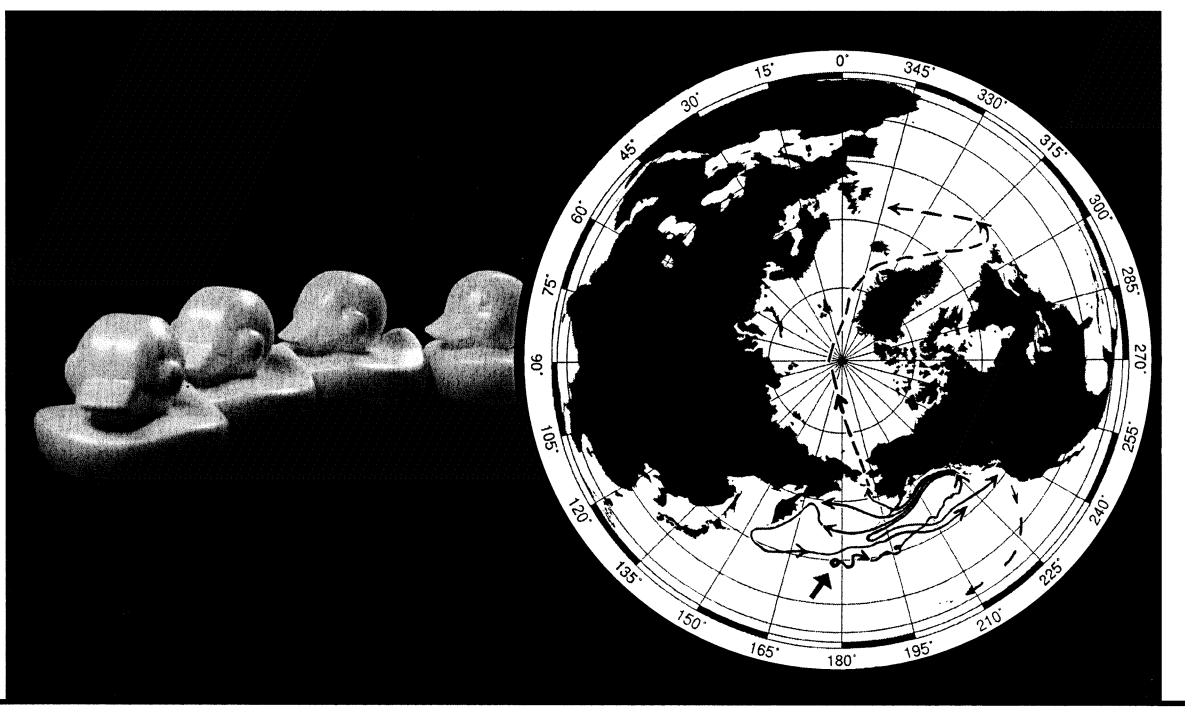
Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

The Quack Heard "Round the World"

29,000 plastic bath tub toys are now afloat on the Pacific Ocean. The yellow ducks (pictured below) are the most famous. The toys were headed from China to Tacoma, Washington, aboard a container ship when it was caught in a fierce storm in the mid-North Pacific Ocean (see arrows on map). In the storm, 12 containers went overboard (one with toys) on January 10, 1992. After the container burst open, the toys were free to drift with the wind-driven ocean currents.

At the Alaska Fisheries Science Center, we map ocean surface currents using an Ocean Surface Current Simulations model called OSCURS to study the effects of current changes on fish populations. OSCURS normally uses special drifters which are tracked by satellites to map ocean currents -- the toys were natural drifters! The ducks provided us with a great chance to see how good the OSCURS model would be at guessing where and when the toys would reach land. The lines and arrows on the globe (see map) show their most likely paths across the North Pacific Ocean, which evetually will lead them back to the Washington coast in 3 years. Some may find their way to Hawaii! The dashed lines show where the toys that head toward the North Pole may go after being frozen in the polar ice, eventually reaching Europe. The British Parliament has discussed giving the ducks protected status when they arrive! Each toy will have an amazing story to tell us after it has been found on a beach.



National Marine
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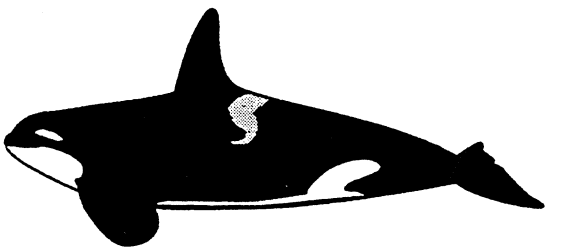
125th Anniversary
Activity Book Series

Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

What is a Marine mammal?

First, let's talk about what mammals are!



Marine mammals are _____

cold-blooded

warm-blooded

Marine mammals breath air through _____

lungs

gills

Marine mammals have _____

eggs

live young

Marine mammals give their babies _____

milk

meat

Marine mammals have all these characteristics and they live in salt water!

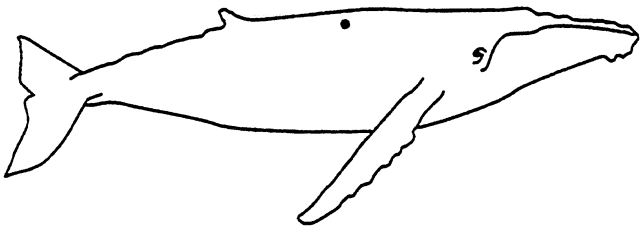
Alaska Fisheries Science Center
Graphics Unit 9/96

Name _____

Color the whales and dolphin and make them into a hanging mobile.

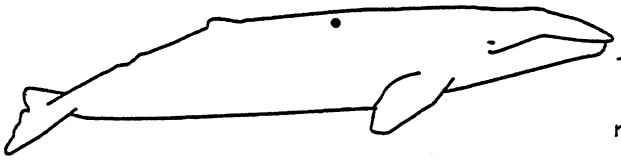
Each animal has special markings and different shades of color. You can find information and pictures in your local library.

Use pages 1 and 2 to make mobile; instructions are on page 2



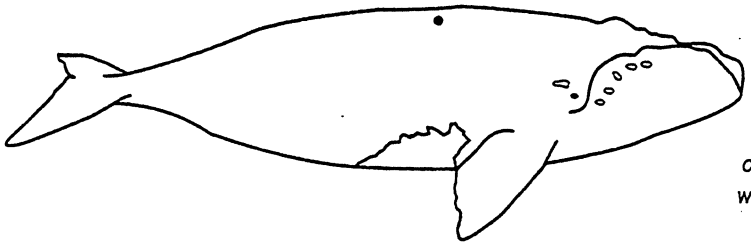
Humpback whale

Humpback whales are up to 53 feet long. They live in all oceans, and migrate from cold waters for feeding to warm waters for breeding. Humpback whales feed on fish and crustaceans.



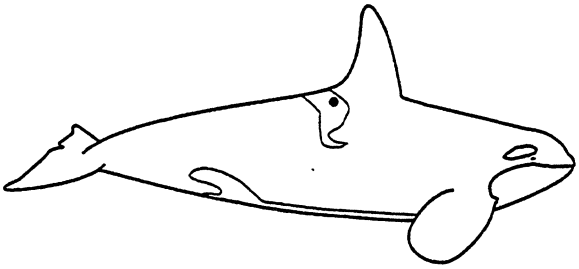
Gray whale

Gray whales are 40-45 feet long. They winter along the California and Baja Mexico coasts, and migrate north to summer feeding grounds in Alaska. Gray whales feed on invertebrates from the ocean floor.



