



Curriculum Guide for Grades 3-12

www.marex.uga.edu/shellfish

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Introduction to the Curriculum Guide

All activities within this curriculum guide are correlated to the Georgia Performance Standards for Grades 3-12 and are intended to be utilized in conjunction with the Second Edition of the Adopt-A-Wetland Manual. In addition to GPS standards, each activity includes suggested grade level(s), focus question(s), objective(s), and key words to assist with planning and implementation. Key words are defined in the comprehensive glossary located at the end of this curriculum guide. A list of materials needed for each activity are also included; as most materials can be readily found or created by items purchased at grocery, craft and hardware stores, the tornado tubes (“Where the River Meets the Sea” on page 53) were purchased through Steve Spangler Science (www.stevespanglerscience.com).

For further information on topics covered and materials utilized in this curriculum guide, please reference the Second Edition Adopt-A-Wetland Manual and the Center for Ocean Sciences Education Excellence (COSEE- Southeast) (www.scseagrant.org/se-cosee). Additional coastal habitat and species fact sheets can be downloaded from UGA Marine Extension’s Shellfish Laboratory web page (www.marex.uga.edu/shellfish) and Georgia Department of Natural Resource’s KNOW THE CONNECTION (www.knowtheconnection.com).

Let us know what you and your students thought about these activities by submitting pictures and evaluations of activities featured in the AAW Curriculum Guide for Grades 3-12. If you cannot find the proper materials or have no time to search, let us help. Most materials for these activities are available on loan through the AAW Traveling Trunk program.

AAW Traveling Trunk requests and activity feedback can be mailed or faxed to:

Adopt-A-Wetland Coordinator
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Chapter One

Introduction

Activities:

Important Roles of the Wetlands
Coastal Storm Surge



Photo by Fran Lapolla

Important Roles of the Wetland

Grade Levels: 3rd, 4th, 6th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3L1, S3L2, S4L1, S7L4, SB4, SEV4, SEV5

Focus Question:

- Why are wetlands important to nature and coastal communities?

Objectives: The students will:

- Identify important roles of wetlands in society.
- Identify ways that wetlands are important for nature.

Materials: (one set per group)

- Pacifier
- Sponge
- Cleaning product
- Sieve
- Can or box of food
- Hand mixer
- Toy bird
- Toy boat
- Basket or container

Key Words:

- | | | |
|--------------|---------------------|-----------------|
| ● Diversity | ● Hydric Soils | ● Phytoplankton |
| ● Filtration | ● Migration | ● Productivity |
| ● Food Web | ● Natural Disasters | ● Toxin |
| ● Habitat | ● Nutrients | ● Zooplankton |

Procedures:

1. Divide the class into groups of 4-8 students. Each student in each group should have at least one item from the above list of materials.
2. Have students collaborate as to the relationship of their object to the importance of a wetland.
3. Groups should present their findings to the class. There are many correct answers and this presentation allows students to gain new perspectives from other students on wetland roles.

Examples of possible answers:

- **Pacifier:** Wetlands act as nurseries to many fish and invertebrate species, providing protection that may not be provided by other habitats.
- **Sponge:** Wetlands soak up excess water during storm surges and floods.
- **Cleaning product:** Wetlands clean run off water as it makes its way through the wetland.
- **Sieve:** Wetlands filter out sediment during rainfall events.
- **Can or box of food:** Wetlands are home to many species of animal that are important food sources for humans; such as blue crabs and shrimp.
- **Hand mixer:** Wetlands constantly mix aquatic nutrients due to the ebb and flood tides.
- **Toy bird:** Georgia's wetlands are important resting and feeding areas for many migratory bird species.
- **Toy boat:** Wetlands provide areas for human recreation such as boating.
- **Basket or container:** Wetlands are a home to a large diversity of plants and animals.

Conclusions:

- Have the students write a short essay based on the following statement:
“Wetlands play an important role in my life because_____”

Further Thinking:

Additional Relationships:

- Can your students find additional items that come to mind when discussing wetland roles and wetland importance?

Incorporate Metaphors:

- Instead of the actual items from the material list, simply utilize pictures and have the students pull a picture from a bag or conduct an open class discussion with the pictures.
- Either way, utilize metaphors to find similarities between the pictured items and the wetland.
- The student’s statement should be similar to the following statement:
“The marsh is like a bed (pictured item) because it provides a resting place for migratory birds (similarity).”

Source: Margaret Olsen and Angela Bliss based on The Blue Crab in North Carolina found at <http://www4.ncsu.edu/~gmparkin/Estuaries.html> and Project Aquatic Wild printed by the Council for Environmental Education

Coastal Storm Surge

Grade Levels: 5th, 6th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S5E1, S6E3, S6E4, S6E5, S7L4, SB4, SES3, SES5, SEV3, SEV5

Focus Question:

- Does a hurricane's storm surge impact wetlands and estuaries along the Georgia coast?

Objectives: The students will:

- Simulate the effects of a hurricane's storm surge on low-lying areas of Georgia's coast.
- Determine the distance inland that the storm surge will affect.

Materials: (one set per group)

- Long plastic container such as an under the bed storage container or stream table
- Milk jug or pitcher
- Sand
- Water
- A variety of materials such as Lego blocks, Monopoly houses or other items with which to build houses (such as shells, sticks, rocks, leaves, grass, straws, cardboard, etc.)
- Sponges (to be cut up and placed to represent the marsh)
- Tiny toy animals, people, cars, etc.
- Plastic straws (to place the houses on stilts-optional)
- Block of wood
- Erasable markers
- Paper towels for clean-up

Key Words:

- | | | |
|------------------|--------------------|--------------------------|
| ● Barrier Island | ● Flood Tides | ● Semidiurnal Tide Cycle |
| ● Beach | ● Hurricane | ● Spring Tides |
| ● Ebb Tides | ● Natural Disaster | ● Storm Surge |
| ● Erosion | ● Neap Tides | ● Wetland |

Procedures:

1. Once all materials have been obtained, have groups fill the left half of the large plastic container or stream table with sand. The sand will represent the land and the substrate under the estuaries. The now empty right side of your container represents the ocean.
2. Moisten the sand in the container and create a meandering deep river down the center of the sand by running your finger through the sand. The river will run from the mainland to the ocean.
3. Off the main deep river that was just created, create several smaller, curving waterways that will represent tidal creeks. These tidal creeks run through the estuaries and are deeper at the river's edge becoming shallow farther away from the river.
4. On both sides of the river (near the ocean), create low areas in the sand and place pieces of damp sponge in these areas which represent the salt marshes.
5. At the mouth of river, create an oval shaped barrier island out of moistened sand. This should be several inches from the mouth of the river and should not completely block the mouth of the river as most of the ocean water should have access to the river.
6. Slowly add water to the ocean side of the container. Add enough water to surround the island and enter the mouth of the river. Do not completely cover the island.

7. On the island, add houses (some should be on stilts), hotels, cars, animals, and people. Also add additional marshes (with sponges) on the mainland side of your island.
8. Along the river add towns, houses, factories, cars, animals and people.
9. On the outside of the container, use an erasable marker and place a mark every inch from the ocean edge of the island all the way up the river. Starting at the ocean's edge of the barrier island, label each mark 0, 1, 2, 3, etc. where each mark represents one inch).
10. To create waves, use the block of wood and very gently tap the water (ocean) by moving it in an up and down motion to create mild waves. Have students observe and record what happens to the island, the marshes and the mainland behind the island.
11. Create a mild storm by creating waves with a stronger force. Do this by pushing the block of wood up and down into the water with more force than before – but not too strongly.
12. Have students observe and record what happens in the model.
13. **Read this part carefully to the students before they begin!!!** Create a hurricane storm surge. To do this, push water from the ocean onto the island and mainland. Use the block of wood to force the water from the ocean onto the island and mainland. At the same time, have another student pour additional water into the model to represent the heavy rainfall during a hurricane.
14. Have students record the final simulation observations and prepare a discussion as effects of the hurricane's surge on their wetland.

Conclusions:

- Describe what happened in your model when you created mild waves (and wind). Describe the flow of water in the wetlands, river, and tidal creeks.
- Which area of your model received the greatest impacts from the waves? Explain why this happened.
- Describe what happened when you created a mild storm in your model. Describe what happened in the wetlands, river, and tidal creeks.
- Which area of your model received the greatest impact from the waves during the mild storm?
- Explain how barrier islands help to protect the mainland from the effect of storms.
- Describe what happened in the model when you created the hurricane storm surge. Explain what happened in the wetlands, river, and tidal creeks.
- Was any area of your model “safe” from the storm surge during your “hurricane?” Explain your answer.
- What recommendations would you make to a developer who is interested in building on coastal properties?
- Describe how the aftermath of a storm surge can impact the lives of the people living in that area and the economy of the community.

Further Thinking:

- Repeat the activity to investigate the effects to the surrounding aquatic ecosystems. Devise some means of adding coloring to the water to represent sewage, chemical contamination and runoff. Some suggestions might be to add colored tissue paper under the houses and factories or place small containers of water dyed with food coloring in various places under the sand near some of the houses and factories. You could also add dirt, tea leaves, or coffee under some areas of the sand to represent sedimentation. Discuss the affects of pollutants and sedimentation on the surrounding marine life.
- Have the students create a campaign to educate coastal developers and real estate agents about the hazards of building too close to our estuaries. Ties in to the Role Play Activity found in Chapter Six of this Curriculum Guide.

Source: Margaret Olsen and Katie Greganti

Chapter Two

Wetland Registration, Watershed Survey & Map Assessment

Activities:

Get Oriented
Cache In!



Photo by Angela Bliss

Get Oriented

Grade Levels: 4th, 5th, 8th

Georgia Performance Standards: M4M2, SS4G1, SS5G1, SS8G1

Focus Question:

- How do students use a compass to complete an orienteering course?

Objectives: The students will:

- Learn to work as a team.
- Learn to utilize navigational tools such as a compass.
- Calculate personal pace.

Materials:

- 3 sheets of blue, red, and green construction paper
- Coordinates for each station of the 3 courses
- 24 envelopes (1 for each of the 8 stations)
- 3 clipboards with blank paper and pencil
- 3 compasses

Key Words:

- Azimuth
- Cardinal Directions
- Compass
- Magnetic North
- Orienteering
- Pace
- True North

Procedures:

1. Prior to this activity, make sure you have covered the basic compass reading concepts and compass use skills.
2. Before class, establish 3 courses (BLUE course, RED course, and GREEN course) with each course having 8 stations. Each station will have the next azimuth for the students to follow and distance to the next station. Try to avoid metal fences when establishing your courses.
3. After you have established the 3 courses, set up each station. Write “WETLANDS” in large letters on the BLUE construction paper and cut into individual letters so 1 letter from the word will be in its own envelope along with the next azimuth and the distance to the next station.
4. Write “TERRAPIN” on the RED construction paper for the RED course and “SPARTINA” on the GREEN construction paper for the GREEN course so that each of the courses’ 8 envelopes will contain a letter, azimuth, and distance.
5. Fill envelopes and place at each station along the course. Be sure to have the letters found in the proper order. This will help students know if they are successfully completing the course.
6. When class arrives, have students calculate their pace. This is easily done by marking off a 100 foot course in which students walk at a regular speed while counting their pace. Have them calculate distance covered per pace by dividing the 100 feet by the number of paces that it took for them to complete the 100 foot course. For instance, if students completed the 100 foot course in 25 paces, then the distance covered per pace equals 4 feet. Students can take that knowledge and determine how many paces it will take them to cover the distances between each station.
7. Divide the class into 3 groups (BLUE group, RED group, and GREEN group). You may choose to designate a student who had a mathematically easy pace, such as 20 or 25, to be

the pacer and you may choose to designate 1-2 students with proven compass skills to be the azimuth readers.

8. Hand out supplies per group and let them know which color their group represents, but do NOT tell them the word or letters that they will be collecting.
9. Tell students the boundaries for the orienteering course. Also, give them a time limit so that students will return to the same spot at the same time even though they may not be able to complete their course.
10. Students must navigate the course based on the azimuths that you have created. If you feel the course is difficult, you can also include hints or riddles in your envelopes.
11. To prevent trash around your facility, have the groups collect their envelopes when finished with each station.
12. When all students have returned, discuss their course and the words that were collected.

Conclusion:

- Were all groups able to find all 8 envelopes and their 8 colored coded letters? If not, what prevented them from doing so?
- What was the most challenging part of the course?

Further Thinking:

- Instead of letters, hide actual pieces of a puzzle at each site. Students must collect all pieces of the puzzle and solve upon completion of the course.
- Make the courses longer with more difficult approaches.

Cache In!

