Our Living Estuaries

"If a child is to keep alive his inborn sense of wonder ... he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in."

– Rachel Carson

This activity book was made possible through a grant from the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), as part of its Living Coasts Program. CICEET works with NOAA's National Estuarine Research Reserve System to develop tools for clean water and healthy coastal environments nationwide.

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NC DIVISION OF COASTAL MANAGEMENT

NC COASTAL RESERVE & NATIONAL ESTUARINE RESEARCH RESERVE

The North Carolina National Estuarine Research Reserve is a cooperative program between the North Carolina Department of Environment and Natural Resources, Division of Coastal Management and the National Oceanic and Atmospheric Administration.

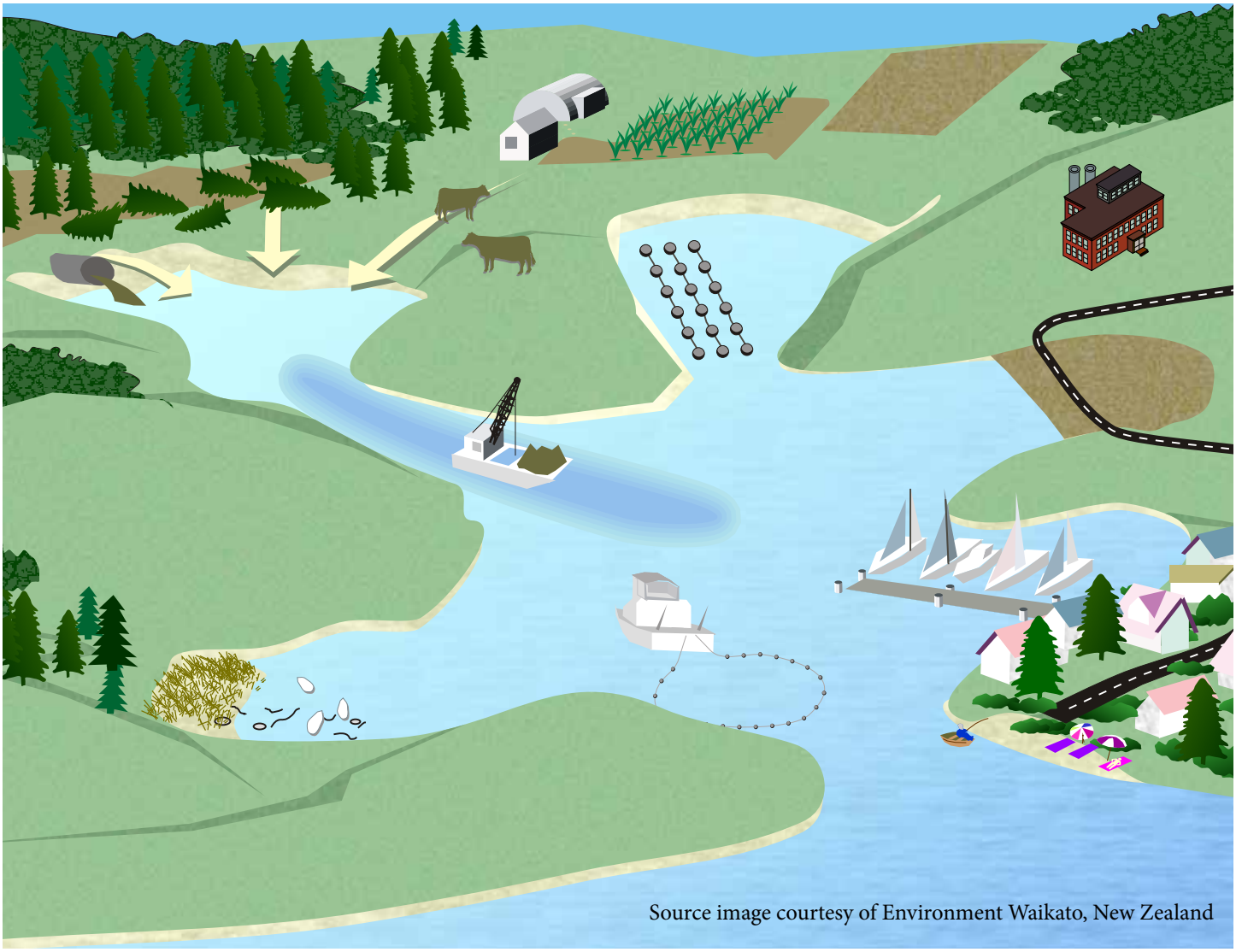
00000 copies of this brochure were printed at a cost of or per copy.

Introduction to Estuaries

An estuary is the coastal ecosystem where fresh water flowing from the rivers meets the salty ocean water. In North Carolina we have 2.2 million acres of estaurine habitat. This is a nutrient rich environment that supports a great diversity and abundance of aquatic life. In fact, estuaries are called nursery habitat because many marine animals, such as fish and shrimp, start out their lives as eggs and juveniles in the estuary. Others, like dolphins, sharks and sea turtles use the estuaries as feeding areas or refuges. Much of the seafood that we eat relies upon having clean and healthy estuaries.

The picture below shows how the conditions in an upstream watershed can effect the estuary.

What are some of the factors upstream that can affect the estuary?