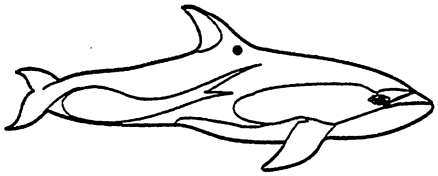
Right whale

Right whales are up to 60 feet long.They live in the cooler waters of the Northern Hemisphere. Right whales feed on krill and other small invertebrates.



Killer whale (Orca)

Killer whales are up to 28-32 feet long. They live in all oceans, and live in pods of 5-20, permanent groups of males, females and calves. Killer whales feed on fish, marine mammals(seals, sea lions, whales and dolphins), squid, birds and turtles; they hunt cooperatively in packs.



Pacific white-sided dolphin

Pacific white-sided dolphins are up to 7 1/2 feet long. They live in the North Pacific Ocean, and travel in groups as small as 15-50 dolphins or as large as several thousand dolphins. Pacific white-sided dolphins eat squid and fish.

Front

1

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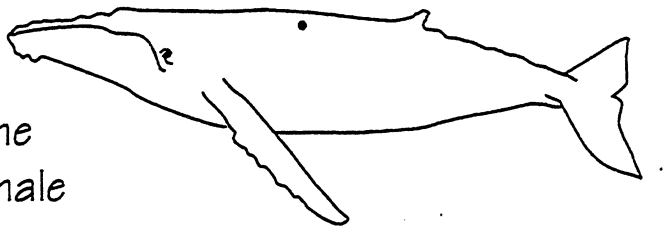
1. Cut out the front and back of each whale and dolphin

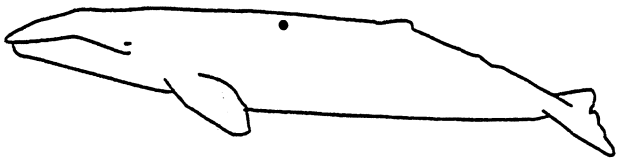
2. Glue or staple them together

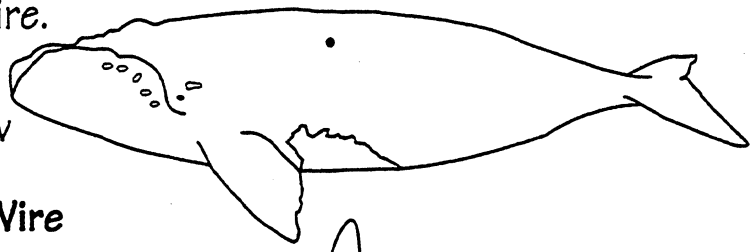
3. Poke a hole at the black dot on each whale and dolphin.

4. Attach string through the hole and tie a knot.

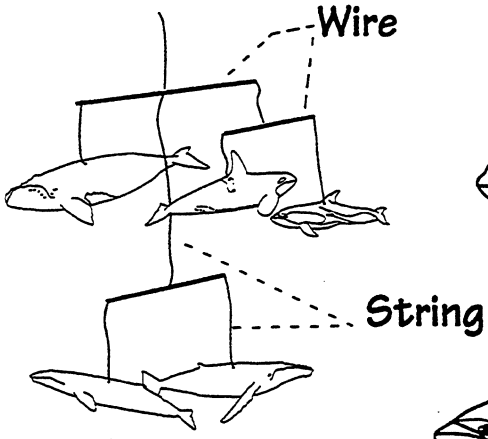
5. Begin balancing mobile using the weight of the whale/dolphin, string and rigid wire.

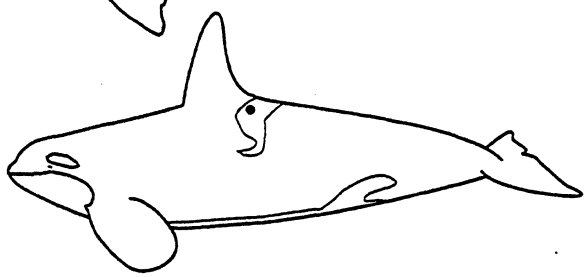


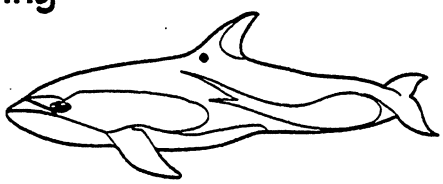




See example below







Back

2

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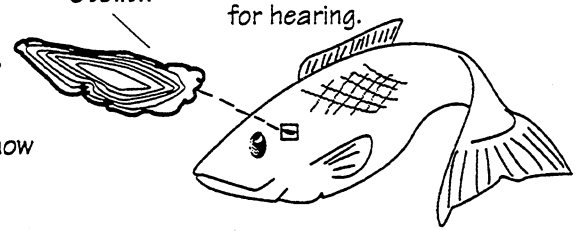
How and Why we age fish...

How: We count the number of lines in the otolith: one year= one line.

This tells us this fish is 5 years old.

Why: Knowing the age of the fish helps us determine how long the fish live and how quickly they grow.



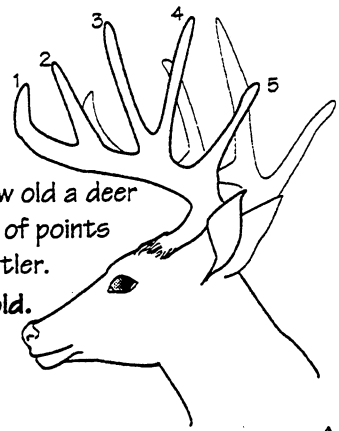
An otolith is a bone located just behind the ear. It is used for hearing.

Other ways in nature to determine age:

You can count the rings on the trunk of a tree.

How old is this tree?

_____



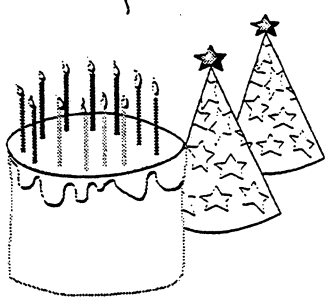
You can learn how old a deer is by the number of points he has on his antler.

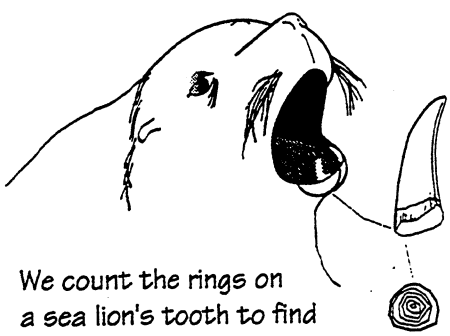
This deer is 5 years old.

Candles on a birthday cake are a good way to learn how old a person is

How old are you?

_____





We count the rings on a sea lion's tooth to find his age, just like the rings on a tree and on an otolith.

How old is this seal?

_____

Can you think of other ways to determine age?

- fish scales - have lines
- bones - have lines
- toenails - on seals, have lines
- ear wax - on baleen whales
- size or weight of animal.