Grade Levels: 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3CS3, S4CS4, S5CS5, SS4G1, SS5G1, S6CS9, S7CS4

Focus Question:

- What is geocaching?

Objectives:

 The students will:

- Learn to work as a team.
- Learn to utilize navigational tools such as a GPS unit.
- Utilize technology to find the cache location(s).

Materials:

- Log Book and pencils
- GPS Unit
- Geocache site(s)
- Replacement cache item(s)
- Optional: Camera to document accomplishments

Key Words:

- Cache
- Geocache
- Global Positioning System
- Latitude
- Longitude

Procedures:

1. Have students access The Official Global GPS Cache Hunt website for local site(s) at www.geocaching.com by utilizing a zip code for your area.
2. From the list of nearby geocaching sites, choose an entry level hunt to find as a class.
3. Be sure to read up on geocaching rules; such as, proper cache to leave, types of cache that you are seeking, if there are attached travel bugs to the cache you seek, etc. All of this information can be found on www.geocaching.com.

Conclusion:

- What was the most difficult part of finding a cache or cache site?
- Is GPS technology more accurate than maps and compass? Why or why not?

Further Thinking:

- Discuss use of GPS research in monitoring wetlands; such as, habitat loss, marsh die back events, or seasonal variations.
- Sponsor and maintain a geocache site as a class project and keep tabs on who accesses your site.
- Sponsor a “Cache In, Trash Out” event.
- Maintain a school wide newsletter of your accomplishments.

Source: Angela Bliss based on The Official Global GPS Cache Hunt webpage

Chapter Three

Visual Monitoring

Activities:

It's All Downstream from Here
Wetland Relay
Being the Pollution Solution



Photo by Angela Bliss

It's All Downstream from Here

Grade Levels: 3rd, 6th, 8th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3L2, SEV5, SS2G1, S6E3, SS8G1, AG-BAS-3

Focus Question:

- What are the impacts of pollution in wetlands and on a watershed?

Objectives: The students will:

- Discuss the movement of trash and pollution from a river or stream to the ocean.
- Understand stewardship of waterways and watersheds.
- Understand the connectedness of communities from inland to the coast.

Materials:

- One item of cleaned trash per student

Key Words:

- | | | |
|----------------------|------------------------------|-------------|
| ● Barrier Island | ● <i>Escherichia Coli</i> | ● Tributary |
| ● Bioaccumulation | ● Non Biodegradeable | ● Watershed |
| ● Biodegradable | ● Non-point Source Pollution | |
| ● Biomagnification | ● Point Source Pollution | |
| ● <i>Enterococci</i> | ● Tides | |

Procedures:

1. Have students line up in a straight line with each student holding 1 piece of clean Garbage.
2. Designate the student at the far left of the line as “upstream” (or the headwaters), designate the student at the far right of the line as the “ocean”, and all students in between represent the many tributaries and water bodies from the headwaters to the ocean.
3. Read the following story. As the story progresses, have the upstream (headwaters) student pass his/her trash to the next student, that student will pass both pieces of trash to the 3rd student, and so on down the line until it all reaches the last student. The last student, representing the ocean, will be left holding and juggling all pieces of trash.

Story for “It’s All Downstream From Here”:

Up in the Georgia Mountains, I visited a small community built by a beautiful stream. During my week long visit, I noticed visitors throwing trash on the ground. The wind was blowing paper plates and napkins into the nearby stream. **(PASS ONE PIECE OF GARBAGE)** When asked why they were littering, they replied “It’s OK, as it’s all downstream from here.” As their picnics continued, more winds blew more trash and litter into the stream. **(PASS ONE PIECE OF GARBAGE)** The lightweight paper objects floated away and the stream quickly cleared up and appeared as if no litter had been dumped into the water at all! Where did it go? I was curious and decided to see where it went, so I packed my belongings and took off down the mountain in search of the garbage.

Due to the long journey, I had to spend the night in another small town located along a large stream connected to the tributary that I had visited that morning. As I was eating dinner, I noticed various people sitting by the stream flipping cigarette butts into the water. **(PASS ONE PIECE OF GARBAGE)** As cigarette butts contain harmful chemicals that can make animals sick if ingested, I yelled for them to stop. They replied, “Don’t worry; it’s all downstream from here!” **(PASS ONE PIECE OF GARBAGE)** In an instant, the litter had been carried out of sight by the swift stream current. **(PASS ONE PIECE OF GARBAGE)** Where is this litter going? The next morning, I continued on my journey to find where this garbage was going; it has to end up somewhere and what does this “somewhere” look like?

As evening came, I ended up in a large city, known as Savannah, which is located along a huge river known as the Savannah River. What a magnificent sight to watch the sun set over such a beautiful waterway! After a good night’s rest, I woke up to enjoy a delicious breakfast along the river and noticed a boat owner changing his oil with his boat in the water. Worse yet, he dumped the oily refuse straight into the river! “STOP!” I yelled. He replied “What’s your problem, it’s all downstream from here!” In a few moments, the outgoing tide had taken the oily water out to the ocean and only a slight rainbow pattern appeared on the surface of the water. **(PASS A PIECE OF GARBAGE DOWN THE LINE UNTIL IT ALL GARBAGE ENDS UP WITH THE LAST STUDENT. COMPLETE THE STORY.)**

Heading downstream on the Savannah River, I ended up on a little barrier island known as Tybee Island. It seemed like a clean little town, but the residents seemed very angry. As I walked out onto the beach, I understood why they were so angry. I saw all the residents walking the beautiful sandy beaches with huge bags! Where their seashells that plentiful? NO! They were picking up paper plates, napkins, and cigarette butts that had washed up on the beaches.

I asked one of them what had happened and he told me that the trash comes from upstream each day and collects out in the ocean. With each high tide, litter is deposited in the wrack line along the beaches. Problems have also resulted from unseen pollution; such as *E. coli* and *Enterocci* bacteria. He continues to talk and discuss various times that the area beaches have closed due to high levels of bacteria entering the rivers, wetlands, and oceans after high rainfall events. The bacteria that results from wildlife and pet wastes left on the ground or seeping into water ways through leaky septic systems, can be really harmful to swimmers.

“It seems that the folks upstream don’t understand that rivers and streams are part of watersheds that eventually meet up with the ocean. Along the way, their garbage and lazy practices pollute waterways and negatively effects water quality. When all the pollution accumulates, the bioaccumulation greatly affects the wildlife and human health. Their garbage does end up somewhere, just somewhere away from them!”

Observations:

- Ask the student representing the ocean, how it felt to be left balancing everyone's trash?
- Which of these trash items used in the scenario could have been recycled or reused?
- As our trash fills the land at nearby landfills and we must destroy new habitats to create new landfills, how can you reduce the amount of trash removed from your home each week?
- How can your watershed be affected by pollution?
- Which items can be labeled as biodegradable and non biodegradable?

Conclusion:

- Have students research their watershed using the following web page:
<http://cfpub.epa.gov/surf/state.cfm?statepostal=GA>
- Have students research the impacts of certain types of pollution on biotic or abiotic components within their watershed.
- Draw your watershed including: cities, agriculture, factories, water treatment plants, wastewater treatment plants, landfills, and any other infrastructure that could potential pollute the watershed.
- Have students research recycling stations or opportunities in your area.

Source: Angela Bliss based on the activity known as the “Town of Away” (Source Unknown)

Wetland Relay

Grade Levels: 3rd, 4th, 5th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3L1, S4L2, S5E1, S6E5, S7L4, SB4, SES6, SEV2, SEV3, SEV4, SEV5

Focus Question:

- How do human activities and/or natural occurrences affect the inhabitants and the health of coastal wetlands?

Objectives: The students will:

- Identify human impacts on wetlands.
- Identify natural impacts on wetlands.

Materials:

- Large area (playing field or gymnasium)
- 2 cones to mark race boundaries
- 25 Wetland Relay facts

Key Words:

- | | | |
|-------------------------|------------------------------|--------------------------|
| ● Dredge | ● Groundwater | ● Point Source Pollution |
| ● Effluent | ● Legislation | ● Run Off |
| ● Environmental Impacts | ● Natural Disaster | ● Toxin |
| ● Food web | ● Non-point Source Pollution | ● Wetland |

Procedures:

1. Place 2 cones approximately 50 feet apart.
2. Divide the class into two groups. Group one will represent WETLANDS and group two will represent HUMAN AND NATURAL IMPACTS.
3. Have WETLANDS group proceed to one cone and HUMAN AND NATURAL IMPACTS proceed to the other cone. Both groups should form a straight line behind the cones and face each other.
4. Read the following Wetland Relay Facts and have the proper group member run to the other side and line up at the back of the other group's line. This student has now traded sides.
5. Throughout the activity, take advantage of the opportunity to discuss the facts or the state of the WETLANDS or HUMAN AND NATURAL IMPACTS group.
6. For advanced groups, read the fact and then let them decide if it favors the WETLANDS or HUMAN AND NATURAL IMPACTS group. After they decide, have the proper representative run to the opposing side.

Wetland Relay Facts:

1. It is the year 1600 and Native Americans live in harmony with the estuaries.
⇒ No one runs.
2. Wood is needed to fuel trains for the railroads, and wetland forests are cut down to supply this fuel. The neighboring estuaries fill in with soil carried by the run off from the land as there is no more wetland to filter the sediment from the water.
⇒ One WETLANDS member run to the other side.

3. In the 1930's, the U. S. Government provided free engineering services to drain wetlands and estuaries in efforts to create farmland.
⇒ One WETLANDS member run to the other side.
4. Informative programs begin to educate the public on the incredible values of ecosystems known as wetlands.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
5. Many dams are built to supply water for major upland cities. This prohibits the flow of natural sand and movement of aquatic animals to and from our wetlands.
⇒ One WETLANDS member run to the other side.
6. In 1970, the GA Marshlands Protection Act was legislated. Under this act, Georgia marshes are recognized as a vital natural resource system providing functions such as nursery grounds for fish and wildlife species, buffers against storm surge and a vital link in the local and state economies.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
7. The Clean Water Act passed Congress in 1972. This act controls point source pollution of lakes, streams, and estuaries caused by discharges from pulp mills, oil refineries and chemical manufacturing plants. The act also regulates "non-point sources," such as surface runoff from logging sites, livestock and city streets. This act protects wetlands and estuaries by limiting dredging, filling, and draining, at least in theory.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
8. The Coastal Zone Management Act of 1972 established The National Estuarine Research Reserves System network for long-term research, water-quality monitoring, education and coastal stewardship.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
9. The Resource Conservation and Recovery Act of 1976 protected groundwater by regulating the handling and disposal of waste, especially hazardous waste. Established federal standards to be followed by generators and transporters of hazardous waste as well as by facilities that treat, store, or dispose of such waste.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
10. The Emergency Wetland Resources Act of 1986 slowed wetland and estuary loss.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
11. A major shopping center is built and several hundred acres of wetlands are lost. The runoff from this site finds it way into the local estuary and causes great harm to the animals.
⇒ One WETLANDS member run to the other side.
12. In the 1980's, the Federal Government began non-regulatory programs to restore wetlands. The restoration of these wetlands improves the health of our coastal estuaries.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.

13. President Bush promises "no net loss" of wetlands in 1989.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
14. In 1989, the North American Wetland Conservation Act is established to encourage partnerships between public agencies and other interests to protect, restore, and enhance wetlands.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
15. Many people are moving to coastal regions and wetlands are filled to make way for houses.
⇒ One WETLANDS member run to the other side.
16. A pipe breaks at a local industry, leaking toxic materials into the surrounding estuary.
⇒ One WETLANDS member run to the other side.
17. The wetland Reserve Program restores 118,000 acres of wetlands and estuaries.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
18. In 1989 and 1999, Hurricanes Hugo and Floyd swept through the coast of the Carolinas. Both caused extensive flooding which added debris, raw sewage, oil, and other pollutants to the estuaries of the area.
⇒ One WETLANDS member run to the other side.
19. In 1999, an oil spill occurred off the coasts and damaged many fragile estuarine habitats.
⇒ One WETLANDS member run to the other side.
20. In 2002, GA coastal residents noticed that the *Spartina* was dying. This process of marsh dieback continued to destroy thousands of acres of marsh in LA, GA and some in SC.
⇒ One WETLANDS member run to the other side.
21. The Senate Commerce Committee recently passed the Coastal and Estuarine and Land Protection Act (S. 861) in 2003 which provided money for land acquisition in coastal areas.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
22. On November 19, 2004, EPA and the U.S. Army Corps of Engineers signed the Watershed Management Partnership Agreement to promote watershed and estuary health, economic sustainability and community vitality through effective management of the Nations watersheds and estuaries.
⇒ One HUMAN AND NATURAL IMPACTS member run to the other side.
23. In the Spring of 2005, the southeast experienced an unusual amount of rain. The rivers leading to the Atlantic flooded and picked up pollutants from the land which they carried into the estuaries.
⇒ One WETLANDS member run to the other side.
24. A Power Plant became a point source polluter when it accidentally dumped millions of gallons of hot water into the river which caused a fish kill in a nearby estuary.
⇒ One WETLANDS member run to the other side.