Source image courtesy of Environment Waikato, New Zealand

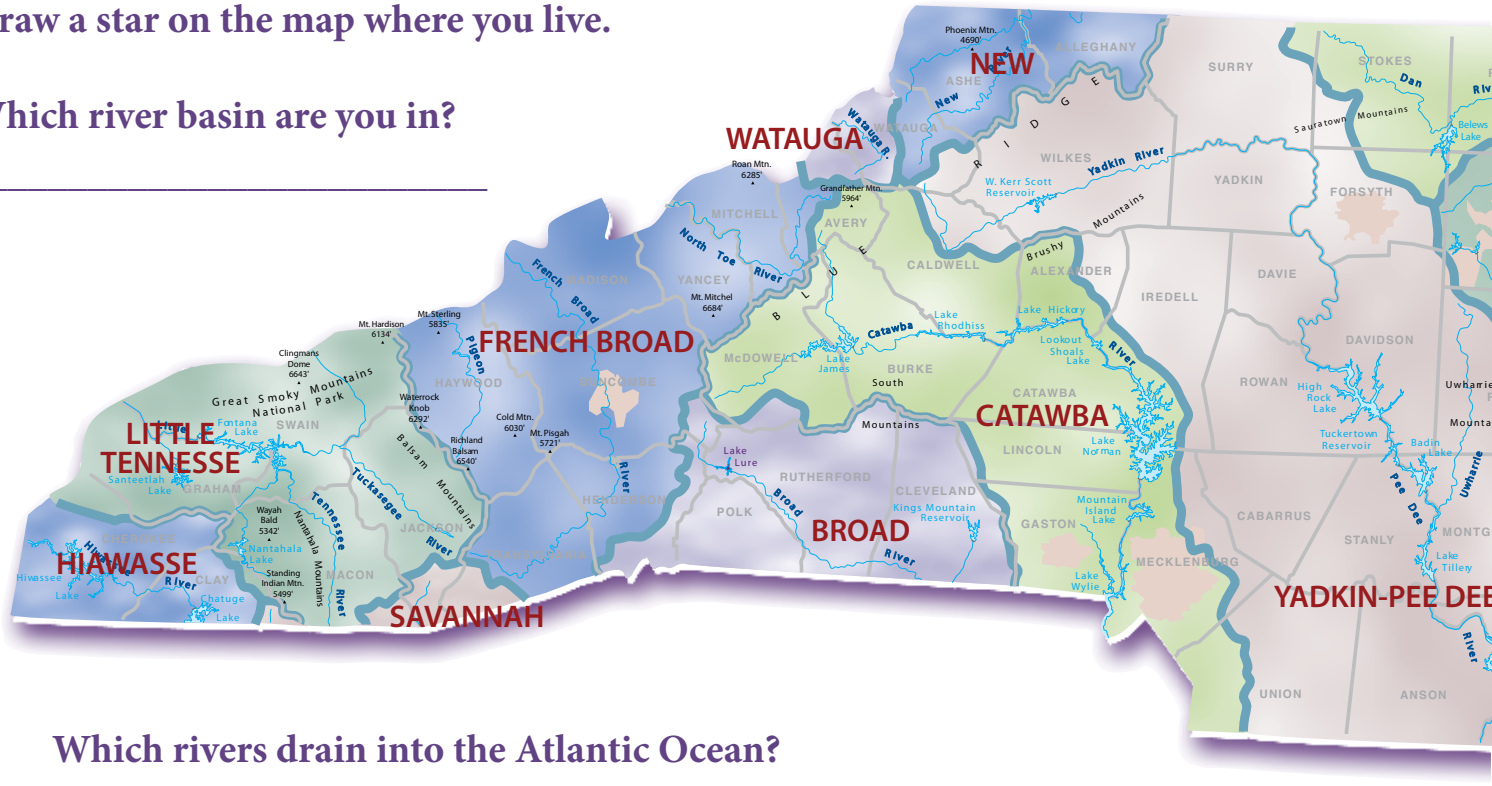
How Are You Connected To The Estuary?

Twelve North Carolina rivers flow into the Atlantic Ocean. Seven of these empty into estuaries along our state's coastline. The other five rivers drain into different states. Estuaries come in many different shapes and sizes. They include a wide range of habitats including swamps, marshes, beaches and oyster reefs. In the northern part of the state, large sounds exist because of the barrier islands that formed far away from the mainland.

Draw a star on the map where you live.

Which river basin are you in?

_____



Which rivers drain into the Atlantic Ocean?

_____

Which rivers drain into NC estuaries?

_____

What are the large sounds of NC?

_____

Which sounds are smaller?

_____

Trace a river you are near down to the estuary.

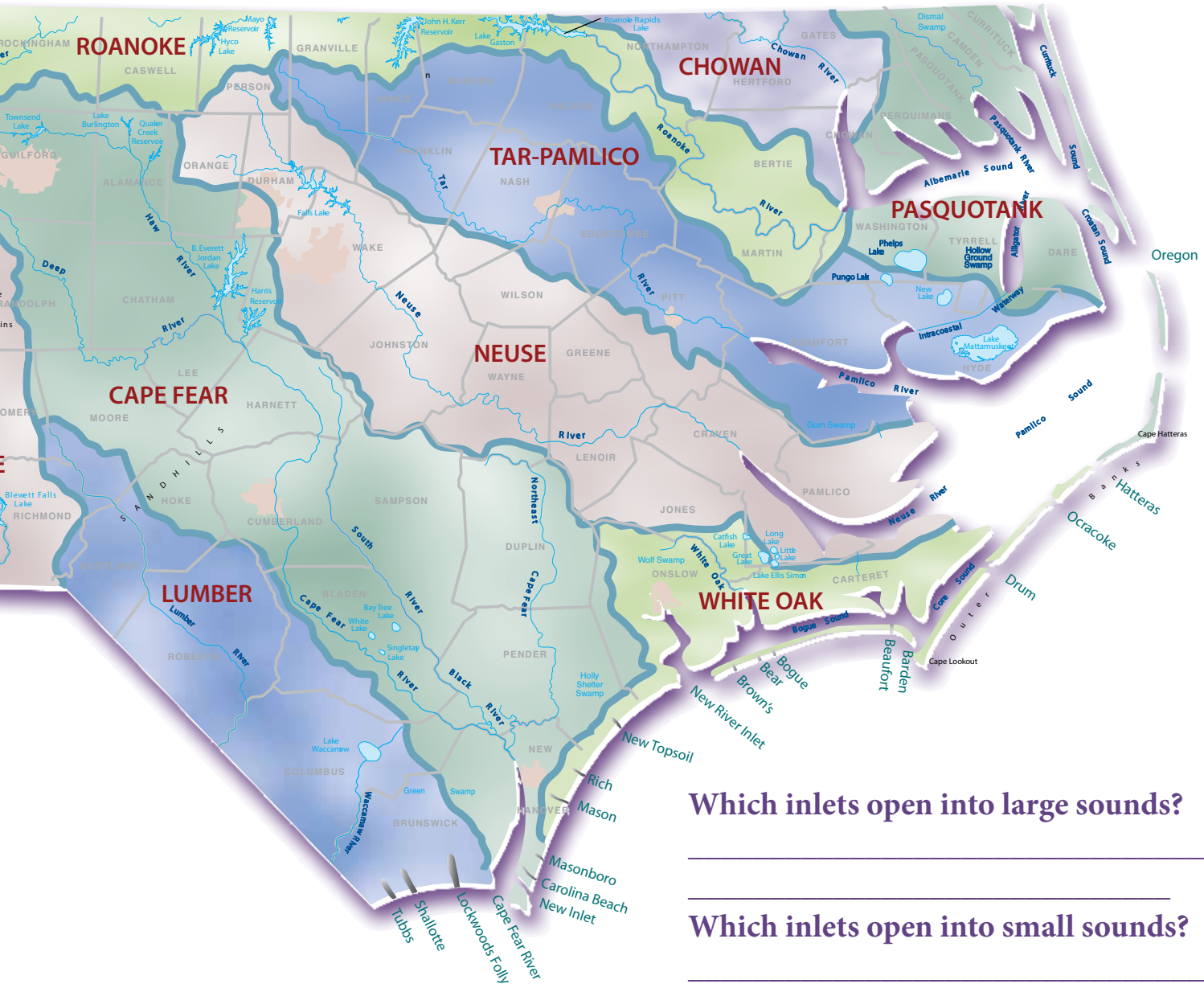
Which sound (if any) does your river drain into? _____

How salty is this estuary? _____

Inlets provide entry points for ocean waters into the sounds along the coast.