_____

_____

_____

Fisheries Oceanography Coordinated Investigations FOCI

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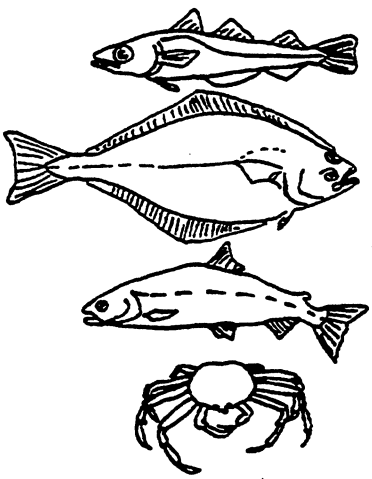
Gretchen (an Observer) needs to count the number of different fishes and crabs. See if you can help her by finding the following animals:



Pollock _____

Halibut _____

Salmon _____

Crab _____

Observers count the numbers of different fish caught by commercial fishing boats, so that NMFS can determine how to manage U.S. fisheries.

Resource Ecology and Fisheries Management REFM
Observer Program

Alaska Fisheries Science Center
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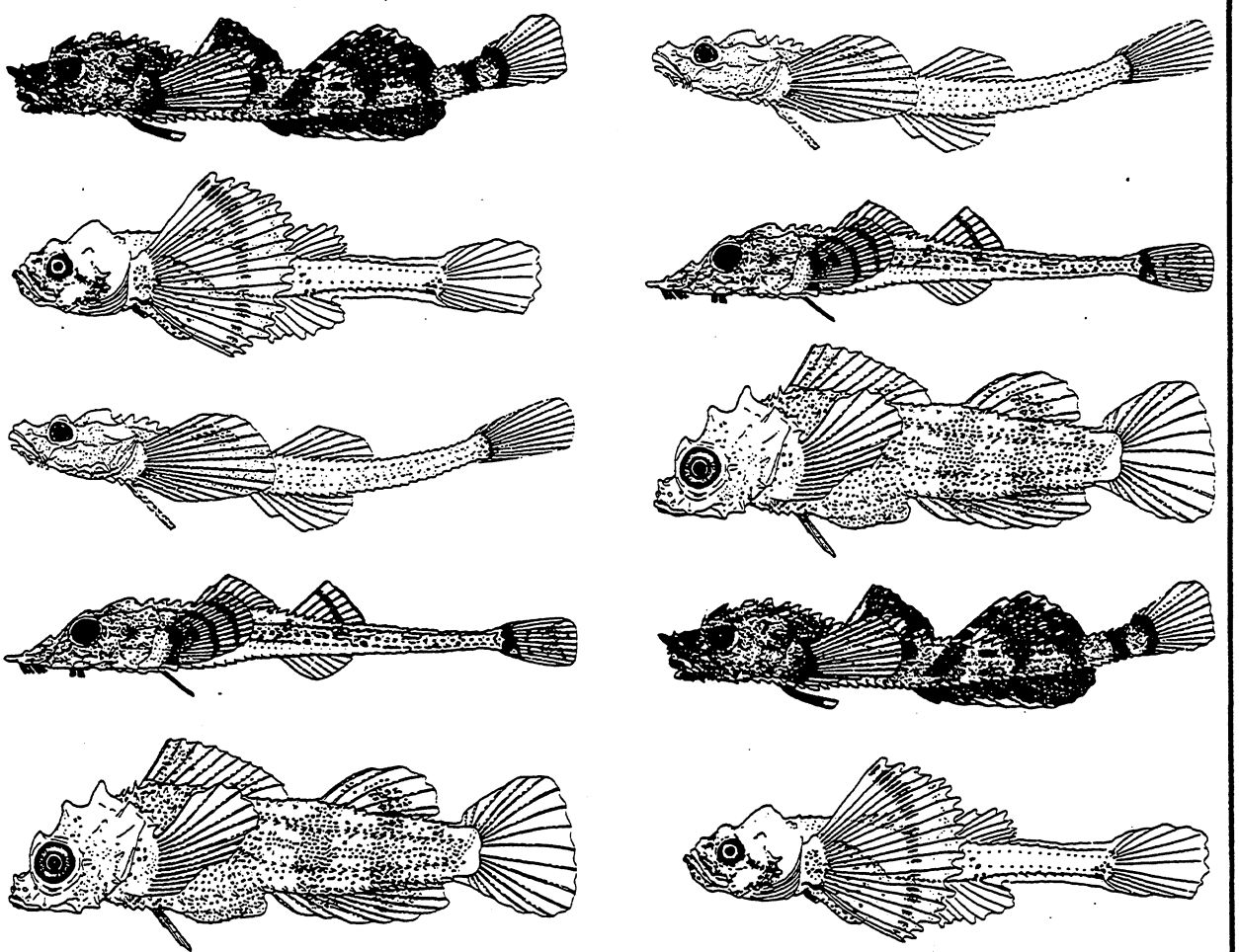
Help Morgan Find the Poachers!

The fishes are the most numerous and diverse of the vertebrate (those with back bones) animals on Earth. Over 20,000 species of fish have been identified -- they live in our oceans, lakes, rivers, streams, or other aquatic environments. Sometimes it is almost impossible to tell some fish species apart because they look alike. Fisheries biologists often group these look-alike species together in families -- some fish families are made up of more than 100 species.

Look at the two columns below and try your hand at matching the poachers or alligator fish from the family Agonidae. These fish (from 50 species) are found in the north Pacific and Atlantic Oceans where they live near the bottom in shallow water. Look carefully at the fish in the two columns -- what features did you use when you made your matches?



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A Fish is not A Stick

Structures and Senses of Fishes

Fish are found in all the waters of the world, from the surface waters to the ocean depths. When fish are fully grown, their bodies can be divided into three parts (head, trunk and tail).
Usually their bodies are covered with scales or body plates and most fish have fins which they use for swimming.

These are just a few of the many characteristics that an ichthyologist (a scientist who studies fish) or you, may use to identify a fish. The following handout (written by a NMFS scientist) provides a general description of a "fish" which can be used by anyone interested in or studying these fantastic animals.

Name _____

UNITED STATES DEPARTMENT OF THE INTERIOR, Stewart L. Udall, Secretary
James K. Carr, Under Secretary
Frank P. Briggs, Assistant. Secretary for Fish and Wildlife
BUREAU of Commercial FISHERIES, Donald L. McKernan, Director

Fishery Leaflet 132

STRUCTURE AND SENSES OF FISHES

By Ralph Hile
Fishery Research Biologist

THE "TYPICAL" FISH

If one here required to "describe a bird," he doubtless would be distressed at the necessity of covering in a single account the tiny hummingbird the soaring eagle, and the bulky, perpetually grounded ostrich. Even it assigned a such smaller group of animals, such as the dog, he would give no little thought to the range from the Mexican hairless to the sheep dog or from the bulldog to the whippet. In either situation the final description unquestionably would be couched in vague but commendable generalities.

Affairs are no different with the description of "a fish." If anything, fishes offer an even thornier problem than do birds or dogs. In the first place, they are an extremely numerous group and accordingly one with great latitude for variation. Indeed, more than half of all species of vertebrates (animals with backbones) are fishes. Furthermore, fishes have adapted themselves to an enormous- variety of environments. On the one hand they are to be found in the icy waters of the polar regions, while on the other, they can exist miraculously uncooked in hot desert pools up to temperatures well- above 100. F. They may roam widely over the vast expanses of the open sea or spend their entire existence in the cramped, underground quarters of an artesian well. They thrice in high mountain lakes and in the abyssal depths of the ocean. They may even desert temporarily the aquatic habitat to scamper over mud flats or climb small trees in search of food. If pools dry up, they may bury themselves in the mud and spend the dry season breathing air. only the most extreme conditions-as the briny waters of the Great Salt or the foully polluted areas that man has created—can defy them. On the whole, it can be said that where there is water, there are fishes—and three-fourths of the earth's surface is covered with water.