25. Humans are taking water out of the rivers that flow into the estuaries. They use this water for things such as irrigation for crops and bottled water. Also, plants growing in the estuaries don't get enough water or nutrients, which makes the whole food web suffer.
⇒ One WETLANDS member run to the other side.

Conclusions: The students should write a one page summary explaining how human activities and/or natural occurrences affect life in and the health of wetlands.

Be the Pollution Solution

Grade Levels: 3rd, 6th, 9th, 10th, 11th, 12th

Georgia Performance Standards: M6D1, SSCG21, SEV2, SB4, SEV5, S3L2

Focus Questions:

- What are landfill alternatives for trash that litters are communities?
- How does litter affect the wetland habitat?

Objectives:

 The students will:

- Collect, identify and compile litter data.
- Decide landfill alternatives for collected objects.

Materials:

- Clipboards with data sheets (1 per group and 1 for class compilation)
- Trash bags or grocery sacks (Several per group)
- Pencils (1-2 per group)
- Latex gloves (Enough gloves for all students to have 2 with each group receiving extras in case any of their gloves rip)
- An area nearby in need of clean up

Key Words:

- | | | |
|-----------------|------------------------------|---------------|
| ● Biodegradable | ● Environmental Impacts | ● Regulations |
| ● Compost | ● Non Biodegradable | ● Restoration |
| ● Conservation | ● Non-point Source Pollution | ● Stewardship |
| ● Contaminate | ● Point Source Pollution | |

Procedures:

1. Discuss safety issues and rules of litter pick up; such as, precautions on broken glass, cautions of nearby roadways, obvious boundaries of clean up, etc.
2. Divide class into groups of 3-5 students.
3. Have students select a RECORDER with all other students being responsible for picking up litter.
3. Pass out materials to groups (clip board, data sheet, gloves, and pencils).
4. Have students collect litter for 30-45 minutes. Make sure the RECORDER keeps track of the trash types and amounts of litter that each group collects.
6. When collection is over, have all groups record data on one data sheet while discussing their findings.
7. Have kids help separate and count trash into the following categories:
 - Recyclable
 - Reusable
 - Compostable
 - Landfill
8. Properly dispose of items in trash or recycling bin.
9. Discuss findings:
 - What was the most common trash item each group found?
 - What was the most unusual item in each group?
 - How many pieces of trash were found by the entire class?
9. Have students calculate the percentage of trash items that could be recycled.

Conclusions:

- What were sources of the trash?
- Define biodegradable and non-biodegradable. What did we find that fits each of these categories?
- How can litter hurt us or the animals of the marsh, coast or beach?
- How can we prevent and or reduce litter?
- How can we become better stewards of our waterways and wetlands?

Further Thinking:

Trash Math:

- If each person in your family makes 4 pounds of trash a day, how many pounds of trash does your family make in a week? In a year? Most of this trash is most likely to end up in a landfill. If everyone on Earth produced 4 pounds of trash each day, how much trash is produced in the United States each day? How much is produced globally each day based on 4 pounds per person?

Stewardship Ideas:

- Stewardship means that you are responsible for taking care of the resources around you. Write a brief essay on valuable resources around you and how you can be a better steward of these resources.

Biodegrade Renegade:

- Biodegradable items break down over time if exposed to the proper amounts of light and water. Paper bags are typically biodegradable, except when placed in a landfill where the bags are not exposed to light or water. Should these bags be labeled as biodegradable? What about other items that we commonly see, such as a cotton sock, cigarette butt, glass bottle, Styrofoam cup, and aluminum can. Find the length of time for these items to decompose, complete the following chart based on a saltwater environment and answer the following questions:
 - Do items biodegrade equally in freshwater and saltwater environments?
 - Which will biodegrade first in a saltwater environment: an aluminum can or a cigarette butt?

Decomposition Rates for Common Types of Marine Debris

Paper Towel
Cloth
Apple Core
Juice Carton
Styrofoam
Steel Can

Disposable Diaper
Plastic 6 pack ring
Monofilament line
Glass Bottle
Aluminum Can
Cigarette Butt

Answer Key to Student Decomposition Table

Decomposition Rates for Common Types of Marine Debris

Paper Towel	4 weeks*	Disposable Diaper	450 years
Cloth	1-5 months	Plastic 6 pack ring	400 years
Apple Core	2 months*	Monofilament line	600 years
Juice Carton	3 months*	Glass Bottle	Never
Styrofoam	10-50 years*	Aluminum Can	200 years
Steel Can	50 years*	Cigarette Butt	80 years

* Indicates decomposition in saltwater. Freshwater degradation would take longer

http://www.dgif.state.va.us/fishing/sarep/PDF/resp_litter.pdf

Being the Pollution Solution Data Sheet

Investigators _____ Date _____

Location: _____ Length of Pick up _____

Site Description:

Residential Area Business District Park/Green Space Schoolyard

Is water nearby? If so, is it Freshwater or Saltwater?

Directions:

Use gloves and DO NOT pick up sharp or unknown items

Record the numbers and identify the items until your collection time has ended.

PLASTICS:

Bottles	
Lids	
Straws/Wrappers	
Bags	
Other	

METALS:

Bottle tops	
Nails/Screws	
Other	

PAPER:

Food Wrappers	
Cigarette Butts	
Other	

ADDITIONAL ITEMS COLLECTED:

Thank you for being a good steward!

Chapter Four

Biological Monitoring

Activities:

Marsh Bingo
Catch and Release: The Saga of Georgia Shrimp
Classification in the Wetland
Wetland Sculpture Race
A Growing Problem
High Tide Feeding Frenzy



Photo by Angela Bliss

Marsh Bingo

Grade Levels: 4th, 7th

Georgia Performance Standards: S4L1, S7L4

Focus Question:

- What species utilize the wetlands of coastal Georgia?

Objective: The students will:

- Identify animals found in wetlands and marshes of coastal Georgia.

Materials:

- Marsh Bingo Sheets (one per student or group of students)
- One set of the animal cards from the Wetland Classification Cards
- Bowl or bag from which to draw the animal cards
- Beans or pennies to mark off the bingo squares
- Optional: Copies of the Wetland Classification Cards per student or group
- Optional: Field guides of coastal Georgia animals

Key Words:

- Food Web
- Invasive Species
- Hammock
- High Marsh
- Low Marsh
- Non point Source Pollution

Procedures:

1. Pass out the Marsh Bingo cards and have students research and write the animal names into the BINGO card boxes.
2. When the students are finished identifying the animals, go over the names of those on the Marsh Bingo cards and start with the actual BINGO portion of the activity.
3. Choose the level of card coverage necessary to call out MARSH BINGO for that round (Example: diagonally, top line of the card, full card, etc)
4. The first student that calls out MARSH BINGO wins that round.
5. Repeat as desired. For a longer activity, call out a letter from the word “MARSH” along with an animal in order to mark off squares. Be sure to keep track of what combinations have been called.

Conclusions:


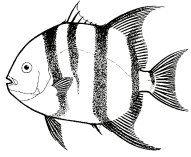




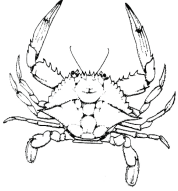






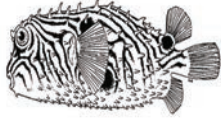










- When the round or rounds have ended, have students discuss any questions that they may have on the wetland animals that were called out during the game.
- Have students research wetland animals mentioned during this activity to learn how those animals utilize portions of coastal Georgia wetlands. (Example: Diamondback terrapins use the tidal creeks for swimming, the high marsh for laying nests, and the low marsh for eating periwinkle snails.)

Further Thinking:

- To increase the difficulty of their wetland animal research, ask the students to find the Kingdom and Phylum of each organism on their marsh bingo cards.
- Students can form food chains and/or food webs from the animals listed in this activity.

Source: Mary Sweeney-Reeves, Margaret Olsen, and Angela Bliss

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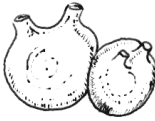




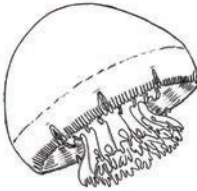
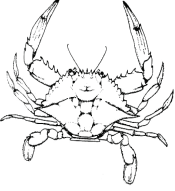







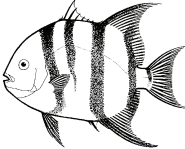


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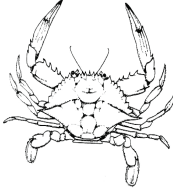








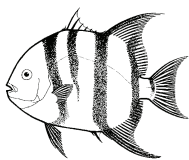





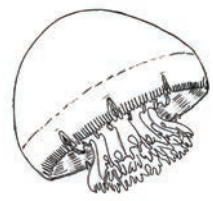

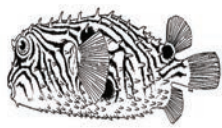

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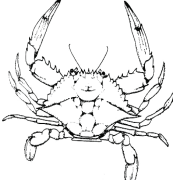



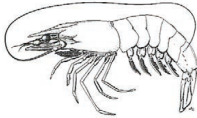











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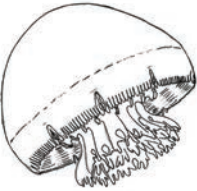




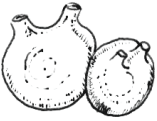

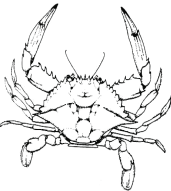









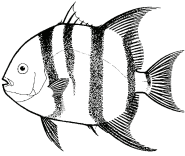
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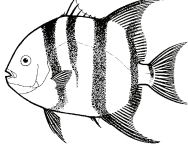







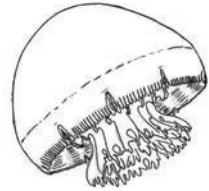

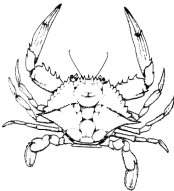












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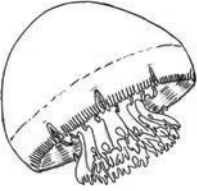
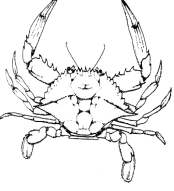


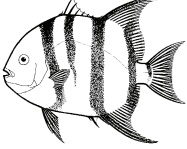







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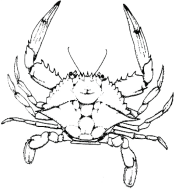








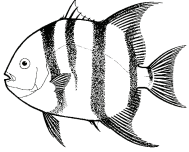


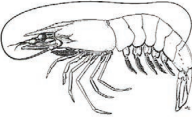






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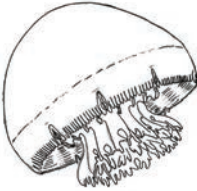
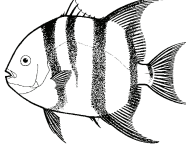




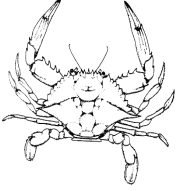
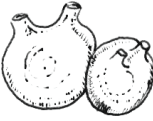














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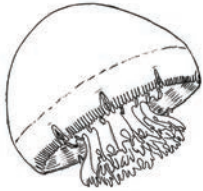




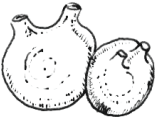

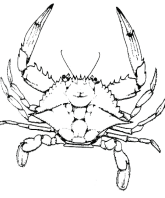









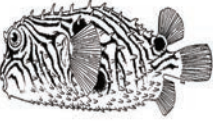
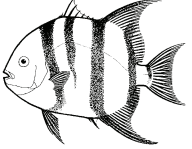
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Catch and Release: The Saga of a Georgia Shrimp

Grade Levels: 6th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: M6D1, M6P4, M7D1, S7CS6, MA1D3, SEV3, SEV2

Focus Question:

- How do you calculate shrimp populations from five sampling sets?

Objectives:

 The students will:

- Gather data through repetitious sampling.
- Calculate shrimp populations within their wetland sample area based on their collected data.