Currently there are 20 inlets in North Carolina.

Can you find all of them?



Which inlets open into large sounds?

_____

_____

Which inlets open into small sounds?

_____

_____

Can you see an inlet with no sound?

_____

Do you think inlets are stable geological formations? _____

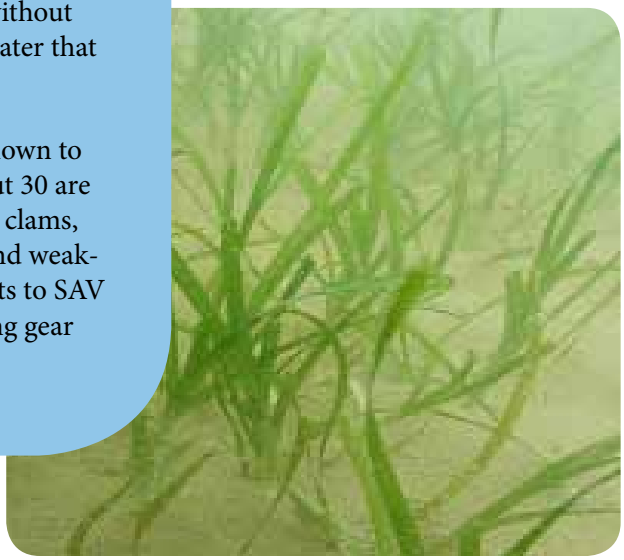
Why or why not? _____

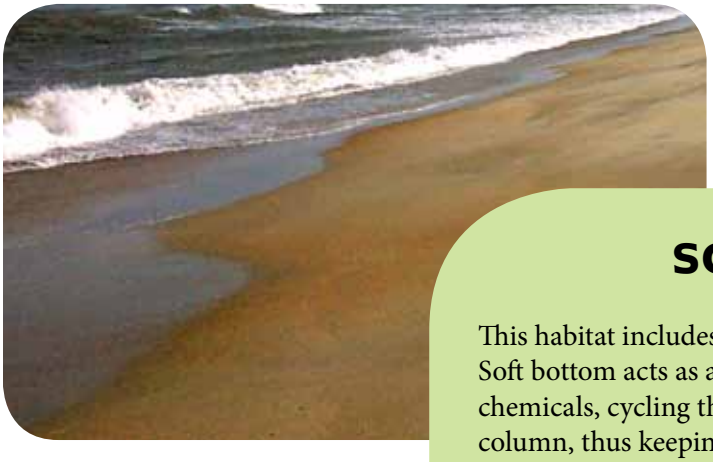
Estuaries are Habitat

SUBMERGED AQUATIC VEGETATION

Also known as SAV, this habitat is an underwater garden for juvenile fish and small invertebrates and a barometer of water quality. Sea grasses and other underwater plants grow in the shallows of coastal sounds and estuaries. These plants cannot survive without clean, clear water. Sunlight can't penetrate water that is clouded by sedimentation and nutrients.

Over 150 fish and invertebrate species are known to use SAV as adults or juveniles, of which about 30 are important commercial fishery species. Hard clams, red drum, shrimp, blue crabs, gag grouper and weakfish are all dependent on SAV. Specific threats to SAV include boat prop damage, boat wakes, fishing gear and polluted stormwater runoff.





SOFT BOTTOM

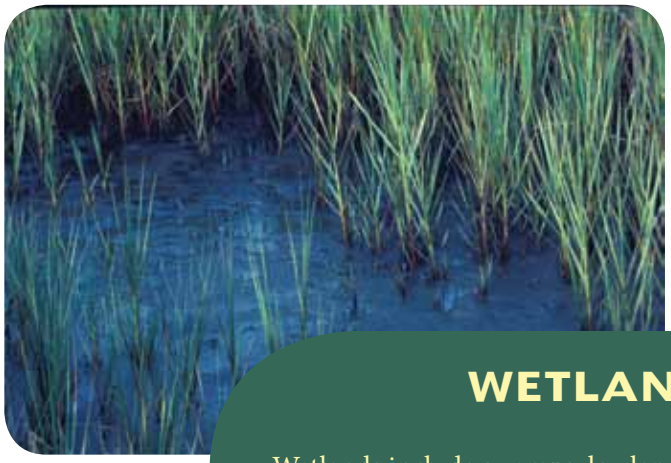
This habitat includes mud flats, beaches, shoals and sand bars. Soft bottom acts as a storage area for nutrients, sediment, and chemicals, cycling them between the bottom and the water column, thus keeping the ecosystem in balance. Intertidal flats and sand bars buffer wave energy, reducing shoreline erosion.

Bottom-dwelling algae and zooplankton provide a vast food supply for both young and adult fish. Soft bottom provides a hiding place for burrowing marine animals. Shallow soft bottom, especially adjacent to wetlands, is a primary nursery area for numerous fish and invertebrates.

WATER COLUMN

The water column is essential to aquatic life. What happens to our waters greatly influences the overall health of the fish and shellfish inhabiting them. Specific pollution threats to the water column include excessive sedimentation and turbidity, excess nutrients, bacteria, toxins, invasive species and alteration of the natural flow of water. Fish that are dependent on the water column for foraging include menhaden, bay anchovy, bluefish and river herring.

Most of the water column habitat in North Carolina estuaries is very shallow, only a few feet, and is dramatically affected by daily tidal fluctuations.



WETLAND

Wetlands include swamps, lowlands, marshes, bottomlands and sloughs. They also play a vital role in recycling organic waste from both the water and the land. Riparian wetlands border vital nursery areas and filter pollutants from overland runoff, while protecting shorelines and producing detritus for export to other habitats.