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Fisheries Service
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The establishment of the property of discussion in terms of a typical animal is vital to the present argument, for it would be futile to attempt within a space of a few pages a description of structure and special senses that would hold even approximately for all fishes. The Sections that follow accordingly were written largely with a single species, the North Atlantic herring, in mind. Supplementary comments are introduced, however, to bring out certain of the more striking specializations.

There is much to recommend the herring (Clupea harengus) for selection as our typical fish. First, it is one of the abundant food fishes in the world. Second, it is an inhabitant of the open ocean, an area in which a high percentage of all species of fish live. Finally, the herring is relatively unspecialized and consequently exhibits no extremes in size, form, or structure.

EXTERNAL STRUCTURE AND PRINCIPAL ORGAN SYSTEMS EXCLUSIVE OF SPECIAL SENSE ORGANS

External Features

The external structure of the herring (fig. 1) is admirably designed to offer a minimum of resistance to movement through the water and hence to insure the maximum speed and efficiency in swimming. In outline the body is spindle-shaped although somewhat heavier toward the front than toward the rear; the cross-section is elliptical. The head is integral with the body—that is, a neck is lacking. So effective is this natural streamlining that man-made objects constructed to move with a minimum of resistance as, for example, the submarine, invariably take on a similar shape. Nor is the body form the only provision for free movement through the water. The body surface is generally free from projections that might offer resistance. The eyes are smooth and do not extend beyond the contours of the head; the gill opening is covered with a smooth flap (operculum); and the scales lie closely against the body surface. Resistance is lessened still further by an over-all coating of slime.

Only the fins extend beyond the body, and they have been demonstrated by means of experiments with objects constructed to resemble the body of a fish to be essential; to stability in the water. During rapid swimming the fins may be depressed or folded along the body so as to minimize resistance. Erect, they serve well as brakes.

Fins are of two general types—paired and unpaired or median. The paired pectoral and pelvic (known also as ventral) fins which are attached to the girdles bearing the same names correspond to the fore- and hind-limbs of terrestrial vertebrates. The relative positions of the paired fins vary considerably among fishes, and in some (as the eels) the pelvics or even the pectorals may be entirely lacking. The unpaired fins are dorsal (on the back), caudal (the tail), and anal (on the belly). Fishes never have more than two pairs of paired fins, but the number of dorsal and anal fins is variable.

Name _____

The diversity of size and structure of fishes is much as would be expected in a group adapted to live under such a wide range of conditions. Sizes run the full gamut from certain Philippine gobies that may be only a half-inch or less in length when fully grown to the whale shark which certainly attains a length of 40 or 50 feet and possibly may reach 70 feet. Shapes are equally variable. As extreme examples we may cite: the elongate eel with its snake-like body that so often gives rise to erroneous suspicion of reptilian affinty; the skates and rays which look like they have been flattened by a roller; the ocean sunfish with a body as deep as it is long; the gloular puffer; the flounders and soles with both eyes on the same side of the head; and the ever-popular sea horse, which at first glance would hardly be detected as a fish. The preceding are merely selected illustrations of the extraordinary extremes in the size and shape of fishes, not a few of which approach the monstrous.

Yet, for all their variability, a bird is still a bird, adog is still a dog, and a fish is still a fish. Furthermore, the fullest realization of the existence of wide variations and unusual extremes does not preclude the information of reasonably definite concepts of "typical" or "average" animals. These concepts, to be sure, are likely to be colored somewhat by percsonal experience. On the whole, however, they are fully valid since almost all of them will bear close resemblance to the kinds of birds, dogs, and fishes most commonly encountered.

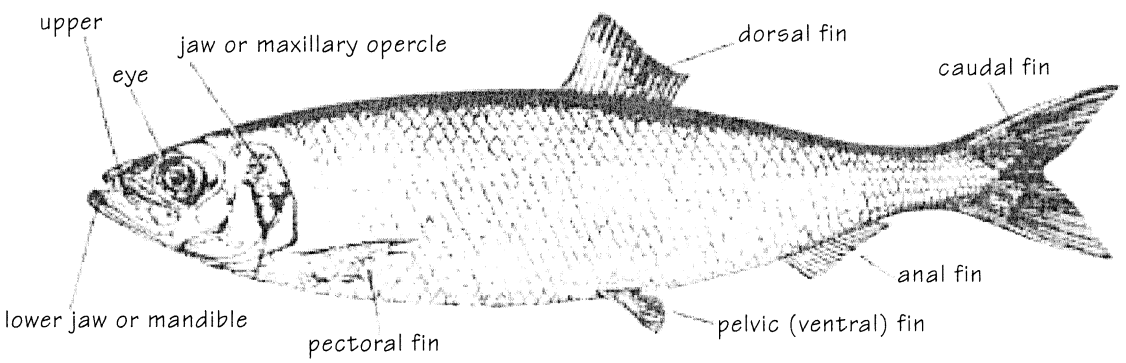


Figure 1 External structure of herring (Clupea harengus).

Name _____

In the herring the fins are supported by soft "rays," but in many species (as the yellow perch) the front part of the dorsal and anal fins and the outer parts of the paired fins are supported by bony spines. These spines give the fins greater rigidity and also provide organs of offense and defense.

Fins of fishes exhibit numerous remarkable modifications, a description of which would require many pages. Among the most interesting may be mentioned the enormously developed pectorals of the flying fish which enable that animal to "fly" or more properly to glide through the air over distances of several hundred yards. Possibly the most fantastic modification of a fin is found in the anglerfish in which the first spiny ray of the dorsal fin, greatly elongated, highly flexible, and with a flap-like structure at the tip is located on the snout in such a position as to serve as a line and bait to attract unwary fish into the angler's capacious mouth. In some species the "bait" at the end of the line consists of a bulb that can be made luminous as desired and in one this bulb is further equipped with a series of horny hooks!

The streamlined structure of the herring that was emphasized at the beginning of this section is characteristic of the pelagic inhabitants of the ocean and of other fishes that depend on speed of movement to capture or to avoid becoming food. Any substantial deviation from this streamlining inevitably detracts from swimming efficiency and requires a way of life in which speed and agility are not fundamental to survival.

Skin

The streamlining of fishes is carried over to the skin, which in all probability fits more closely than the skins of other vertebrates. Fishes need have no fear of developing bagginess and wrinkles with advancing age.

A primary function of the skin is the provision of a relatively impervious, tough, and elastic protective covering. The effectiveness of this protection is increased greatly in most fishes by the presence of scales. Scales may be considered characteristic of fishes; their absence (as in many catfishes) or reduction to insignificant size (common eel) represents special development. In structure, scales range from the tooth-like scale of the shark (indeed, the teeth of the shark are nothing more than modified scales) and the heavy, bony plates of the sturgeon to the more common types to be found on such "teleost" or "bony" fishes as the herring, brook trout, or sunfish. The scales of the teleost fishes are imbricated-that they overlap more or less in the manner of shingles. A feature of the scale structure of many fishes that is particularly valuable to scientists is the "annulus" or ear-mark which permits the determination of age.

Also located in the skin are certain sense organs (which will be mentioned again later), numerous glands (including the mucous glands and the unusual light-producing organs of deep-sea fishes), and the color cells that are responsible for the intricate and occasionally gaudy patterns to be found in some fishes. The skin serves further as the depository for a waste product known as guanin, which has the power of reflecting light and thus can produce white, silvery, or on occasion iridescent effects.