Materials: (one set per group)

- 1 opaque container with slits cut in the lid. (Slits should be large enough for round toothpicks to pass through when shaken.)
- Toothpicks (Record the number of toothpicks in all group's containers before beginning class.)
- Each opaque container should have varying numbers of toothpicks (for example: Group 1: 175 toothpicks, Group 2: 250 toothpicks, Group 3: 350 toothpicks, etc)
- Catch and Release data sheet
- Markers to “tag” samples
- 1 calculator
- Pencil for recording information

Key Words:

- | | | |
|--------------------------|--------------------|-----------------------|
| ● Carrying Capacity | ● Invasive Species | ● Population |
| ● Catch/Release Sampling | ● Meroplankton | ● Dynamics |
| ● Competitive Exclusion | ● Overfishing | ● Population Estimate |
| ● Ecology | ● Permits | ● Sustainable |
| ● Food Web | | |

Procedures:

1. Divide class into smaller groups of 3-4 students.
2. Pass out pencils, markers, data sheets, calculators, opaque containers with toothpicks inside.
3. Have students delegate group members to be the SHAKER, RECORDER, and TAGGER(s).
4. Have the SHAKER shake the container 5 times.
5. The toothpicks that fell out of the container represent the initial shrimp catch. Count the “shrimp.”
6. The TAGGER(s) should tag each shrimp with their marker which represents a “tagging device” and report their findings to the RECORDER.
7. The RECORDER should record this number on the data sheet as this value will become the INITIAL CATCH or (N) as seen in the example on the data sheet.
8. Have the group return all “shrimp” to the container as the initial catch has been marked and returned to the population.

INITIAL CATCH IS OVER, LET THE SCIENTIFIC SAMPLING BEGIN!!

In scientific research, biologists return to previously sampled tidal creeks and begin sampling. The shrimp population of these wetland creeks represented by the opaque containers can be determined by repeating the following sampling methods: (Be sure to record data in proper spaces on data sheet.)

9. Have SHAKER shake the container 5 times.
10. The TAGGERS should count the following:
RECAPTURES or (R): All MARKED “shrimp”
TOTAL SHRIMP CAUGHT or (T): All MARKED and UNMARKED “shrimp”
11. The RECORDER should record both reported numbers on the data sheet in the proper spaces for Sample #1.
12. As a group, divide the (N) value by the (R) value and write in the proper space located in the Sample #1 row.
13. Multiply this newly calculated value by (T) to determine the population estimate based on this one sample.
14. The RECORDER should record this value under **POPULATION ESTIMATE (N/R) x T** for Sample #1.

As true scientific research should be accurate and accuracy comes from repetition, scientists perform the same test multiple times.

THEREFORE, REPEAT SAMPLING AT LEAST 4 MORE TIMES:

15. Repeat steps 9-14 for Sample # 2 and record data in the proper row.
16. Repeat steps 9-14 for Sample # 3 and record data in the proper row.
17. Repeat steps 9-14 for Sample # 4 and record data in the proper row.
18. Repeat steps 9-14 for Sample # 5 and record data in the proper row.

THE GROUPS CAN CONTINUE REPETITIONS FOR A MORE ACCURATE STUDY OR THEY CAN STOP NOW TO EVALUATE CLASS FINDINGS

When finished sampling:

19. Average ALL values listed in the column labeled **POPULATION ESTIMATE or (N/R) x T**. This new value should be recorded on the data sheet.
20. Have groups report their findings and then let them all know how close their estimates fell to the actual number that had been stored in the opaque containers.

Observations:

- Why did you delegate only one person to shake the container? What would happen if the SHAKER role rotated among the group?
- How close did you come to the actual number of specimens in your container? The students' findings should fall close to the actual toothpick counts. (FYI: The example noted on the data sheet actually had 115 toothpicks stored in the opaque container. After sampling and calculating, this group registered approximately 109 “shrimp.”)

Conclusions:

- What would happen if your wetland habitat and tidal creek had a small population of shrimp and many people wanted to catch these animals?
- What natural activity could negatively impact Georgia shrimp populations?

Further Thinking:

- Shrimp utilize the wetlands through various stages of their lives; from meroplankton larval forms drifting with the semidiurnal tides to swimming adults moving out to the deeper waters of the sound. What natural or manmade occurrences could negatively or positively affect shrimp populations off the Georgia coast?

- Which phase of the shrimp’s life was impacted by the natural or manmade occurrence?
- Create a life cycle drawing of a shrimp and list various animals that eat shrimp at each phase.
- List habitat requirements of shrimp during various phases of its life from the wetlands to the ocean.
- Can an ecosystem exceed its carrying capacity? If so, what happens when this occurs? If not, what would prevent the population from exceeding the ecosystem’s carrying capacity?
- Alter the number of “shrimp” in the estuaries, then resample at least 5 times. Possible scenarios listed below:
 - Beautifully green lawns of new coastal subdivisions increased nutrients of the coastal wetlands and created an algal bloom that decreased dissolved oxygen in the wetland’s water. (TEACHER: Remove half of “shrimp” population, record new population number, return to students for sampling.)
 - Increased number of fishing permits for those using net gear. (TEACHER: Add 150 “shrimp” to the population, record actual “shrimp” population, return to students for sampling.)
 - Migratory birds blown off course due to storms and unable to make a feeding stop in the wetland. (TEACHER: Add 75 “shrimp” to the population, record actual “shrimp” population, return to students for sampling.)
 - Increased run-off from expanded highway flows into the wetland creeks and marshes which alters the pH during the shrimp spawning season. (TEACHER: Remove all but 50 “shrimp” from the population, record new population number, return to students for sampling.)
 - Competitive exclusion occurs where an invasive species has been released. The introduction of Lionfish off of Georgia’s coast has decreased adult shrimp populations. (TEACHER: Remove all but 75 “shrimp” from the population, record new population number, return to students for sampling.)

Source: Angela Bliss based on “Estimating Fish Populations” activity from [Awesome Ocean Science](#) by Cindy Littlefield

Shrimp Population Data Sheet					
EXAMPLE					
Number of Shrimp caught in the Initial Catch (N) - 22					
Sample Number	Total Shrimp Caught in Sample (T)	Number of RECAPTURES (R)	Initial Catch/Recaptures N/R	Population Estimate (N/R) x T	
1	20	4	22/4=5.5	5.5 X 20=110	
2	15	5	22/5=4.4	4.4 X 15=66	
3	26	4	22/4=5.5	5.5 X 26=143	
4	33	7	22/7=3.1	3.1 X 33=102.3	
5	28	5	22/5=4.4	4.4 X 28=123.2	
				Average Population = 108.9	
Number of Shrimp caught in the Initial Catch (N) -					
Sample Number	Total Shrimp Caught in Sample (T)	Number of RECAPTURES (R)	Initial Catch/Recaptures N/R	Population Estimate (N/R) x T	
1					
2					
3					
4					
5					
				Average Population =	

Classification in the Wetland

Grade Level: 5th

Georgia Performance Standards: S5L1

Focus Question:

- How are organisms classified?

Objectives: The students will:

- Classify and sort wetland animals (vertebrate and invertebrate).
- Classify and sort wetland vertebrates (fish, amphibian, reptile, bird and mammal).
- Determine habitat zone(s) of vertebrates and plants within the wetland.

Materials: (one set per group)

- Plant and vertebrate Wetland Classification Cards
- Adopt-A-Wetland Manual
- Optional: Field guides for coastal wetland plants and animals

Key Words:

- | | | |
|----------------|--------------|--------------|
| ● Habitat | ● Mud Flats | ● Taxonomy |
| ● Hammock | ● Salt Marsh | ● Wetland |
| ● Invertebrate | ● Sound | ● Vertebrate |

Procedures:

1. Divide class into groups of 5-8 and give each group a set of the Wetland Classification Cards and Adopt-A-Wetland Manual.
2. Ask the students to separate the cards into plants or animals.
3. Have students separate the animal cards into vertebrate and invertebrate.
4. Next have students group the vertebrates into the following groups and discuss why each animal was placed in each category: **Fish, Reptile, Bird or Mammal.**
5. Have students group all the animal cards according to where they would live in a Wetland: **Hammock, Salt marsh, Mud flats or Sound.**
6. Discuss the characteristics of each animal that enable them to live where they do. Some of the animals may be full time residents in the wetland where others may only temporarily utilize this habitat.
7. After the students have grouped all the animal cards, ask them to group the plant cards by which wetland zone they would inhabit: **Hammock, Salt marsh, Mud flats or Sound.**
8. Discuss the characteristics of the plants that enable them to live in that wetland zone.

Conclusion:

- Discuss diversity of each wetland zone. Which wetland zone has highest diversity? Which wetland zone has lowest diversity?
- As a class, discuss the student's methods of classification.
- Have each student pick one animal and research the animal's scientific name (Kingdom, Phylum, Class, Order, Family, Genus, Species).

Source: Margaret Olsen and Mary Sweeney-Reeves.

“I Belong Where?”

Grade Level: 7th

Georgia Performance Standards: S7L1, S7L5

Focus Question:

- How are organisms compared scientifically?

Objectives: The students will:

- Classify indigenous wetland species based on physical characteristics using a dichotomous key.
- Demonstrate the process for the development of a dichotomous key.

Materials: (one set per group or student)

- 10 cards selected from the set of Wetland Classification Cards

Key Words:

- | | | |
|-------------------|----------------------|------------|
| ● Characteristics | ● Indigenous Species | ● Plankton |
| ● Classification | ● Nekton | ● Taxonomy |
| ● Dichotomous Key | ● Organism | ● Wetland |

Procedures:

1. Beginning with the collection of classification cards in the center of the working area, instruct the students to decide upon a way to divide the cards into two groups, A and B. One characteristic must be defined and used to decide which pieces are placed in which group. For example, a collection of cards might be divided into groups of those that are animals and those that are not animals.
2. Record what factor was used to make the division and note which members of the original collection belonged to each resulting group.
3. After the cards have been divided into two groups, divide the first group (A) into two more groups, based on one criterion (C and D). For example, if group A contains all animals, group C might contain animals with backbones and group D would contain animals with no backbone. Divide group B into two more groups (E and F) based on one decisive factor.
4. Record data on the new groupings and dividing criteria.
5. Continue to divide the groups until each item is by itself, then, name each of the individual objects. Keep careful records.
6. Looking at your records and the divisions you made, create a dichotomous key that would lead someone else to make the same distinctions you did.

In constructing keys, keep the following in mind:

- Use constant characteristics rather than variable ones.
- Use precise measurements rather than relative terms like "large" and "small."
- Use characteristics that are generally available to the user of the key rather than seasonal characteristics or those seen only in the field.
- Make the choice a positive one - something "is" instead of "is not."

When using a key, keep the following in mind:

- Always read both choices, even if the first seems to be the logical one at first.
- Be sure you understand the meaning of the terms involved. Do Not Guess.

- When measurements are given, use a calibrated scale. Do Not Guess.
- Since living things are always somewhat variable, do not base your conclusion on a single observation. Study several specimens to be sure your specimen is typical. If the choice is not clear, for whatever reason, try both divisions. If you end up with two possible answers, read descriptions of the two choices to help you decide.
- Having arrived at an answer in a key, do not accept this as absolutely reliable. Check a description of the organism to see if it agrees with the unknown specimen. If not, an error has been made somewhere, either in the key or in its use. The ultimate check of identifications is a comparison of the unknown with an authentically named "Type Specimen."

Conclusions:

- When two people use the same dichotomous key to identify the same object, is it possible (should it be possible) for them to have different final answers? Explain your answer.
- Why are classification and identification important?
- Write a brief description that describes the process of developing a dichotomous key.

Further Thinking:

When your key is complete, swap with another group and ask a classmate to use it to classify and identify the same collection of items. Does your key lead others to the same identifications you made?

Wetland Sculpture Race

Grade Levels: 3rd, 4th, 5th, 6th, 7th

Georgia Performance Standards: S3CS4, S4CS4, S5CS4, S6CS5, S7CS5, S7L5

Focus Question:

- What types of animals utilize wetlands in Georgia?

Objective: The students will:

- Learn and identify characteristics of a diversity of animals that utilize a Georgia wetland.

Materials: (one set per group)

- One container of sculpting material, like playdough
- Animal Pictures (taken from the Estuary Classification Cards)

Key Words:

- | | | |
|-------------------|----------------|--------------|
| ● Adaptations | ● Food Chain | ● Species |
| ● Diversity | ● Food Web | ● Vertebrate |
| ● Characteristics | ● Invertebrate | ● Wetland |

Procedures:

1. Divide the class into groups of 4 or 5 and give each group a container of playdough.
2. Review the “Rules of the Race” carefully before beginning.