Tidal marshes provide nursery areas, refuge and foraging habitat for countless species including crustaceans, fish, birds, reptiles and mammals.

Riparian wetlands comprise about 7% of North Carolina's coastal watersheds. Since precolonial times, North Carolina has lost nearly half of its wetlands.

SHELL BOTTOM

Oyster beds and reefs are the dominant shell bottom habitat, but clam, scallop and mussel shells can also be found. Living shellfish on shell bottom filter algae and bacteria from the water column. Water filtration by oysters, clams, and other shellfish clears the water column enhancing the growth of submerged aquatic vegetation. Shell bottom protects shorelines from erosion.

Oysters and other shellfish attach to the hard surfaces of dead shells and at least 12 economically important fishery species use shell bottom as a nursery. Larger benthic fish forage on and around shell bottom habitat. Small resident species find refuge and spawning sites among the shells.

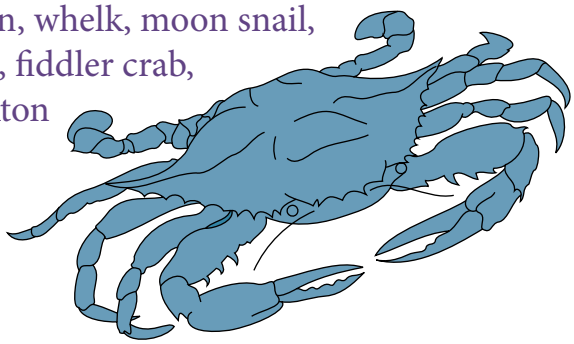
For more information about these habitats, visit http://www.ncfisheries.net/habitat/index.html.

Estuaries are Habitat

There are five types of habitat that can be found in North Carolina estuaries.
Read about each habitat and then see if you can match these plants and animals to the habitat where they are found. Some organisms may be found in more than one of the habitats, so draw as many connecting lines as you think are needed.

Shellfish
oysters, clams,
bay scallop,
shrimp

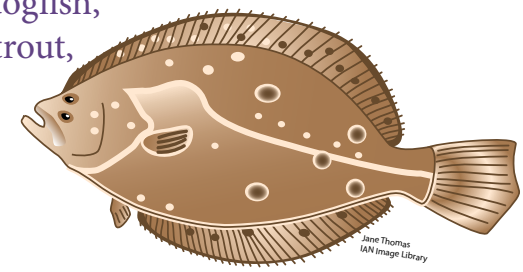
Invertebrates
tubeworms, copepods, brittlestar,
sea urchin, whelk, moon snail,
blue crab, fiddler crab,
zooplankton



Plants
smooth cordgrass,
phytoplankton,
eelgrass,
black needle rush,
bald cypress

Mammals
dolphin, humans,
raccoon, mice

Fish
menhaden, red drum,
flounder, pinfish, dogfish,
bluefish, speckled trout,
summer flounder,
croaker, sharks



Shorebirds
American oystercatcher,
pelican, osprey,
great egret,
white ibis

Reptiles
sea turtles,
snakes

WATER COLUMN

SHELL BOTTOM

SUBMERGED AQUATIC VEGETATION

WETLAND

SOFT BOTTOM

Food Chains

Plants and animals must have energy to survive, grow and reproduce. The energy in sunlight can be directly used by plants, while animals get their energy from food. Food chains are a simple way to visualize how energy flows in an ecosystem.

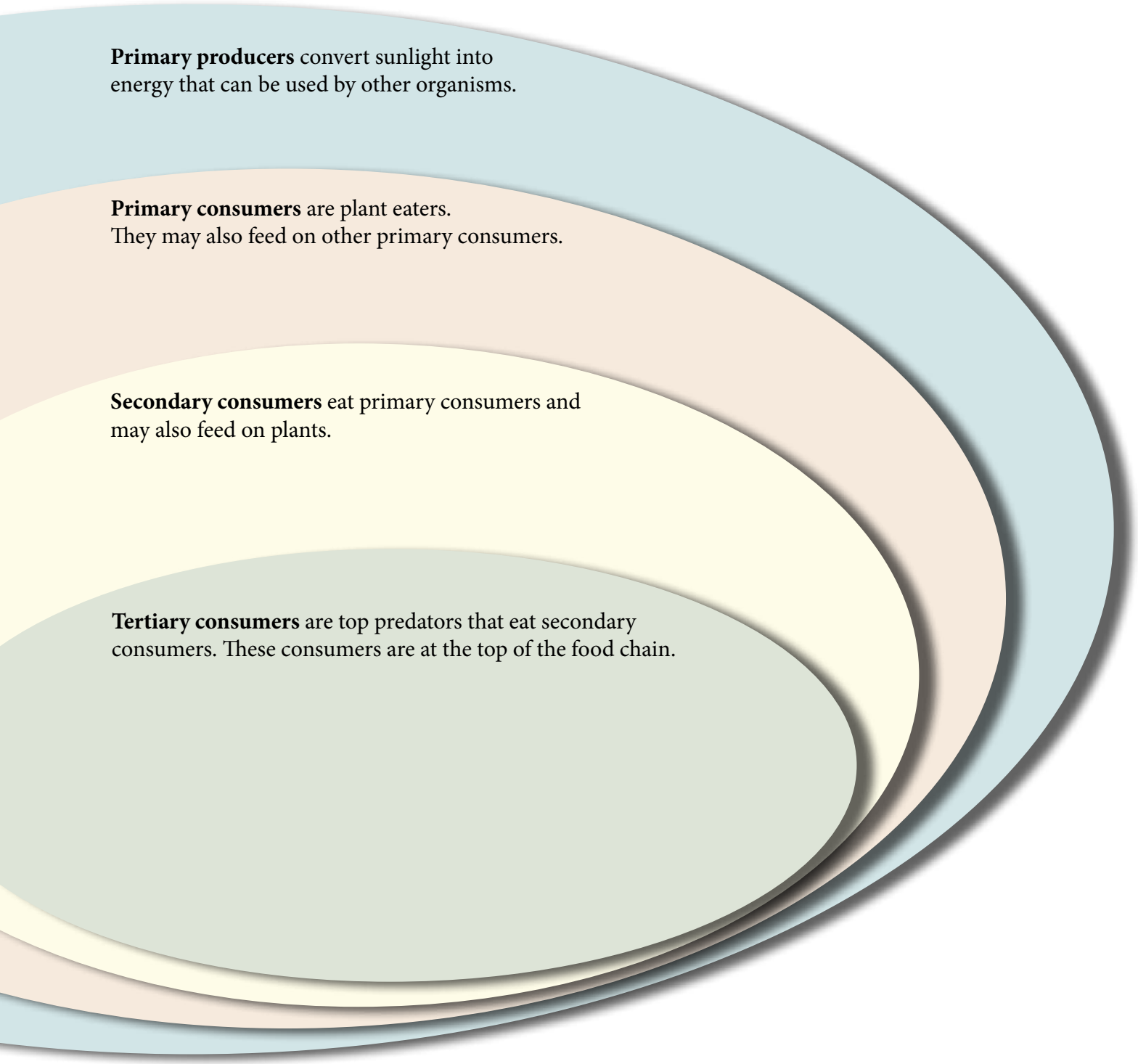
Here is an example of a simple estuary food chain: phytoplankton - shrimp - flounder