Name _____

Skeletal System

The skeleton of a fish may consist of actual bones, as is true with the marine herring in which ossification is nearly complete, or it may be cartilaginous as in the sharks and rays. The major divisions of the skeleton may be listed as: the central vertebral column or backbone with its associated structures, the ribs, the median or unpaired fins, and the terminal tail; the girdles (pectoral and pelvic) and the attached paired fins; the skull , including the supporting structure of the operculum or gill cover. So numerous are the bones and so complicated is the skeletal structure that a detailed description here is entirely out of the question. This point is well illustrated by figure 2 in which the principal bones of the small mouth bass are named.

The usefulness of the skeleton does not end with its service as a scaffold supporting the body. It functions also in a protective capacity (witness the protection afforded the brain by the cranium and the spinal cord by the vertebrae), offers surfaces for the attachment of muscles, and provides leverage for movements. Because of the supporting effect of the water the two last-named functions are of notably less significance among fishes than among terrestrial vertebrates. Water offers sufficient resistance to sinking that locomotion can be accomplished readily by lateral strokes of the tail. The fish has no need for the intricate system of levers represented by the legs and wings of the higher vertebrates.

Musculature

The absence of such complicated appendages as the legs and wings of the terrestrial vertebrates makes it possible for fishes to maintain to a large extent the primitive condition in which the muscles of the body are arranged regularly down each side in a series of definite and similar segments. In most fishes these vertical segments are divided into dorsal (upper) and ventral (lower) sections by the lateral line. Fishes also have numerous specialized muscles such as those concerned with the movement of the jaws, operculum, and fins. Mention should be made also of the "smooth" muscles that are essentially parts of certain organs (as, for example, the wall of the digestive tract) and of cardiac muscles of the heart and certain major blood vessels.

A most interesting specialization of muscle tissue is found in the electric organs of certain eels and rays, which are capable of imparting a shock sufficiently strong to knock done a full-grown man.

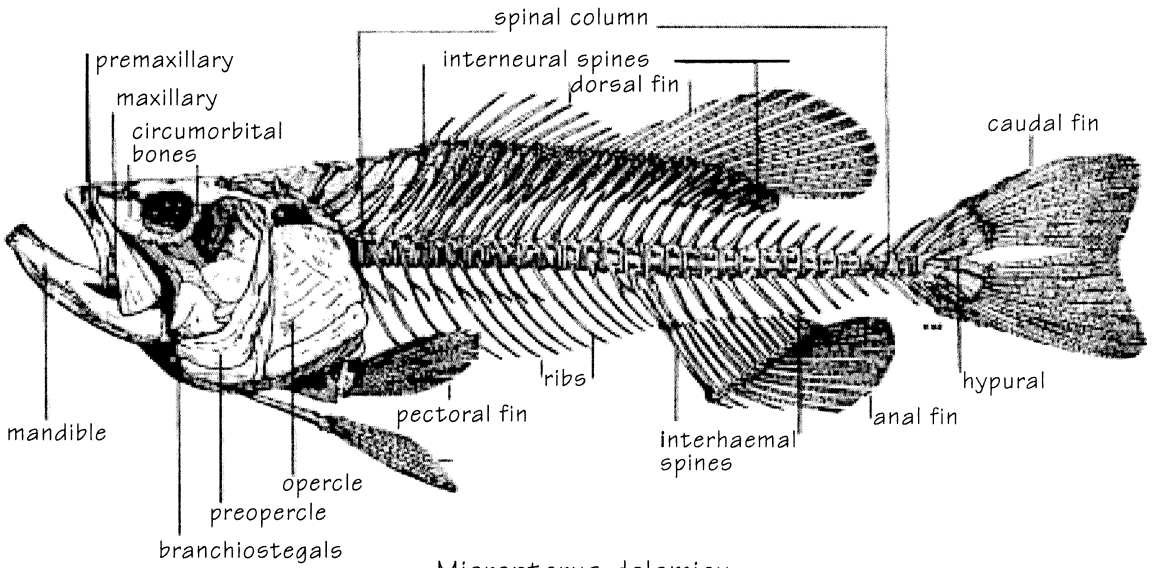
Respiration

In most fishes respiration takes place entirely by means of gills. (Figure 3 shows the gills and various internal organs of the green sunfish.) Each of the gill filaments, which are Attached to the outer curve of the gill arches, is richly supplied with blood vessels. As water passes over the gills, carbon dioxide and other wastes are discharged from the blood and oxygen dissolved in the water is absorbed into the blood stream through the delicate membrane of the filaments.

The swim-bladder which is believed by students of evolution to have been developed originally as an organ of respiration still retains that function in certain relatively primitive fishes such as the lungfish, gar pike, and bowfin. The swim-bladder in most fishes (it is not present in all species) serves principally, however, as an organ for the maintenance of hydrostatic equilibrium between the fish and its environment.

Name _____

Fig. 2. Skeleton of smallmouth black bass.



Micropterus dolomieu

skeleton drawn by Mrs. Ann S. Green

Nervous System

In comparison with the higher vertebrates the nervous system of the fish must be considered poorly developed. The brain is extremely small in relation to the size of the body—too small indeed even to fill the tiny cranial cavity allotted to it. The lack of "gray matter" is especially appalling in the bony fishes (of which the herring is one), for in that group the cerebrum, traditional center of thought and reason, is almost totally by lacking. Poor development extends also to the nerves which are relatively few.

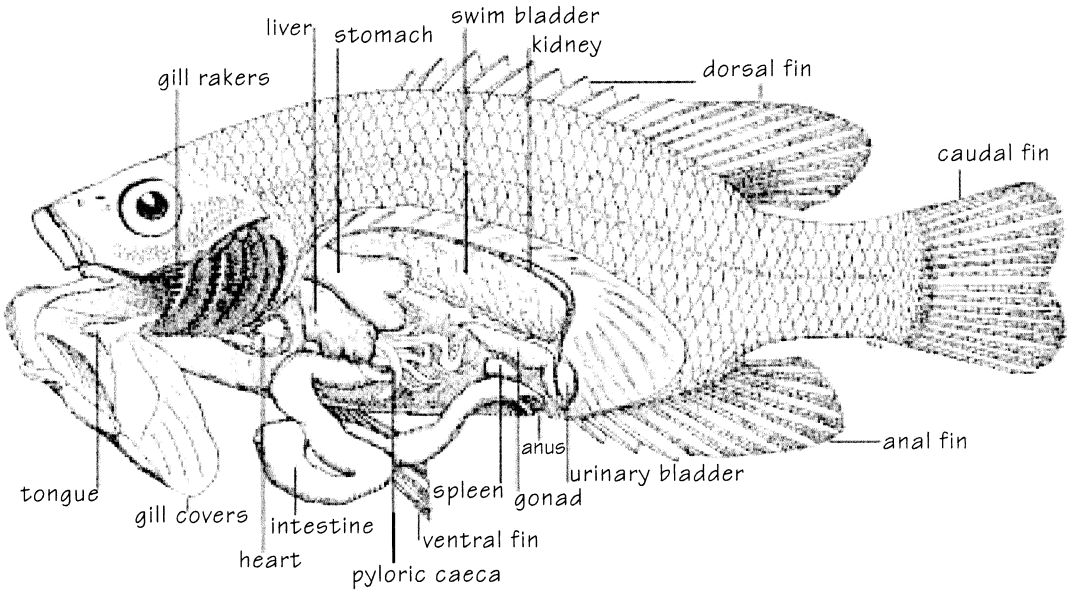
Circulation

In the higher vertebrates two chambers of the heart (one auricle and one ventricle) are concerned with pumping the blood from the heart to the lungs and two with the distribution of oxygenated blood to various parts of the body. Since the fish's blood undertakes no "side trips," these animals are able to get along with a single auricle and a single ventricle.