Rules of the Race:

- Each group will select a team name to assist with score keeping.
- Each team will select one team member to be the first sculptor.
- The teacher will call all the sculptors to the front of the room and show them the same picture from the Wetland Classification Cards.
- The sculptors return to their team and all start to sculpt at the same time while their groups try to guess what is being sculpted.
- The sculptor may not say a single word. The other students may ask questions, but the sculptor cannot answer with words. He/she may nod or shake their head. The sculptor continues to mold the organism until someone correctly identifies it.
- The first team member from any group to say the correct name of the organism being sculpted wins that round of the race.
- The next round begins with another person from each group being the sculptor.
- Continue rotating sculptors until your appropriated time is over.
- The team that wins the most rounds is the winner.

Conclusion:

- Have the groups list the organisms that they sculpted during this activity and write a list of adaptations necessary for those organisms to survive in a wetland.

Further thinking:

- Have students sculpt animals of a wetland food chain and share with the class.
- Have the class create a wetland food web from all sculptures.

Source: Margaret Olsen

A Growing Problem

Grade Levels: 3rd, 4th, 5th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3L1, S4L1, S4L2, S5E1, S7L4, SB4, SEV3, SEV5

Focus Question:

- How does the growth of an invasive species affect the balance of native species in that ecosystem?

Objectives:

 The students will:

- Identify the problems associated with invasive species.
- Simulate the growth of an invasive species in an ecosystem.
- Determine methods that can prevent invasive species spread and introduction.

Materials:

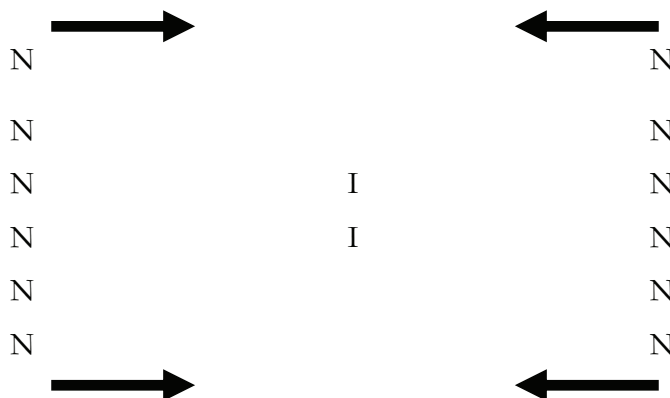
- Large, open area (about the size of a basketball court)
- Cones to mark boundaries
- Invasive Species Fact Sheets
- Signs labeled with “N” for native species and “I” for invasive species that can be worn around the neck (optional)

Key Words:

- Competition
- Indigenous species
- Non Indigenous Species
- Competitive Exclusion
- Invasive Species

Procedures:

1. Clearly define boundaries for the playing area and mark if necessary.
2. Choose one or two students to be an invasive species that is specific to your area. These one or two students are designated as the “I”s and will begin in the middle of the playing area.
3. Evenly divide the remaining students and have them stand on opposite sides of the playing area as shown below. They represent the “N”s.



4. Rules of the game:
 - All students must stay within the boundaries of the game area.
 - Each round begins with the instructor yelling a signaling word (spread, grow, invade, etc).

- All “N” students should try to run from the side they are on to the opposite side without being tagged by the “I”s. Once “N”s have crossed to the opposite side, they are safe and cannot be tagged by the “I”s.
- Each “I” student is allowed one tag per round of play.
- If an “N” student is tagged by an “I,” then they must link one arm with the “I” student thereby representing the spread of an invasive species. This new invasive student exchanges their “N” sign for an “I” and is now able to tag as part of the invasive chain.
**NOTE: For larger classes, you may want to have a maximum number of students that can be included in the chain (ex. when the chain reaches ten students, the large chain must split into two smaller chains of five).
- Rounds of play continue until only one “N” student is left, and all the other students have become part of the “I” chains.

Conclusions:

- What factors (or lack thereof) allow invasive species to grow so rapidly in an area?
- What are some preventative measures that can be used to either contain invasive species in an area or stop their introduction into new areas?
- What problems might long chains or dense mats of an invasive plant cause in an aquatic ecosystem?
- What could happen to fish and invertebrates that rely on plants other than the invasive plant for food or shelter?

Further Thinking:

- Play a game in a smaller or larger area and have the students hypothesize whether the different size will make it easier or harder for the invasive species to spread.
- If using an invasive species with a known control (biological, chemical, or physical), students can be introduced into the game as controls (“C”s) and given the ability to tag the invasive (“I”) students (one per round). How does the introduction of a control affect the invasive population?
- Divide the students into groups and have them research and report on an invasive species of their choice.
- Begin an “Invasive of the Month” bulletin board in your classroom and have each student contribute a fact for the board.

High Tide Feeding Frenzy

Grade Levels: 1st, 3rd, 9th, 10th, 11th, 12th

Georgia Performance Standards: S1L1, S3L1, S3L2, SEV5

Focus Questions:

- Why are tides important for oysters?
- How do bacteria, disease and invasive species impact oyster reefs?

Objectives:

 The students will:

- Learn the four components of a habitat.
- Identify problems resulting from non point source pollution; such as bacteria and disease.
- Identify problems resulting from the introduction of invasive species.

Materials:

- 50 two inch squares of green, blue, yellow, and white construction paper
- 10 two inch squares of black, brown, red construction paper
- Opaque bag to hold construction paper squares
- Large space suitable for students to sit on the ground (classroom size or larger) with designated boundaries

Key Words:

- | | | |
|-------------------------|--------------------|--------------------------|
| ● Bacteria | ● Habitat | ● Semidiurnal Tide Cycle |
| ● Characteristics | ● Intertidal | ● Sessile |
| ● Competition | ● Invasive Species | ● Spat |
| ● Competitive Exclusion | ● Oyster Reef | ● Subtidal |

Procedures:

1. In this activity, students will act like oysters and try to survive to the next tidal cycle by catching the necessary habitat components; which are food, water, shelter, and space.
2. Have students list 4 habitat components essential to an oyster reef:
GREEN (Food)-Plankton brought in from the ocean with the high tide
WHITE(Shelter)-Hard substrate on which the oysters can attach and grow
BLUE (Water)-Being covered with the high tide in order to respire and breathe
YELLOW (Space)-Available reef areas where oyster room to thrive and grow
3. Have students act as spat and drift around the designated area until you yell “SPAT STICK”.
4. Once the spat have found a place to PERMANANTLY attach, explain that oysters are filter feeders and must find plenty of food, water, shelter, and space while stuck in one place.
5. As the spat try to wave their arms and take in the habitat components, walk and weave around them representing the incoming high tide and randomly distributing the various colored squares in the air for them to catch.
6. Students must catch at least 1 blue, 1 yellow, 1 white, and 1 green habitat square in order to survive to the next high tide event. Students must catch all squares that they touch, which is important for the negative impact portion of this activity. Catching additional squares of these colors is encouraged as it will produce large more robust oysters on the reef.
7. Run through a round or two with only these four positive habitat components and discuss their catch.
8. Discuss the negative habitat components (invasive species, bacteria, and disease) that can occur to a natural oyster reef and then add one, two, or three of the new impacts to the

other habitat components. Each negative habitat component does have a consequence so you will need to examine their catch after each round.

BLACK-diseases such as Dermo or MSX

BROWN- bacteria from pet wastes, leaky septic systems, or run-off

RED-invasive species

9. Have students act as spat and drift around the designated area again until hearing “SPAT STICK.”
10. Represent an incoming tide again and remind students that they cannot discard squares that they touch or that touch them. Discuss the results.
11. **RESULTS:**
 - Students who only caught the squares representing the 4 habitat components of food, water, shelter, and space have survived until another tidal cycle.
 - Students who caught ANY black, brown, or red square, irrelevant of the positive habitat squares, have suffered the following impacts:
 - BLACK- Dermo affects digestion.
Lose 2 GREEN food cards per each BLACK card.
 - BROWN- Bacteria from animal wastes has polluted the surrounding waters.
Lose 1 BLUE water card per BROWN card.
 - RED- Invasive species have settled nearby and taken your space and eaten your food.
Lose 1 GREEN food card and 1 YELLOW card per each RED card.
12. If any oysters succumb to the negative habitat components or the impacts from these, they have died and have become the valuable shell material on which new oysters can settle. These students can rejoin the next round as drifting spat.
13. Repeat as desired and optional scenarios are listed below.

Conclusions:

- As a class, discuss the positive and negative components of a habitat. Have students list possible sources of these negative habitat components.
- Discuss why students chose their location on the oyster reef. Did they tend to cluster or spread out?
- Did their survival strategies change over the course of the activity?

Further Thinking:

- Optional scenarios:
 - Remove all but 5 blue squares to represent a drought. Discuss results of importance of freshwater and its effects on salinity values. Reset cards.
 - Add 20 brown squares to represent an increase in animal waste from the greyhound convention on a nearby island. Discuss results of increased bacteria loaded animal waste and increased nutrients on oysters and other wetland wildlife. Reset cards.
 - Add 50 red squares to represent a population bloom of invasive species. Discuss how invasive species can affect an oyster reef's healthy habitat component.
- Have students hypothesize outcomes of these varying scenarios and chart the repetitions for further discussion.

Source: Angela Bliss.

Chapter Five

Physical/Chemical Monitoring

Activities:

Where the River Meets the Sea
Osmosis in the Wetland
Mystery Marsh Water



Photo by Angela Bliss

Where the River Meets the Sea

Grade Levels: 3rd, 4th, 5th, 6th, 7th

Georgia Performance Standards: S3L1, S4L1, S4L2, S5P2, S5CS8, S6E3, S6CS5, S7L4

Focus Question:

- What happens when the fresh water meets the salt water in an estuary?

Objective: The students will:

- Investigate the formation of a “saltwater wedge” like that in the Savannah River.

Materials:

- 2 one liter clear plastic bottles
- 1 tornado tube
- Blue food coloring
- Salt
- Water
- Plastic container to catch water drips
- 3 inch square of stiff cardboard

Key Words:

- Adaptations
- Currents
- Density
- Density Current
- Drought
- Estuary
- Equilibrium
- Hydrologic cycle
- Salinity
- Saltwater wedge

Procedures:

1. Fill the two 1-liter bottles with water.
2. Add the food coloring and salt to one of the bottles. Be sure to add enough food coloring for a dark color and enough salt for a concentrated solution.
3. Cover the mouth of the bottle and mix.
4. Screw the tornado tube to the mouth of the bottle with the colored salt water.
5. Place the stiff cardboard on top of the bottle of fresh water.
6. Work over a container (to catch any spills). You will need a partner to help with this.
7. Quickly place the bottle of colored salt water on top of the cardboard and slide the bottle around until the mouths of both bottles are aligned. Hold the bottles at the bottom to prevent squeezing.
8. One person should carefully pull the cardboard strip out while the other person holds the bottles.
9. Quickly screw the two bottles together with the tornado tube between them.
10. Lay the bottles on their sides.
11. Gently squeeze the bottle of colored salt water and observe what happens.
12. Continue to gently squeeze the bottle of colored salt water until equilibrium is reached. If there is time, once the transfer of salt water is started, just let it sit and the salt water will continue to flow into the bottle of fresh water.
13. Once there is equilibrium between the salt and fresh water, tilt the bottles to represent a saltwater wedge flowing up a freshwater river. (Placing a white sheet of paper behind bottles aids in viewing)

Conclusions:

- In your own words describe what happens when the fresh water of rivers meet the salt water of the ocean in an estuary. Be sure to include how this effects the organisms that live within the boundaries of the saltwater wedge.
- Have the students draw what they see in the two bottles.
- In the bottles, where is the salt water in comparison to the fresh water? Label their locations on your diagram. Explain why this happened.

Further Thinking:

- How would a drought affect the location of a saltwater wedge?
- How would this affect organisms that might live upriver from the ocean?
- If this were an actual estuary, what could cause the fresh and salt water to mix and eliminate the saltwater wedge?
- What effect would the mixing of the fresh and salt water have on the plants and animals that live there?
- How can you relate the density differences displayed in a saltwater wedge to oceanic density driven processes such as density currents? What would happen if density differences no longer existed in the ocean?

Osmosis in the Wetland

Grade Levels: 3rd, 4th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S3L1, S4L2, S7L2, S7L2, SB1, SEV1

Focus Questions:

- What happens when a salt water fish species goes “up the creek?”
- What is osmoregulation?

Objectives: The students will:

- Investigate how changes in the concentration of salts in water affect the water/salt balance in living cells.
- Identify what adaptations are necessary for an organism to live in the fluctuating salinity of the estuarine environment.