Use the following list of plants and animals to make food chains that you might find in an estuary. On the facing page write each organism in the correct circle and draw a line to connect them.
Feel free to add other plants or animals that aren't on this list.

- copepods
- pelican
- striped mullet
- phytoplankton
- American oystercatcher
- cownose ray
- bluefish
- dinoflagellates
- leatherback sea turtle
- amphipod
- common sea star
- herring gull
- cannonball jellyfish
- red drum
- hard clam
- spotted seatrout
- moon snail
- detritus
- bay anchovy
- sand dollar
- Atlantic bottlenose dolphin
- pinfish
- bay scallop
- skate
- grass shrimp
- Atlantic brief squid
- blue crab
- people
- eastern oyster
- sunray venus clam
- zooplankton
- algae
- scalloped hammerhead shark

In reality, food chains are connected to each other to create food webs.
To see how complex food webs can be, draw lines between the members of your food chains.

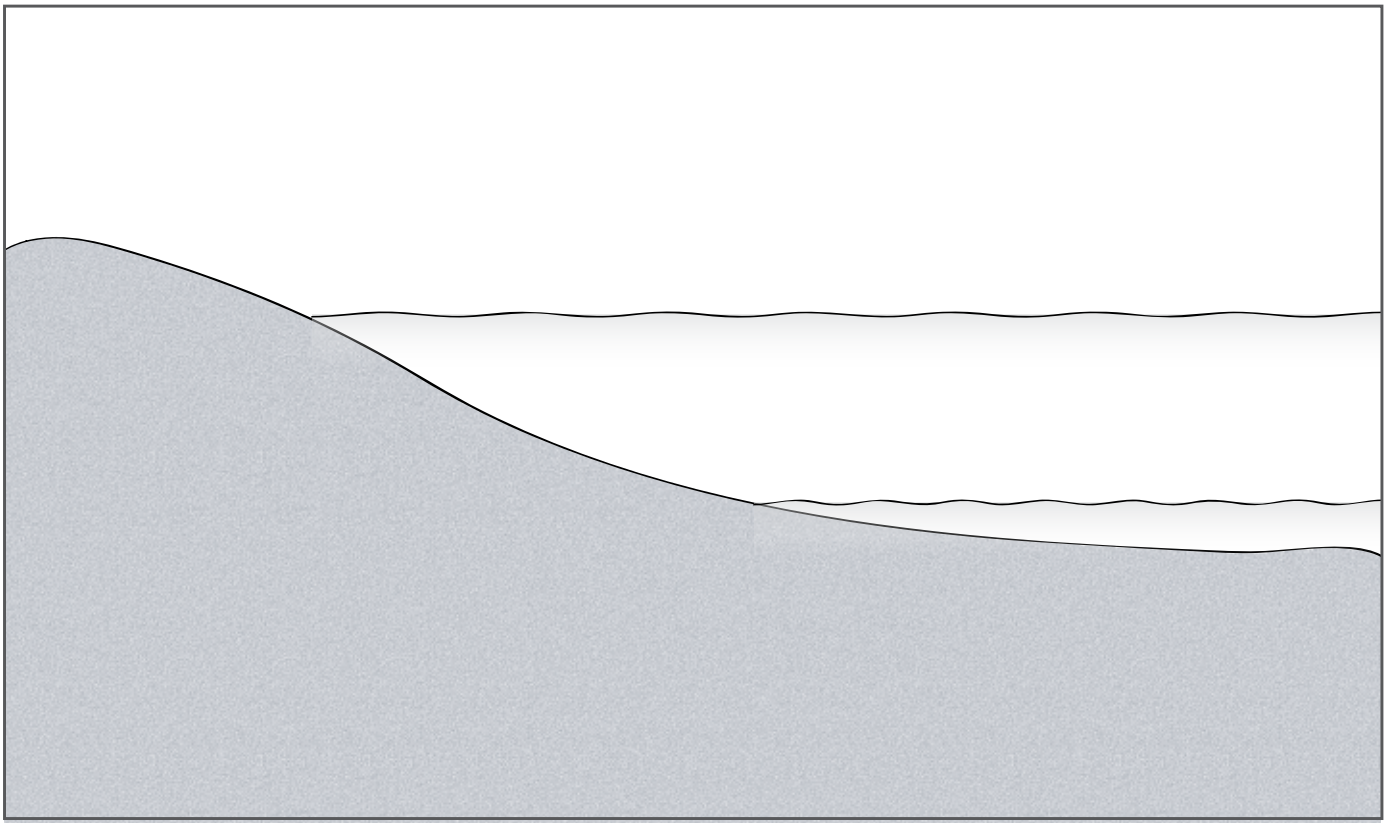
Each circle represents a different trophic level - a trophic level is a particular position occupied by a group of organisms in a food chain. In general, only about 10% of the food energy in a trophic level is passed up the food chain. This means there are many more organisms in the lower trophic levels and fewer animals at the top. If so little energy is transfered to the next trophic level, what do you think happens to the other 90% of the energy?



Can you think of some ways that environmental impacts at one level in the food chain may affect the levels above and below?

Erosion in the Estuary

As water flows along the shoreline, it can wash away, or erode, the natural shoreline. Erosion may be caused by daily tidal flow, storm surges and boat wakes. Even though some erosion results from natural processes, it can be a threat to shoreline property. Many property owners wish to protect their land and take action to decrease or prevent erosion.