The blood of a fish is pumped forward from the heart to the base of the gills, passes through the capillaries of the gill filaments, and is then distributed to the body tissues through arteries and capillaries. Blood collected by other capillaries returns to the heart through veins, directly or by way of the renal, (kidney) or hepatic (liver) porta system.

Name _____

Fig. 3. Dissection of the green sunfish showing internal organs.



Lepomis cyanellus

Modified drawing after Kellogg by Mrs. Ann S. Green

Digestive Tract

The digestive system consists of major organs as in the higher vertebrates, namely, the mouth, gullet, stomach, intestines, pancreas, and liver.

The size and position of the mouth vary widely with the feeding habits of the fish. In bottom-feeding forms (as the suckers) the mouth may be turned downward. When the principal foods are found in the open water (as with the herring), the mouth usually is terminal. The structure and distribution of the teeth also vary with feeding habits. Predatory fishes ordinarily are equipped with numerous strong, sharp teeth on the jaws and in other parts of the mouth and pharynx as well. In other species teeth may be shaped for crushing or grinding or may be lacking altogether.

The collection of food is assisted in some species by the gill rakers (attached to the inside curve of the gill arches), which are so modified as to constitute a comb-like structure that strains small particles from the water.

The remainder of the alimentary tract offers few features that call for comment here. Mention should be made, however, of the pyloric caeca, tube-like sacs attached to the stomach near its exit. Their exact function la not known. These structures may be lacking entirely in some fishes (for example, the northern pike) or may number nearly two hundred (mackerel).

Name _____

Excretory System

With respect both to position in the evolutionary sequence of vertebrates and to general complexity of structure, the kidneys of fishes may be termed intermediate. Anatomically, they appear as a pair of dark red elongate organs situated immediately below the vertebral column. The internal structure is such that numerous minute tubules are in sufficiently close contact with the blood to permit the extraction of waste products. These tubules empty into paired excretory ducts which run along the entire length of the kidneys and then join to form a common avenue of drainage. Enlargements of the urinary ducts near their hinder end form bladders of various shapes.

The fish's kidney is not a perfectly efficient organ, for, as we have seen, waste materials are deposited in the sk in quantities large enough to have a profound effect on the color.

Reproduction

The ovaries (one or more commonly two) of female fishes lie in the upper part of the body cavity, more or less parallel to the kidneys. In most fishes the eggs are first discharged into a hollow central cavity of the ovary and then passed to the exterior through special ducts. Among certain fishes in which the young are born alive (many sharks), the terminal portion of these ducts may be expanded to supply accommodations for the developing offspring. In other viviparous fishes (as the mosquito fish) development of the young take place within the ovary itself.

The number and size of eggs vary enormously according to the nature of reproductive habitats. Egg production is highest among pelagic fishes that spawn in the open sea; an extreme example of high fecundity is provided by a ling that was found to contain more than 28 million eggs. The herring, although itself a pelagic spawner, produces eggs on a much less pretentious scale—usually within the range of 21-47 thousand. Nest builders as a rule produce substantially fewer eggs than do "wild spawners," and in viviparous species the number may be extremely small (only 4 to 14 eggs per speason in one of the rays). Eggs of pelagic fishes are of necessity minute, but in some sharks they may be larger even than ostrich eggs.

The testes of male fishes occupy a position in the body comparable to that of the ovaries of the females and like them are provided with special ducts to lead the sex products from the body. Males of viviparous species are equipped with special organs (developed from the pelvic or anal fins) to facilitate internal fertilization of the eggs.

The size of the reproductive glands exhibits a tremendous increase as spawning approaches (especially the ovaries which in extreme cases can make up 25 to 30 percent of the body weight). At other periods, however, the ovarian and testes may be so small as to make determination of sex impossible without microscopic examination.

Name _____

Anatomical Miscellany

It should be emphasized again that the apace available here offers scant opportunity for delving into the minutiae of piscine architecture. The descriptive accounts of the preceding pages have been unavoidably more or less perfunctory. only here and there has it been possible to indicate the enormous range of variation of anatomical structure or to detail one of the myriad fascinating specializations. Furthermore, certain organs and organ systems have been neglected in tote. Nothing was said, for example, of the lymphatic system with its lymphatic hearts and "glandular" spleen. Disregarded too have been other organs with which the fish could not well dispense -the red gland of the swim bladder, the thyroid, the thymus, the suprarenal bodies,....

To a certain degree the deficiencies of these pages are alleviated by the three figures illustrating certain features of the external and internal anatomy. Those who may desire more detailed information should consult the references given at the end of this leaflet.

SPECIAL SENSES OF

Smell

The olfactory organs consist of deep pits lined with special sensitive tissue. The size and the position of these organs on the head vary rather widely. In some fishes the sense of smell, is extremely acute. Sharks, for example, are attracted from great distances by the smell of blood or of decaying flesh. The extent to which the olfactory sense is employed for the location of food varies not only with species but also with circumstances. Experiments conducted in England showed, for example, that pollock which were not very hungry regularly smelled food before taking it, but that when they were ravenous they readily bolted down clams soaked in such obnoxious substances as turpentine or chloroform.

Sight

The general structure of the fish's eye is similar to that of other vertebrates. There are, however, certain modifications for seeing under water. The outer wall of the eye is flatter in fishes than in land vertebrates. The lens, on the contrary, is much more rounded (in fact, is almost spherical) in fishes. Fishes focus their eyes, not by changing the shape of the lens as do terrestrial Vertebrates , but rather by shifting its position. There is good evidence that fishes are relatively nearsighted. Experiments have proved also that they are capable of distinguishing colors. Eyes tend to be small and inefficient in species that live regularly in turbid water, and may be entirely lacking in fishes that inhabit underground waters.

Name _____

Hearing

In fishes as in other vertebrates, the ear is an organ both of equilibrium and of hearing. An important difference, however, lies in the fact that fishes lack the external and middle ear of higher forms. The sense of balance is located in the three semicircular canals. That portion of the ear concerned with hearing lacks the intricate internal structure to be found in higher vertebrates. This fact, together with experimental evidence, has given rise to doubt as to whether fishes hear at all in the ordinary sense. It seems probable that their "hearing" consists of little if anything more than the detection of vibrations in the water.

In many fishes the ear is connected with the swim-bladder by a tube-like outgrowth from the latter organ or by a series of small bones. It is considered possible that this arrangement intensifies the impulses from vibrations in the water.

Yet another structure that may "assist' the ear is the lateral line organ which on the basis of experimentation is believed capable of detecting low-frequency vibrations (in the neighborhood of six per second).

Taste

Almost nothing is known about the sense of taste in fishes. In fact, there is considerable question—for most species, at least-as to whether this sense actually is present. Many of the functions of taste are performed by special organs distributed over the body or on barbels. (See next section.)

Touch

This is probably the most highly developed sense of fishes. Sense organs in the form of buds or small pits and in contact with nerves are distributed over the entire body. They are especially numerous, however, in such strategic locations as the surface of barbels and feelers. In many bottom-dwelling forms the highly sensitive barbels perform

The question as to the extent to which fishes feel pain has long been a subject for debate. Although we shall never know exactly how a fish feels when it is hooked, there is ample evidence that the experience is not sufficiently upsetting to cause even a halt to feeding activities. It is not at all uncommon for fishes that have escaped before being landed or have been released upon capture to take the hook again immediately afterwards.