Materials:

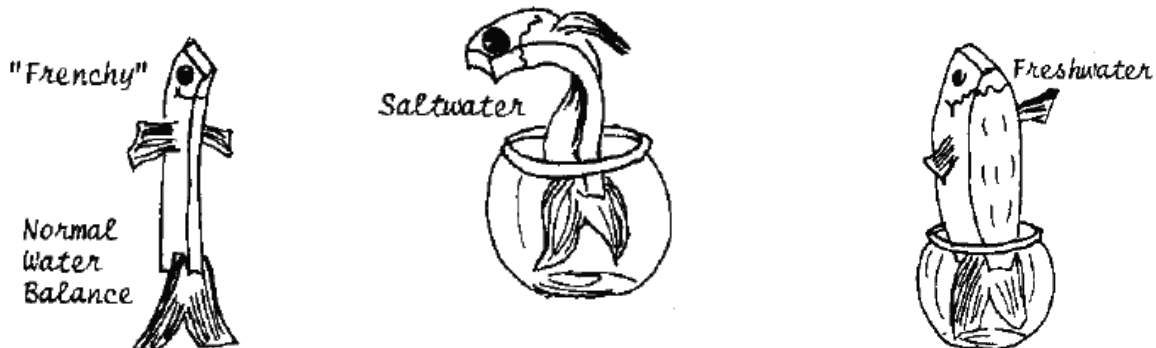
- Fresh potato (cut into “French fry” type slices)
- Salt
- Two glasses (glass, paper or foam)
- Water
- Knife

Key Words:

- | | | |
|-------------------|------------------|-----------------|
| ● Adaptation | ● Habitat | ● Osmosis |
| ● Characteristics | ● Hypersaline | ● Permeability |
| ● Diffusion | ● Hyposaline | ● Water Balance |
| ● Equilibrium | ● Osmoregulation | ● Wetland |

Procedures:

1. Divide students into groups of 3-4.
2. Peel and slice a fresh potato into French fry sizes and shapes.
3. Each team of students should have two glasses or containers—one filled with fresh water (tap water is fine) and the other filled with salty water (about 1-2 tablespoons, stirred until the salt is dissolved).
4. Each team should have about 4-8 slices of potato.
5. Place half the potato slices in a glass with tap water and the other half in a glass with salty water.
6. Feel the potatoes at the start and record your observations.
7. After 30-40 minutes, feel the potatoes in each glass and record what you observe.



Conclusions:

- What happened to the potato slices left in the fresh water? Relate this result to a marine fish being dropped into fresh water, what would happen to it?
- What happens to the potato slices left in the salty water? Relate this result to a fresh water fish dropped into the ocean.
- Based on your observations, diagram or describe the flow of water between the potato plant cells and the water in each of the two environments.

Further Thinking:

- Explain how changes in the concentration of water affect the water balance in living cells of estuarine animals or plants.
- What adaptations do animals and plants that live in estuaries need?

Source: Margaret Olsen from an existing activity from Unit Three; Coastal Ecology; North Carolina Marine Education Manual by Lundie Mauldin (Spence) and D. Frankenberg

Mystery Marsh Water

Grade Levels: 3rd, 4th, 5th, 6th, 7th, 8th

Georgia Performance Standards: S3CS5, S3L1, S4CS5, S4CS8, S5CS5, S5CS8, S6CS6, S6CS9, S6E3, S7CS6, S7CS8, S7CS9, S8CS8

Focus Question:

- How can you identify whether a water sample is estuarine or non estuarine based on density properties?

Objectives:

 The students will:

- Identify objects based on characteristics such as density.
- Determine salinity of a sample by using the density properties.
- Relate various salinities of wetland, oceanic, and freshwater systems.
- Design an experiment to solve a problem.

Materials:

- 4-5 whole clear straws
- 4-5 clear straws cut into 2-3 inch pieces
- Food coloring
- Pipettes or medical droppers
- Cups
- Salt

Key Words:

- | | | |
|---------------|--------------|---------------|
| ● Brackish | ● Hyposaline | ● Sound |
| ● Density | ● Salinity | ● Tidal creek |
| ● Estuary | ● Solute | |
| ● Hypersaline | ● Solution | |

Procedures:

1. Prepare, in advance, a series of four solutions in half-gallon containers for the students' experiments.
 - A. In the first container marked R (for red), place 2 cups of coarse salt and one gallon of water. Add enough red food coloring to make a deep red solution.
 - B. In the second container marked G (for green) place 1 and 1/3 cups of coarse salt to one gallon of water. Add green food coloring.
 - C. In the third container marked place B (for blue) 2/3 of a cup of the coarse salt to a gallon of water. Add blue food coloring.
 - D. In the fourth container marked C (for Clear) add no salt.
2. Divide students into groups or have them work independently.
3. Give students or groups containers of each solution, straws, and pipettes.
4. Read the following scenario and set of rules:

Scenario: A team of scientists collected a series of water samples from a freshwater river, a tidal creek, the sound and the ocean. The team was interested in studying the salinity or saltiness of the water. On the way back to the laboratory, they ran into a sudden rain storm and the labels came off the samples. You have been assigned the task of figuring out which sample came from which collection site.

Information to help solve the mystery:

1. The only known fact about the samples is that, since they came from different locations, they should have different densities due to the varying amounts of salt present in the original water bodies.
2. Because the water samples are not clean and have not been purified, do not taste them.
3. Food coloring has been added to help you see the different water samples.
4. You are to use the materials provided and design an experiment or experiments to figure out which water sample came from which location. Remember you are a scientific assistant and you must keep accurate notes on the procedures used in your experiments.
5. Prior to beginning your investigation, predict which sample you think was collected from each site and record this hypothesis in your notes.
6. When finished, present your findings to the class. Explain which sample came from each location (freshwater river, tidal creek, estuary, or ocean). Also, describe the experimental design you used in your experimentation.

Conclusions:

- Where would you expect to find the densest water?
- Does a changing tide affect the salinity? Explain your answer.

Further Thinking:

- Explain how weather could affect salinity?
- How would the density of the marsh change if a heavy rain occurred?

Source: Margaret Olsen from the North Carolina National Estuarine Research Reserve Activity Guide Series. Reserve Education office Beaufort, North Carolina www.ncnerr.org

Chapter Six

Problems in Your Adopted Wetland?

Activities:

A Wetland's Story: Part 1 & Part 2

Wetland Invasive Invasion

Making Decisions: A Role Play for Wetland Resources



Photo by Angela Bliss

A Wetland's Story Part 1 & Part 2

Grade Levels: 5th, 6th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S5E1, S6E5, S7L4, SB1, SB4, SES6, SEV1, SEV2, SEV4, SEV5

Focus Question:

- How does the human population affect the health of a wetland?

Part 1: Who Polluted the Wetland?

Part 1 Objectives: The students will:

- Illustrate how man has adversely affected wetlands over time.
- Identify several stresses on wetland habitats.

Part 1 Materials:

- Large clear container full of water
- Labeled film canisters or opaque containers filled with the following:
 - Oyster shell fragments: Labeled “Native Americans”
 - Sawdust or wood chips: Labeled “Boat Builder”
 - Soap bubbles: Labeled “Car or truck Owner”
 - Soil: Labeled “European settlers”
 - Baking powder: Labeled “Farmers”
 - Fishing line and weights: Labeled “Fishermen”
 - Baking soda: Labeled “Gardener”
 - Plastic/gummy fish: Labeled “Industry”
 - Raisins and toilet paper pieces: Labeled “Residents”
 - Red wine vinegar: Labeled “Stockmen”

Part 1 Key Words:

- | | | |
|---------------|------------------------------|---------------|
| ● Bacteria | ● Legislation | ● Run Off |
| ● Contaminate | ● Non-point Source Pollution | ● Sewage |
| ● Degradation | ● Phosphates | ● Stewardship |
| ● Erosion | ● Point Source Pollution | ● Wetland |

Part 1 Procedures:

1. Place the container of water at the front of the room so all students can see.
2. Divide the class into 10 groups.
3. Hand out one labeled film canister to each group.
4. As you or a student reads the scenario, students with the appropriately labeled film canisters should empty their film canister into the container of water when they hear their labeled group name.
5. Discuss their observations from Part 1.
6. Proceed to Part 2 for a stewardship lesson.

Scenario:

This is the story of a wetland ecosystem that was named “Between Land” by the **Native Americans**. This culture lived, hunted and fished along the shores of our coastal waters and wetlands. Sometimes, the remains of their feasts washed into the water; but during that time period, waste consisted of fragments of oyster shells or whelk shells. (Have the Native American group add their container full of oyster shell fragments.)

The Native Americans built their camps on higher ground or hammocks in the marsh because they knew that, even in a heavy rainstorm, these areas would not flood.

As the years passed, various groups of people moved to the coast. As the people that have lived and worked near the wetland’s shores have changed over time, the waters of the wetland have changed as well.

When the **European settlers** came to the coast, they cut down the trees along the shoreline and the edges of the wetlands in order to build their homes. The soil from the creekbanks washed into the wetlands because there were no longer any trees or roots to hold it back. (Have the European Settlers group add their container of soil.)

As settlers grew in number, they got to know the land and the abundant fish species that lived in the creeks of the estuary. The increased popularity of the sport increased the number of **Fishermen** which led to over-harvesting of fish in the creeks and rivers. Sometimes fisherman left their nets, lures and fishing line. Abandoned fishing equipment can cause great harm if ingested by wildlife or if animals become tangled in the gear. (Have Fisherman group add fishing line and weights.)

During this time of settlement, farms were established and the **Farmers** grew crops along the shoreline and learned to use fertilizers to help grow more corn, tobacco, and strawberries. Initially farms were small and few in number. As the need grew, so did the need for larger more productive fields. Fertilizers proved to be an economic boost and helped farmers grow larger crops, but as time passed, more fertilizers was used and farms grew as large as the land allowed. Although most farmers were responsible with application processes, many were not. (Have the Farmers group add baking powder.) Large quantities of fertilizer washed into the wetland’s creeks and marshlands when the rain fell and added extra nutrients to the waters.

Stockmen moved into the area as well and began to raise livestock nearby. Increased livestock increased the amount of nutrients in the wetland as the animal waste seeping into the water. (Have the Stockman group add red wine vinegar.) These excessive nutrients, known as non-point source pollution, from the animal wastes and fertilizers from the fields, caused great harm to the wetland habitat as the increased nutrients caused algal or plankton blooms. Some species of plankton that may bloom are toxic to terrestrial and aquatic wildlife while all blooms cause severe oxygen loss when the blooms end and the plankton sink to the wetland bottom to decompose.

Due to the popularity of the coast and boating, the boat building industry exploded! **Boat builders** used the larger estuary creeks to carry logs from the sawmill to the boatyard so that they would be able to build boats. Some of the bark, wood, and sawdust fell into the waters of the estuary and sank to the bottom of the creeks and decayed. (Have the Boat Builder group add sawdust or wood chips.) The decaying debris caused a growth in bacteria populations as it underwent decomposition.

Soon, others learned about Georgia's coast and they wanted to live here to enjoy the wetlands and the beautiful coastal views. **Residents** built many houses along the coast and many were built on top of our wetlands. As coastal areas have water tables near the surface, the new residents had no place to bury septic tanks and saltwater slowly corroded the sewer lines. So where did the sewage go from the leaky pipes? The raw sewage flows into the water and creates a horrible bacteria problem. (Have the Residents group add raisins and toilet paper pieces.)

Industrial activities, such as releasing warm water into the tidal creeks and wetlands, decrease oxygen levels in an already stressed ecosystem. These activities from various coastal **Industries** cause many fish species and estuarine animals to relocate due to low oxygen levels. Those who cannot leave the deadly areas, die. This warm water is actually a pollution type of pollution known as point source pollution. (Have Industry group add gummy fish.)

Along other parts of the wetlands, several homeowners were **Gardeners**. They were all very proud of their beautifully green lawns and lush tropical flower gardens that they had designed to stretch to the edge of the wetland. They needed fertilizers and insecticides to keep the exotic plants healthy and when it rained, large quantities of excess fertilizers and insecticides run off their lawns and entered the estuarine system. (Have the Gardener group add baking soda.)

Within the newly established coastal neighborhoods, many folks wash pollen and salt off their cars and trucks. Instead of the **Car Owners** washing their vehicles in the grass or at an established car wash location, they wash their vehicles in their driveways. The bubbly soap mixture runs straight from their driveways, to the road, down the stormwater drains, and into groundwater and river water supplies. (Have the Car Owner group add soap & bubbles.)

Then one day, a family was visiting from Wisconsin in hopes of seeing the magnificently beautiful wetlands along the Georgia coast. As they went out kayaking in the tidal creeks, the estuary didn't seem clean anymore. "This is AWFUL! Who polluted this wetland?" they cried.