Let's compare two kinds of shoreline stabilization methods - **living shorelines and bulkheads.**

Living shorelines are a creative approach to protecting estuarine shorelines from erosion by using engineered structures to maintain, restore or enhance the shoreline's natural habitats. In some cases, a short wall, or **sill**, built of rock or oyster shell can be added just offshore to help decrease wave energy. Sediment may be added during the construction of living shorelines.

Bulkheads (also called seawalls) are hard vertical structures that block waves from the land. They may be built of plastic, metal or concrete. Because the wave energy is reflected back into the water column, sediment at the base of the seawall and along adjacent shorelines may be washed away.

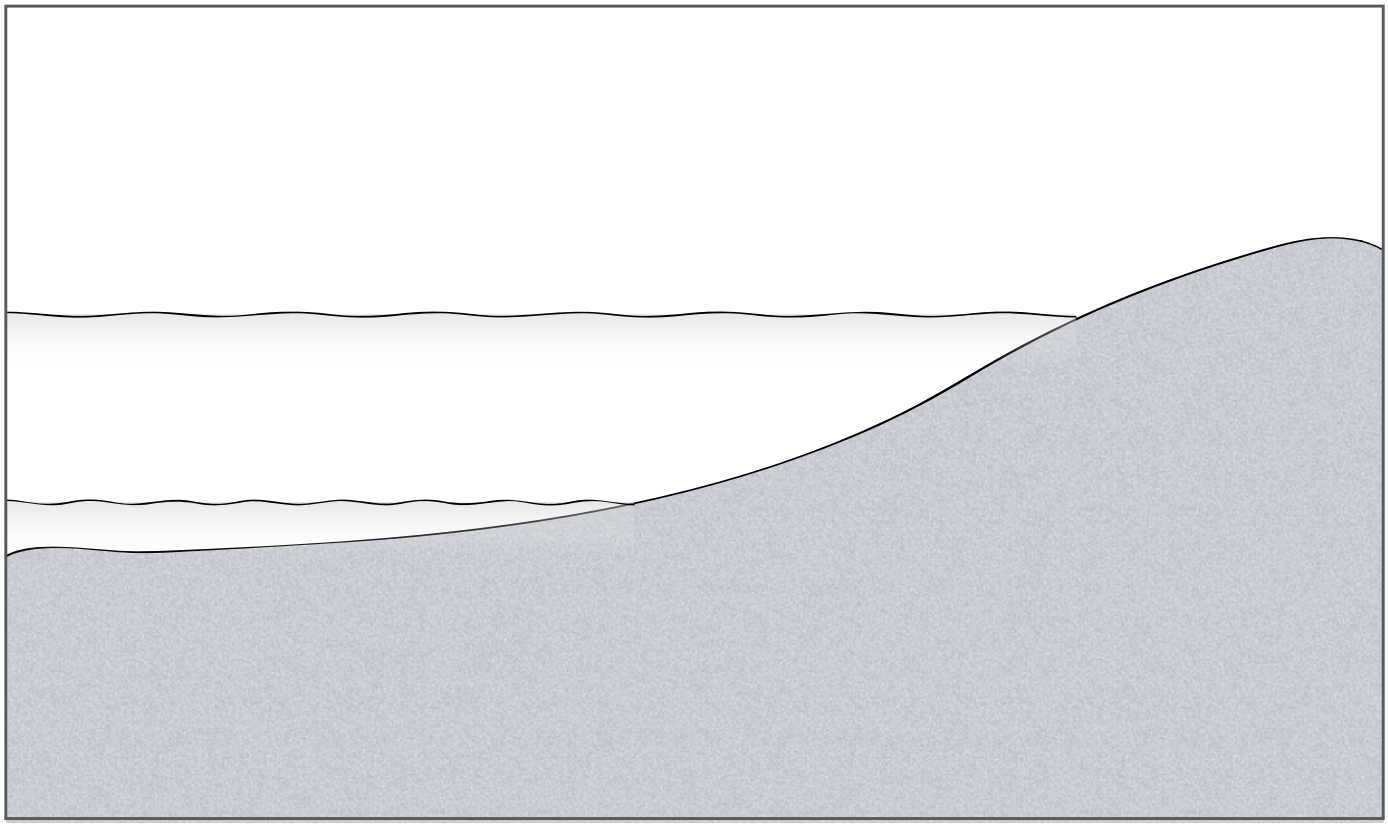
Below are two eroding shorelines. In the left box draw in the components of a living shoreline. In the other box draw the components of a seawall. What are some of the plants and animals that you would expect to find along an estuary shoreline in North Carolina? Include these in your drawings if you think they would be found there.

What are the pros and cons of these two shoreline stabilization methods?

Which do you think does a better job of protecting shoreline habitat for estuarine plants and animals?

Why would people choose seawalls instead of living shorelines?

What are some other things that people could do to decrease erosion and protect estuarine shorelines?



Word Find

l o a r p m i r h s r a m b o o h e h n
a r o e r l u o r i v e r t d t s s n a
y r e s r u n l a l g a e n t s i f i d
e e t t p o a b l n h h a p e f f t n f
e t i u c r s p l e u l t r n a l a a r
l s u a y g e i d c t h s i f y l l e j
f y y r i l a y o e s i p m d s e f u r
b o w y i p g i w n b a i a i e h d m l
a r r c t r r n n i n n e r l d s u i d
d u a a r i a v s i t n e y p i i m g t
c n t r g u s e t e a i a p l m k h r e
v l s i a e s r r i r h h r e e c p l c
e s a l t w a t e r a p c o k n a l r n
t l e m e p i e a v d l o d y t r a l d
p r s u s d o b m c i o h u o e b n n n
n c s e a t u r t l e d n c c o e k e u
y b u l k h e a d e n a o t a d f t l o
t u r b i d i t y t l e n i l e r o h s
k r a h s d a e h t e n n o b o b n t a
e g r e t h e r v o e e i n a e c o e f

pinfish
high tide
primary production
barrier island
tide
inlet
erosion
salt water
biodiversity
jellyfish
seagrass
plankton
invertebrate
brackish
pelican
osprey
bonnethead shark
sea star
food chain
marsh
spartina
crab
fish
river
estuary
sediment
mudflat
nursery
mullet
oyster
wetland
dolphin
seaturtle
sound
downstream
forage
beach
intertidal
egret
ibis
shellfish
shoreline
turbidity
crustacean
clam
algae
shrimp
bulkhead
ocean