Name _____

SOURCES OF INFORMATION ON THE STRUCTURE AND SENSES OF

No listing of technical publications on the anatomy and senses of fishes will be attempted here.Those interested can secure considerable information from such college textbooks as B. E. Walter's Biology of the Vertebrates (The Macmillan Company), or L. A. Adams' An Introduction to the Vertebrates (John Wiley and Sons, Inc.).

J. R. Norman's A History of Fishes (A. A. Wyn, New York, 1948) is a veritable storehouse of facts on fishes. Less pretentious in scope than Norman's volume but most entertainingly written is Brian Curtis' The Life Story of the Fish, His Morals and Manners (Jonathan Cope, London, 1949). Two other books that are recommended are The
Ways of Fishes by L. P. Schultz and E. M. Stern (D. Van Nostrand Co., Inc., 1948), and Chapman Pincher 'a A Study of Fish (Duell , Sloan and Pearc, Inc., 1948).

A recent publication that contains a wealth of information on both the anatomy and senses of fishes is the 2-volume work, The Physiology of Fishes, edited by Margaret E. Brown (Academic Press, New York, 1957).

Reprinted August 1964

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Marine Trivia Answers

1. (c)
2. scallop shell (Shell Oil)
3. (c) Capitol city of the Bahamas
4. (b) Sharks have cartilage instead of bones.
5. (a)
6. (a) Wool sponge is worth about $50 per pound.
7. (c) Marine fish must drink seawater to keep from getting dehydrated. Fresh water fish do not drink water, in fact they take in more than enough water by osmosis.
8. (b) Florida stone crabs are able to regenerate their missing claws.
9. (b)
10. (a) Scallops "swim" through the water by opening and closing their shells- a form of jet propulsion.
11. False, however this myth has been widely perpetuated.
12. False, in fact sea turtles are endangered species protected by law.
13. False. Eels are fish.
14. True
15. clams, mussels, and oysters
16. False
17. (b) Turtle Excluder Device
18. (b)
19. (a)
20. (c)
21. 10
22. 8
23. (b)
24. (b)
25. (d)
26. (a) About one minute
27. (c) The heat and pressure of the canning process soften the bones a source of calcium.
28. (a)
29. (c)
30. Alaska, Florida, and Michigan

Name _____

Water World Answers

Multiple Choice

1 — a
2 — b (remember that fresh water is frozen in glaciers and ice caps)
3 — c
4 — c
5 — a
6 — d
7 — b
8 — a
9 — d
10 — d
11 — b
12 — c
13 — c
14 — c

Fill in the Blanks

15 — Superior, Huron, Michigan, Erie, and Ontario
16 — Lake Michigan
17 — Gulf of Mexico
18 — Antarctica
19 — Hawaii
20 — Colorado
21 — Ohio
22 — Red Sea
23 — Atlantic, Pacific, Indian, and Antarctic (or Southern)
24 — Hawaii, Washington, Oregon, California, and Alaska
25 — Indian Ocean
26 — Atlantic and Pacific Oceans
27 — Michigan
28 — Venezuela
29 — Lake Superior
30 — Missouri River
31 — Canada
32 — Crater Lake, Oregon
33 — Columbia River
34 — Rio Grande
35 — Baltic Sea
36 — Florida, Mississippi, Louisiana, and Alabama

True or False

37 — T
38 — T
39 — F
40 — T
41 — T
42 — T
43 — T
44 — T
45 — T
46 — F

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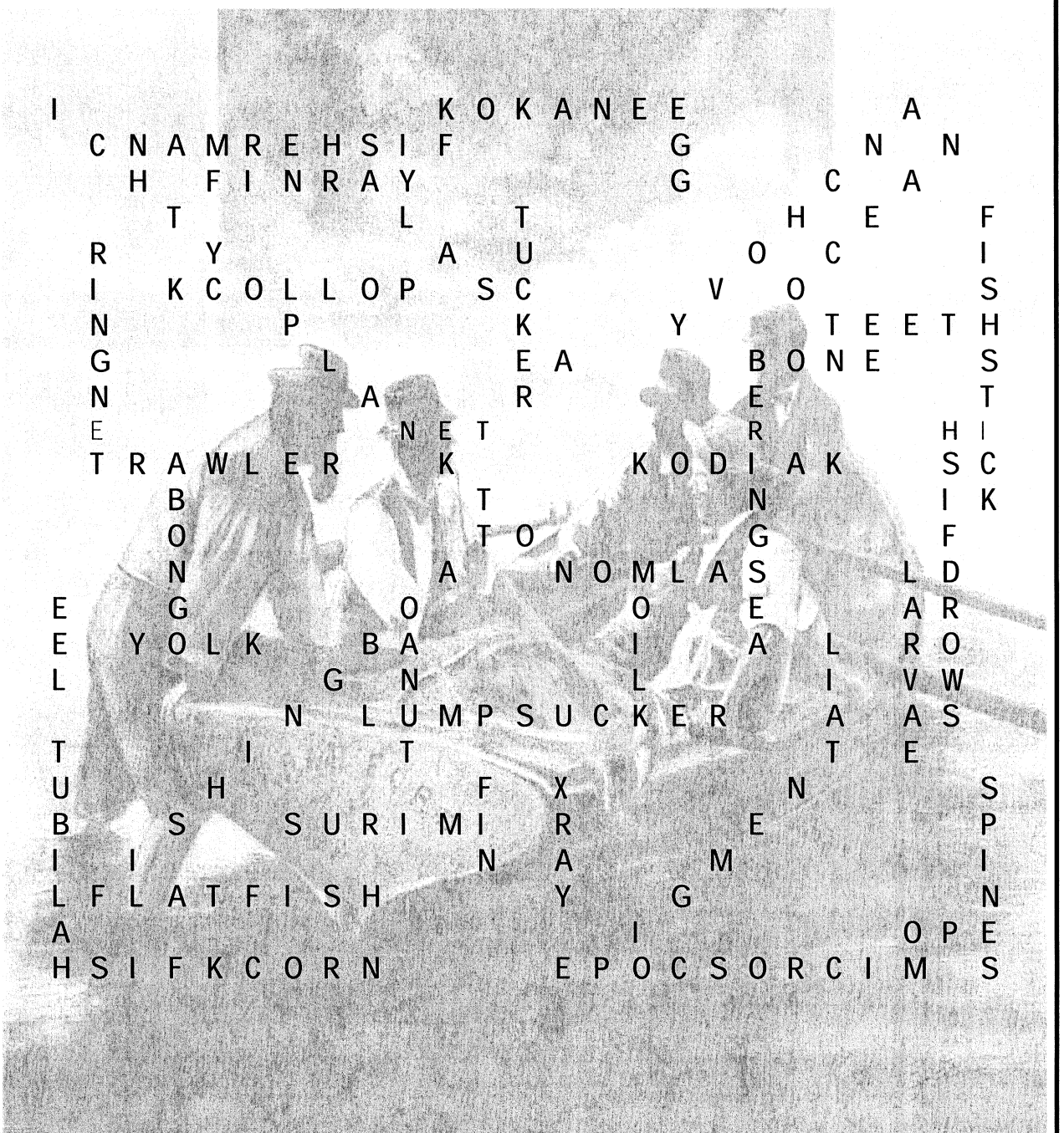
Fish Word Search Answers