Part 1 Conclusions:

- How can we prevent the wetlands and tidal creeks from becoming polluted?
- How could each group represented in the story alter their behavior to be more environmentally aware?
- What is the difference between point and non-point source pollution? Which type of pollution was represented in this activity?

Part 2: Cleaning the Wetland: Reversing the Damage

Part 2 Objectives: The students will:

- Design a plan to prevent pollution for various sectors of society.
- Illustrate method(s) for cleaning up currently polluted wetland areas.

Part 2 Materials:

- Small containers with wetland sample from Part 1 (for each group)
- Pieces of sponge
- Wire screen
- Paper towels
- Eyedropper
- Plastic spoon
- Netting (bags that onions or oranges come in will work)
- Pieces of cloth (cheese cloth)
- Dish detergent
- Large beaker or mayonnaise jar to place the pollutants in after they are recovered

Part 2 Key Words:

- Biodegradable
- Clean Water Act
- Conservation
- Environmental Impacts
- Non Biodegradable
- Mitigation
- Pollution
- Regulations
- Restoration
- Sustainable

Part 2 Procedures:

1. Divide class into groups of 3-5 students.
2. Stir mixture from Part 1.
3. Give each group a container with a portion of water from Part 1.
4. Each group is to devise a way to clean up the water in the wetland. They can use some or all of the items listed above OR they can create methods of their own for cleaning their wetland sample.

Part 2 Conclusions:

The students can utilize the scientific method by hypothesizing and testing ways in which polluted water from a wetland can be cleaned.

Discuss the following questions:

- What basis did you use to determine when your sample had properly been cleaned?
- What procedures did your group follow to restore or mitigate the polluted portion of the estuary?
- Was your group successful in the restoration and mitigation attempt? Explain why or why not.
- What were biodegradable and non biodegradable pollutants that entered the wetland?
- How can conservation efforts of inland and coastal communities positively benefit wetland habitats?

Source: Margaret Olsen and Angela Bliss from North Carolina Sea Grant's "Estuary Story" activity.

Wetland Invasive Invasion

Grade Levels: 4th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S7L4, S7L5, SEV2, SB4, SEV3, SB5

Focus Question:

- Does an ecosystem remain unchanged when invasive species are introduced?

Objective: The students will:

- Demonstrate ecological impacts of invasive species on wetland habitats.

Materials: (one set per group)

- Bowl of warm milk (Cool or cold milk will not work)
- Toothpicks
- 4 colors of food coloring
- Dish detergent
- 4 native species from the Wetland Classification Cards
- Invasive Species Fact Sheets

Key Words:

- | | | |
|---------------|----------------------|--------------------------|
| ● Abiotic | ● Ecosystem | ● Invasive Species |
| ● Biotic | ● Endangered Species | ● Native Species |
| ● Competition | ● Food Chain | ● Niche |
| ● Diversity | ● Indigenous Species | ● Non Indigenous Species |

Procedures:

1. Divide the class into groups of 2-4 students.
2. Hand out supplies per group.
3. Explain that the bowl represents a wetland ecosystem and the milk represents the abiotic components like air, soil, and water.
4. The food coloring represents the biotic components of a wetland. Names of indigenous species found in a local wetland.
5. Let the students add 1-2 drops of food coloring to their bowl of milk for each of the 4 native wetland species.
6. Have the students describe what they see after adding the “biotic” components.
7. The dish detergent represents an non indigenous wetland species.
8. Have students predict any changes in their ecosystem that will occur when they introduce an invasive species.
9. Have 1 student per group dip a toothpick into the dish detergent, then dip the same toothpick with dish detergent into their ecosystem bowl.
10. Allow students to observe for 2-3 minutes.

Conclusions:

- What happens when the invasive species (dish detergent) was added to the ecosystem (bowl of warm milk and food coloring)?
- Which ecosystem would you rather visit: one with biodiversity of native species or one impacted by invasive species?
- How did the dish detergent represent an actual invasive species that is found growing in a coastal wetland?

Further Thinking:

- Research invasive species near you. Do you notice any effects they have had on the natural ecosystems?
- Research plants that are sold at stores or nurseries near you. List 2 native species for sale and 2 invasive species for sale.
- How do invasive species become introduced into coastal wetlands?
- How can we prevent the introduction and spread of invasive species into coastal wetlands?

Source: Angela Bliss from the “Alien Invasion: Plants on the Move” written by Weed Facts at <http://weedinvasion.org>.

Making Decisions: Role Play for Wetland Resources

Grade Levels: 4th, 5th, 6th, 7th, 9th, 10th, 11th, 12th

Georgia Performance Standards: S4CS5, S5CS5, S6CS3, S6CS7, S7CS7, SCsh6, SCsh7S4CS6, S4L1, S5E1, S6E5, S7L4, SB4, SEV1, SEV2, SEV5,

Focus Question:

- How do decisions pertaining to development affect Georgia wetlands?

Objectives: The students will:

- Conduct research regulations and stipulation to coastal wetland development.
- Compile data for viable discussion that suits assigned role.

Materials:

- Scenario with map (shown below) and Stakeholder Roles
- Contact information or computer access for role playing research

Key Words:

- | | | |
|--------------------------|-------------------------|------------------|
| ● Coastal Management | ● Environmental Impact | ● Permits |
| ● Advisory Council | ● Filter Feeder | ● Public Hearing |
| ● Cooperation | ● Mud Flats | ● Stakeholder |
| ● Delineation | ● National Pollution | |
| ● Draft of Vessel | ● Discharge Elimination | |
| ● Endangered Species Act | ● System | |

Procedures:

1. Delegate or have students choose role.
2. Give students or groups 1 week to build case or argument.
3. Have classroom set up in forum style on day of role play activity and let the fun begin!

Scenario: A developer is planning to add a large dock/marina to an existing condominium. The marina will be on the Wilmington River adjacent to Wassaw Sound and accessible for the condominium owners only (Figure 1). The dock would extend to a water deep great enough for a vessel with a 4 – 5 foot draft to tie up. The Georgia Department of Natural Resources needs to know the stakeholder positions and the environmental impact of the construction before permitting such a project.

Map of Proposed Construction Site



Figure 1. A nautical chart of Wassaw Sound and Wilmington River which is the fictional site of a new marina. Picture scanned by Fran Lapolla, UGA MAREX.

Stakeholder Roles: These roles represent the Coastal Georgia communities. The number of students in each role will depend on the size of the class; however, there should be 5-6 members of the Coastal Management Advisory Council.

- GA Office of Coastal Management Regulatory Officer who must be familiar with Coastal habitats and ecosystems and rules of Coastal Management. This person manages the meeting but also must be knowledgeable of all other roles.
- Condo Representative must represent the company who is selling the Condos.
- Dock construction company engineer is in charge of constructing the new dock.
- Recreational fisherman with a legal permit to collect oysters that are filter feeders in the mud flats at Wilmington River.
- Environmentalist from a local advocacy group.
- Representative from a local adjacent property owner.
- Condo and boat owner who would use the new docking facility.
- Representative from GA Department of Resources Coastal Resources Division to assist with permitting questions and regulation.
- Consulting Company's Wetland Delineation Specialist who can determine where saltwater wetlands exist, since they are protected.
- 5 to 6 Coastal Management Advisory Council members who listen to all the facts and vote to make a decision.

Student Assignment:

1. During a one week period of time, you are to research what a person in your assigned role would do. You are also to read the following fact sheets to familiarize yourself with the importance of the various habitats affected by the new dock.
2. You may also call or email the GA Office of Coastal Management and ask questions about coastal management issues for GA.
3. If you live near a marsh or estuarine habitat, visit it and observe how such a dock would affect the system.

4. Some items to be considered by each role (these are not inclusive, just suggestions of things to think about):
 - Dock Construction Company Engineer: How far from shore this dock would have to be for the water to be 5 feet deep. You will need a rough estimate of the depths of Wilmington River.
 - Condominium representative and dock engineer: Estimate how far from shore the dock would need to be to reach a water depth of 5 feet.
 - Recreational fishermen and environmentalists: Consider the distance from marsh edge to the first oyster beds in the mud flat where the dock will be constructed.
 - Wetlands specialist: Determine the marsh area (the distance from high ground to the marsh edge) that will be affected by the proposed dock?
 - Local property owners: Consider how the dock might affect the value of your property.
 - Environmental and GA Department of Coastal Resources Division: Research the types of estuarine animals and plants are in the area near the dock and estimate if adults or juveniles would be affected.
5. On the day determined by your teacher, your class will hold a “Mock Coastal Management Council Meeting” where each group will state their position using some facts that they have learned during the week’s research.
6. After each group presents their information, the Regulatory Officer will call for additional questions or concerns. Then the Regulatory Officer will ask the Coastal Management Advisory Council members to vote and present a decision as to whether to allow the marina to be built.
7. As a group, discuss the outcome of the vote. What do you, the stakeholders, think now that you have heard some facts. Did listening to the facts presented by the other stake holders affect your views? If so, explain how.

Source: Margaret Olsen

Appendices

Includes:

Glossary
Sources for Further Information
Wetland Classification Cards
Fact Sheets



Photo by Angela Bliss

Glossary



Photo by Angela Bliss

Glossary

Adaptation:

Adjustments of organisms to environmental conditions or a modification of an organism as a whole or part to become more fit for survival.

Abiotic:

Non living components in an ecosystem such as rocks, air, and water.

Aerobic:

Oxygenated or occurring in the presence of oxygen.

Anaerobic:

Non oxygenated or occurring in the absence of oxygen.

Aquifer:

A permeable subsurface layer capable of holding a useable supply of water.

Azimuth:

Navigational numerical value ranging from 0° to 360° which correlates to the location of an object as dialed on a compass. True North has two values; 0° and 360°. Due East has a value of 90°, due South has a value of 180°, and due West has a value of 270°.

Bacteria:

Microscopic single celled organisms. Some bacteria are beneficial and contribute to the decomposition of dead matter in the wetlands.

Barrier Island:

A long narrow sandy island running parallel to the shore migrating south with the Long Shore Current.

Beach:

A collection of sediment, typically sand in the southeast United States, which covers the shore.

Bioaccumulation:

The process of substances, such as pollutants or toxins, building up in the tissues or cells of an organism.

Biomagnification:

Accumulation and amplification of chemical substances, like pollutants and toxins, as it moves up the trophic levels in the food chain.

Biodegradable:

The ability to break down by biological means into the raw materials of nature and disappear into the environment. These products can be solids biodegrading into the soil (compost), or liquids biodegrading into water. Biodegradable plastic is intended to break up when exposed to microorganisms. When a landfill lacks the light, water, and bacterial activity needed for materials to naturally biodegrade, major garbage problems are the result.

Biotic:

Living components of an ecosystem such as plants, bacteria, fungi and animals.

Brackish:

Water that contains a mix of fresh water and salt water.

Buoyancy:

The tendency of an object to rise or float within the water column. Organisms can alter buoyancy through trapping air bubbles in their bodies or extending to increase surface area.

Cache:

For Geocaching purposes, a cache (pronounced "cash") represents an item or clue hidden in a specific geographic area found by utilizing a Global Positioning System (GPS).

Cardinal Directions:

The four main directions which are typically highlighted on the face of the compass; N (north), S (south), E (east), and W (west) are referred to as the cardinal directions or cardinal points.

Carrying Capacity:

In wildlife management, the maximum number of animals an area can support during a given period. In recreation management, the amount of use a recreation area can sustain without loss of quality.

Catch/Release Sampling:

See Mark/Recapture Sampling

Characteristics:

Distinguishing qualities used to identify and/or describe an area or organism.

Classification:

Classification is a specific way of organizing information that is based on established criteria or distinguishing characteristics.

Clean Water Act:

A Federal law that controls the discharge of pollutants into surface water in a number of ways, including discharge permits. The Act that sets the basic structure for regulating discharges of pollutants to surface waters of the United States. CWA imposes contaminant limitations or guidelines for all discharges of wastewater into the nation's waterways and finances municipal wastewater treatment facilities. Its goal is to support " the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Coastal Management Advisory Council:

Provides advice to the Department of Natural Resources in the implementation of the Georgia Coastal Management Program and develops and applies policies to guide uses of resources within the coastal area.

Compass:

A useful navigational device available in various forms and based on the magnetic fields of the Earth, a compass indicates magnetic north and should be calibrated for a specific area to represent true north.

Competition:

The contest for available resources amongst species within an ecosystem; such as the contest for space, shelter, food, and water.

Competitive Exclusion:

The process in which a species, such as an invasive species, out competes other organisms due to the absence of predators is known as competitive exclusion and become the dominant species in the ecosystem.

Compost:

A mixture comprised of decaying organic matter. A wonderful material to condition new garden areas or naturally fertilize plants.