Word Ladders

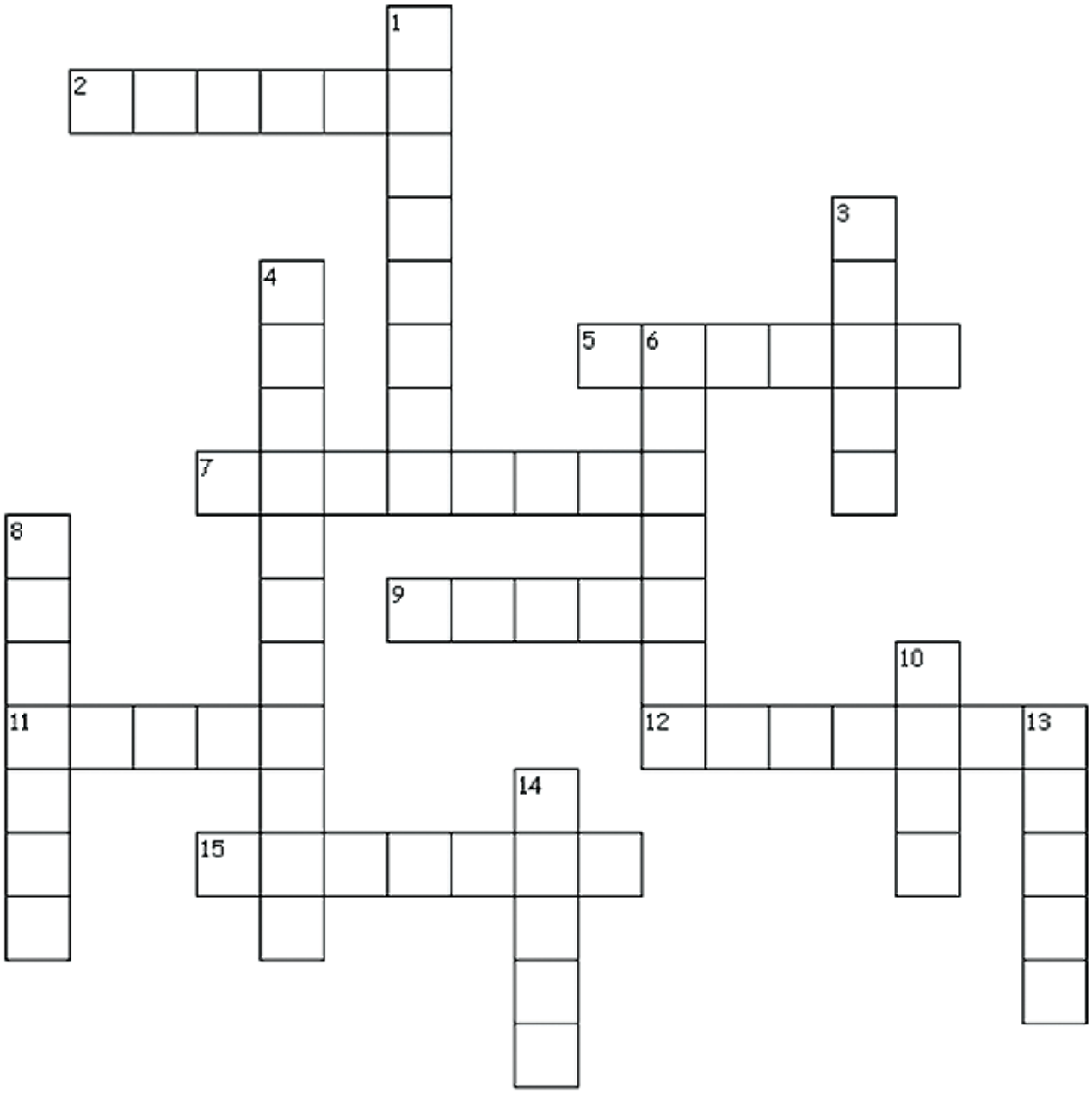
Change one letter each time to create a new word.

Example:
red, bed, bad, bar, car

Clam, _____, _____, _____, Slip
Fish, _____, _____, _____, Wasp
Gull, _____, _____, _____, Sail
Salt, _____, _____, _____, Game

If you get stumped, the answers to these puzzles are on the back cover.

Crossword Puzzle



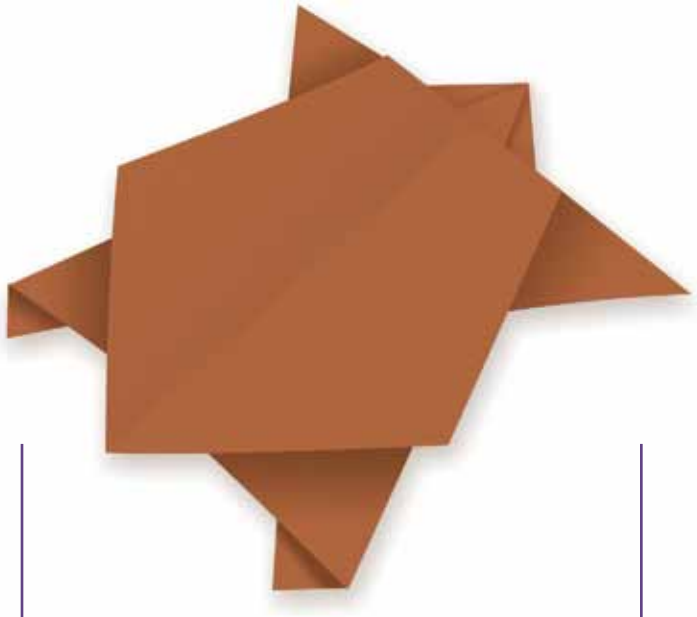
Across

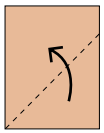
2. Reef building bivalve
5. Diving bird of prey
7. a.k.a. smooth cordgrass
9. An opening to the sea
11. Fierce ocean hunter
12. NC's state saltwater fish
15. Favorite ocean mammal

Down

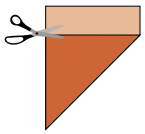
1. It eats other animals
3. A mollusk with an opening on the right or left
4. One kind of microscopic sea life
6. 5-armed ocean resident
8. A threat to estuary shorelines
10. Pinching crustacean
13. Important estuary habitat
14. Freshwater source in estuaries

How to Make an Origami Sea Turtle

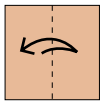




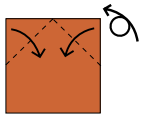
1. Begin by making a square piece of paper. Fold one corner of a piece of paper over to the adjacent side.