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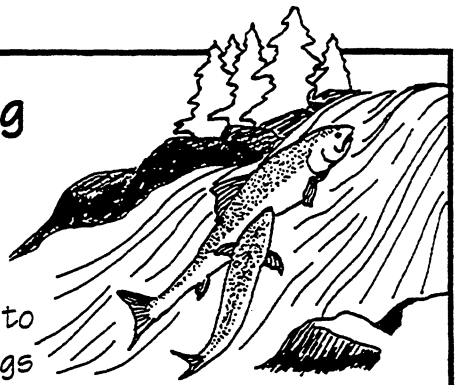
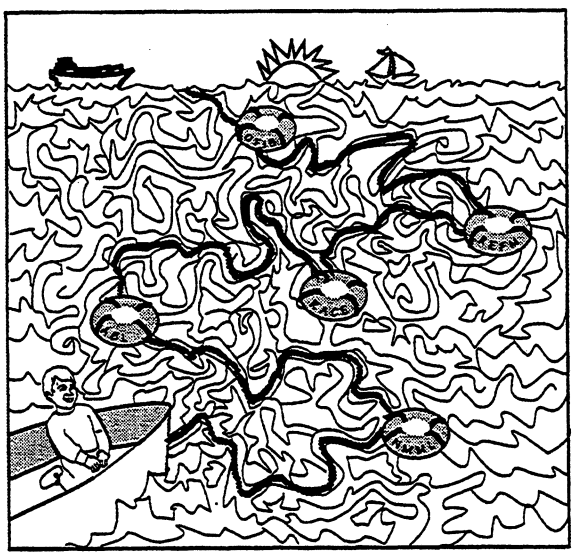
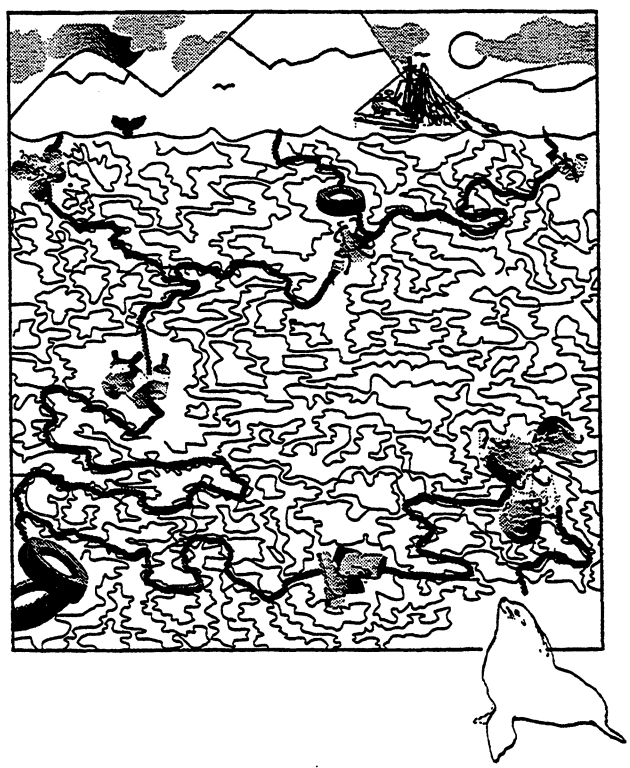
Only the Strong Survive



Only **5** salmon were left to spawn out of 5,000 eggs deposited.





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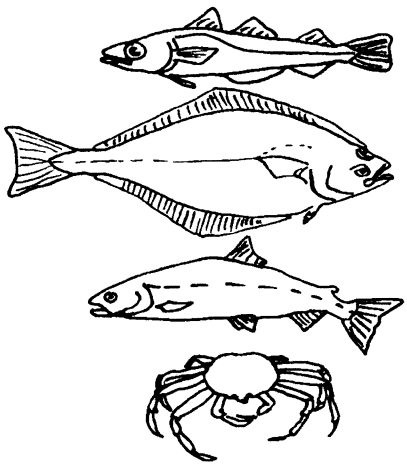
Gretchen counted the different fish and found there were:



Pollock 3

Halibut 3

Salmon 3

Crab 2

What is a Marine Mammal?

First, let's talk about what mammals are!

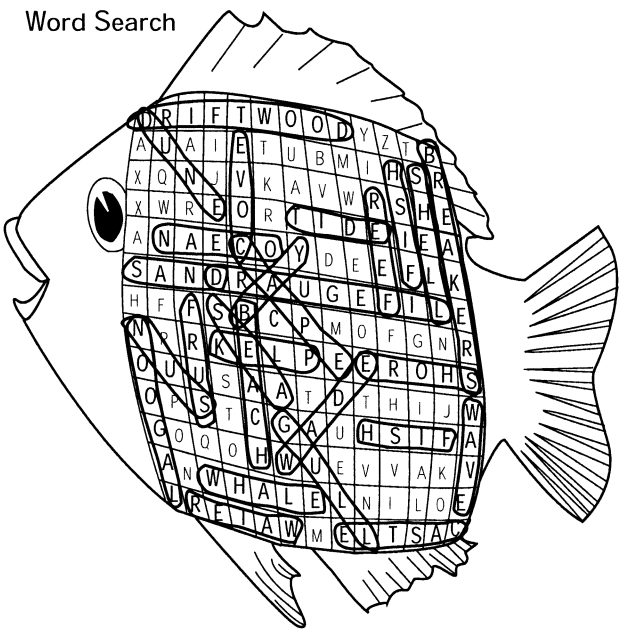
Mammals are warm-blooded

Mammals breath air through lungs

Mammals have live young

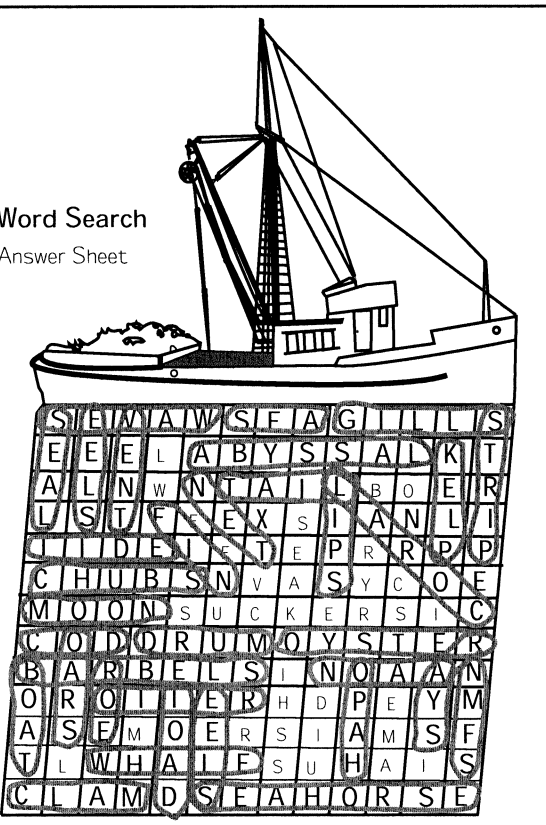
Mammals give their babies milk

Word Search



Word Search

Answer Sheet



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Glossary of Common Abbreviations:

NOAA - National Oceanic and Atmospheric Administration

NMFS - National Marine Fisheries Service

AFSC - Alaska Fisheries Science Center

ABL - Auke Bay Laboratory (AFSC)

NMML - National Marine Mammal Laboratory (AFSC)

REFM - Resource Ecology and Fisheries Management Division (AFSC)

Name _____

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