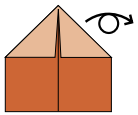
2. Like this. Finish making the square by cutting off the small rectangle.



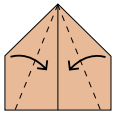
3. Fold side to side and unfold. This is the "valley fold" or "river."



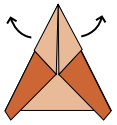
4. Turn over and fold right and left points down to form a "roof."



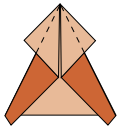
5. Like this. Then turn over.



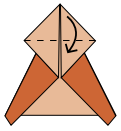
6. Bring the folded edges to meet the valley fold (the river). Crease flat.



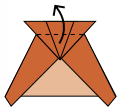
7. Unfold the top side points.



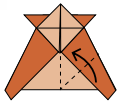
8. Like this.



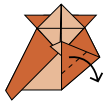
9. Fold the top point down as shown.



10. Fold the point upward to create a head.

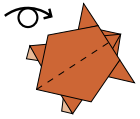


11. Lift the bottom edge to meet the vertical center line.



12. Like this. Press flat and fold outward as shown.

13. Repeat steps 11 and 12 with the other foot.

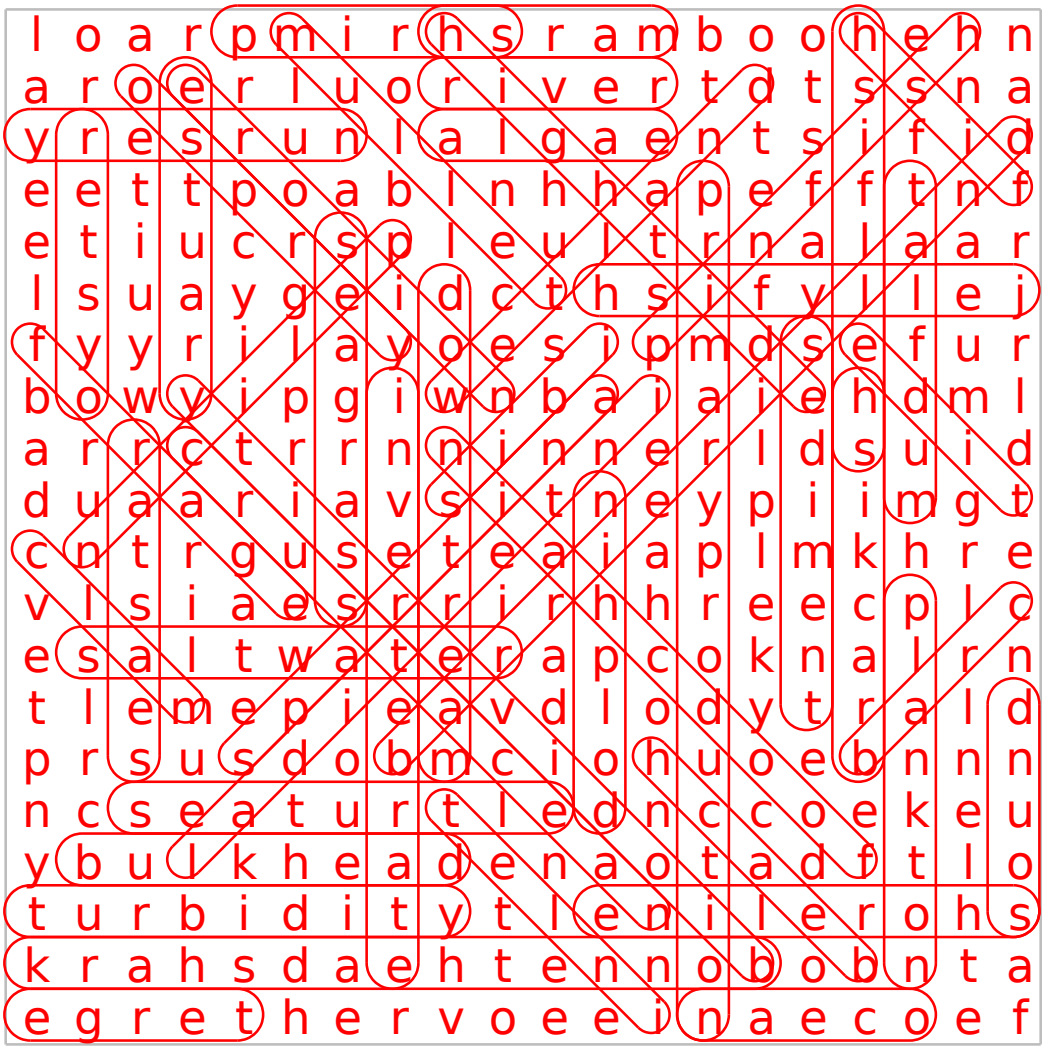


14. Turn over. You've made a turtle!

Origami illustrations courtesy Matt McIntosh, NOAA

Orgami Sea Turtle

Cut out along dotted line for your square piece of paper



pinfish
high tide
primary production
barrier island
tide
inlet
erosion
salt water
biodiversity
jellyfish
seagrass
plankton
invertebrate
brackish
pelican
osprey
bonnethead shark
sea star
food chain
marsh
spartina
crab
fish
river
estuary
sediment
mudflat
nursery
mullet
oyster
wetland
dolphin
seaturtle
sound
downstream
forage
beach
intertidal
egret
ibis
shellfish
shoreline
turbidity
crustacean
clam
algae
shrimp
bulkhead
ocean

Word Ladders

clam, clap, flap, flip, slip
fish, dish, dash, wash, wasp
gull, full, fall, fail, sail
salt, sale, save, same, game

Crossword puzzle answers

Across

2. oyster
5. osprey
7. Spartina
9. inlet
11. shark
12. red drum
15. dolphin

Down

1. predator
3. whelk
4. zooplankton
6. sea star
8. erosion
10. crab
13. marsh
14. river

Suggested Food Chains

- copepods, striped mullet, spotted seatrout, Atlantic bottlenose dolphin
- phytoplankton, bay anchovy, Atlantic brief squid, bluefish
- phytoplankton, bay scallop, cownose ray, scalloped hammerhead shark
- detritus, grass shrimp, blue crab, red drum, people
- dinoflagellates, eastern oyster, American oystercatcher
- zooplankton, hard clam, common sea star
- phytoplankton, sunray venus clam, moon snail, herring gull
- zooplankton, cannonball jellyfish, leatherback sea turtle
- algae, sand dollar, skate
- amphipod, pinfish, pelican/osprey