Conservation:

Conscientious methods practiced to reduce demand on natural resources and better utilize finite global and local supplies of freshwater, timber, etc.

Contaminate:

To become impure, polluted or unclean due to toxins or impurities.

Cooperation:

An organized group of agencies or individuals working together for a common goal.

Current:

Horizontal movement of water or air.

Degradation:

The process by which the environment or organism is progressively contaminated, overexploited and destroyed.

Delineation:

The process of deciding where something (a wetland) begins and ends.

Density:

The ratio of mass to a unit volume measured in grams per cubic centimeters.

In regards to aquatic environments, density directly affects all chemical and biological parameters. Salt water is more dense, or heavier, than freshwater due to the additional mass added to the water by the dissolved salts. As for temperature's effect on the density of water, the warmer the water the more dense the water becomes.

Density Current:

Aquatic currents, typically known as deep sea currents, that are powered by density differences in converging waters.

Dichotomous Key:

A key comprised of a series of questions to which there are only two possible answers with respect to the object being identified. Choose one of the two statements that best fits the organism in question. That choice will tell you where to go next in the key. Continue to follow the statements in the key for one organism at a time until you have reached the name of the organism

Diffusion:

Dispersal of molecules from areas of high pressure to areas of low pressure.

Discharge:

The outflow of water from natural or man made source such as wetlands and drain pipes.

Dissolved Oxygen:

The amount of oxygen dissolved in a body of water as an indication of the degree of health of the water and its ability to support a balanced aquatic ecosystem.

Diurnal Tide Cycle:

Only one high water and one low water occur during a tidal day. The tidal current is said to be diurnal when there is a single flood and a single ebb period of a reversing current in the tidal day.

Diversity:

The number and variety of species present in an area and their spatial distribution.

Draft of Vessel:

The depth of a vessel's keel below the surface (especially when loaded).

Dredge:

Noun: A metal collar pulled along the bottom of a water body to remove materials such as sediment or benthic organisms.

Verb: To remove bottom sediment or material from a channel or riverbed.

Drought:

A period of dryness especially when prolonged; *specifically* : one that causes extensive damage to plants or prevents their successful growth.

Ebb Tides:

Movement of water towards the sea or a receding tide.

Ecology:

The study of the interaction of organisms with each other and components within their physical and chemical environment

Ecosystem:

A ecological unit of organisms and the environment in which they live.

Effluent:

Liquid waste from sewage treatment or industrial process, especially such liquid waste that is released into a river or other waterway.

Endangered Species:

Any species in danger of extinction throughout all or a significant portion of its range/habitat.

Endangered Species Act:

An act passed by Congress in 1973 intended to protect species and subspecies of plants and animals that are of "aesthetic, ecological, educational, historical, recreational and scientific value." It may also protect the listed species' "critical habitat", the geographic area occupied by, or essential to, the protected species.

Enterococci:

This bacterium is found in animal intestines from cockroaches to humans and readily recovered in the outdoors from vegetation and surface water, probably due to contamination by animal waste or untreated sewage from leaky septic systems. Problems with this genus of bacteria that are faced by

society include surgical wound infections and urinary tract infections. Controlling *Enterococci* once it enters a habitat is difficult as these bacteria tolerate a wide variety of growth conditions, from extreme temperature ranges to wide ranges in salinity and pH to high and low oxygen levels.

Environment:

The combination of external physical, chemical, and biotic factors affecting the growth and development of an organism or ecologic community.

Environmental Impacts:

Any alteration of environmental conditions or creation of a new set of environmental conditions, adverse or beneficial, caused or induced by the action or set of actions under consideration.

Equilibrium:

A stable situation in which forces cancel one another.

Erosion:

Chemical or physical disintegration of rock, tidal creek beds, or riparian zones.

Escherichia Coli:

Escherichia coli O157:H7 is one of hundreds of strains of the bacterium *Escherichia coli*. Typically found in the intestines of healthy cattle, deer, and goats; such as those on cattle farms or in petting zoos. Infection with *E. coli* often leads to bloody diarrhea, and occasionally to kidney failure. People can become infected with *E. coli* O157:H7 in a variety of ways; eating undercooked meat, eating vegetables that have not been washed properly, drinking raw milk, or swimming in sewage contaminated waters.

Estuary:

The lower course of a river where the freshwater current is met and mixed in with the salty oceanic tides.

Eutrophication:

The gradual increase in nutrients in a body of water that eventually creates anoxic conditions due to the increased decomposition. Natural eutrophication is a gradual process, but human activities may greatly accelerate the process.

Filter Feeder:

Organisms which actively filter or sift suspended plant and animal matter out of the water column by creating currents. Examples include tunicates, copepods, and oysters.

Filtration:

A process for removing particulate matter from water by passage through porous media.

Flagella:

Fine, long threads which project from a cell and move in undulating fashion. Flagella are responsible for locomotion of plankton.

Flood:

An unusual accumulation of water above the ground caused by high tide, heavy rain, melting snow or rapid runoff from paved areas.

Flood Tide:

The occurrence of water moving landward due to incoming tides.

Food Chain:

A simplified step by step path of food consumption and energy passed from a primary producer to herbivore to carnivore.

Food Web:

A series of interconnected food chains that create a better representation of energy transfer in an ecosystem.

Gas Bladders:

Gas filled organs providing buoyancy in fish.

Geocache:

A term derived to explain the sport of finding globally and locally hidden caches with a GPS unit.

Global Positioning System:

A system of satellites that can be accessed with a GPS unit to pinpoint a location on the Earth.

Groundwater:

The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells and springs. Because groundwater is a major source of drinking water, there is growing concern over areas where leaching pollutants from agricultural or industrial pollutants are contaminating groundwater sources.

Habitat:

The site at which a plant or animal naturally grows or lives. It can be either the geographical area over which it extends, or the particular station in which a specimen is found. In terms of region, a habitat may comprise a desert, a tropical forest, a prairie field, the Arctic Tundra or the Arctic Ocean.

Hammock:

An elevated forested area that is only covered by saltwater at the highest spring tide or storm surge.

Holoplankton:

Animals which spend their entire lives as planktonic organisms.

Hurricane:

A severe tropical cyclone usually with heavy rains and winds blowing over 120km per hour.

Hydric Soils:

A soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper part.; typically gray in appearance

Hydrologic Cycle:

The movement of water between the oceans, ground surfaces, and the atmosphere by evaporation, precipitation and the activity of living organisms as one of the mayor biogeochemical cycles. Each day, water evaporates from the oceans and is carried in the air from the sea over the land, which receives it as precipitation, and finally returns from the land to the sea through rivers, thus completing the cycle.

Hypersaline:

Solutions higher in concentration than its surroundings.

Impervious:

A hard surface area (e.g., parking lot) that prevents or slows the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Indicator Species:

Any species or community whose characteristics show the presence of specific environmental conditions.

Indigenous Species:

Living or occurring naturally in a specific area or environment; native.

Intertidal:

Areas of marsh and beach habitats that are exposed at low tide events and inundated during high tide events.

Invasive Species:

Non-native species that can cause harm to human health, economics, or the environment by disrupting and replacing native species.

Invertebrate:

Organisms without a backbone or spinal cord; such as Phylum Mollusca, Phylum Echinodermata, and Phylum Arthropoda.

Larva:

An immature stage of an animal that drastically differs from the adult form of the animal.

Latitude:

One of the necessary numbers needed to determine a location on the Earth. Latitude lines, such as the equatorial line or the Equator, form concentric circles around the globe to the poles. Latitudes above the Equator are referenced from 0° to 90° north and latitude lines below the equator are referenced from 0° to 90° south. Other latitudinal lines include the Tropic of Cancer, Tropic of Capricorn, and the Horse Latitudes.

Legislation:

Laws or a group of laws proposed to influence actions and consequences of public and private sectors.

Longitude:

One of the necessary numbers needed to determine a location on the Earth. Longitudinal lines run from the North Pole to the South Pole and are measured from 0° to 360°. A commonly known longitude is the Prime Meridian in Greenwich, England.

Low Marsh:

The lower section of the marsh that is regularly covered or inundated with saltwater during daily high tide events. Typically dominated by the growth of one particularly well adapted plant; *Spartina alterniflora*.

Luminescence:

Light emitted from organisms by physiological processes, chemical action, friction, electrical, and radioactive emissions. Luminescence in marine organisms is probably an adaptation for recognition, swarming, and reproduction.

Magnetic North:

The north end of the Earth's magnetic field which drifts across Canada with the every changing global magnetic field.

Mark/Recapture Sampling:

Also known as Catch/Release, it is when a researcher visits a study area and uses traps to capture a group of individuals alive. Each of these individuals is marked with a unique identifier (e.g., a numbered tag or band), and then is released unharmed back into the environment. Then individuals are trapped again and the population can be calculated by comparing the number of marked animals verses the unmarked.

MARPOL

The Marine Plastic Pollution Research and Control Act is a law was passed in 1987 restricting the dumping of plastics into the ocean by making it illegal for any U.S. vessel or land-based operation to dispose of plastics at sea. It is part of an international treaty, where countries representing at least half of the shipping fleet tonnage in the world agreed to Annex V of the treaty, preventing "pollution by garbage from ships." It prohibits the dumping of plastics anywhere in the ocean, and the dumping of other materials, such as paper, glass, metal, and crockery, closer to shore.

Meroplankton:

Animals which are temporary members of the plankton.

Migration:

The periodic passage of groups of animals (especially birds or fishes) from one region to another for feeding or breeding

Mitigation:

Actions taken to avoid, reduce, or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those which restore, enhance, create, or replace damaged ecosystems.

Morphology:

Study of form and structure of individual plants and animals.

Mud Flats:

A relatively level area of fine silt along a shore (as in a sheltered estuary) or around an island, alternately covered and uncovered by the tide, or covered by shallow water.

National Pollutant Discharge Elimination System (NPDES)

As authorized by the Clean Water Act, this permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality.

Natural Disaster:

Violent and sudden change in the environment due to destructive, natural phenomena, e.g. floods, earthquakes, fire, hurricanes, etc.

Neap Tides:

Typically occurring off Georgia's coast during the first and third quarters of the moon and are characterized by a insignificant tidal difference between the high tide level and the low tide level.

Niche:

The ecological role of an organism in a community or environment especially in regards to food web.

Nitrate:

A compound containing nitrogen and oxygen that can exist in the atmosphere or in water and that can have harmful effects on humans and animals at high concentrations.

Non Biodegradable:

Refers to the inability of a substance to be broken down, and the items retain its form for an extended period of time. It is something not biodegradable.

Non- point Source Pollution:

Source of pollution that is not obvious or cannot be traced easily and typically increases during rain events as roads and lawns are washed free from fertilizers, pesticides, oil, antifreeze, litter, paint, sediments, and pet wastes. About 25% of our nation's polluted estuaries and lakes are fouled by urban stormwater, and nearly every coastal state has beaches where stormwater threatens water quality.

Organism:

An individual constituted to carry out all life functions independently.

Orienteering:

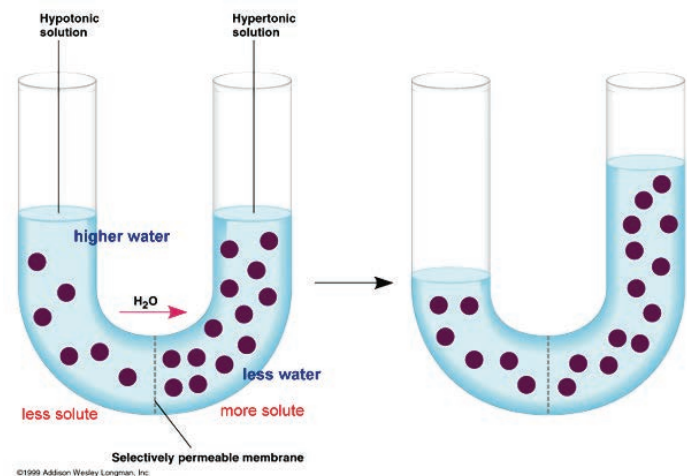
The sport that combines a compass, a course, and competitive teams trying to be the first to complete the course.

Osmoregulation:

The ability to control water loss and gain in an organisms cells and tissues. Due to the ever changing salinity levels in a wetland, these organisms must be able to adjust their water balance (osmoregulate) in order to preserve body fluid.

Osmosis:

Osmosis is the flow of water through a semi-permeable membrane (membranes that are permeable to some substances but not to others) based on concentrations of the two substances. Marine fish with body fluids containing lower concentrations of water than the seawater surrounding them constantly lose water through cell membranes into the water surrounding the fish. Freshwater fish with body fluid water



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concentrations higher than the freshwater of lakes or streams will gain water, which permeates through the cell walls.

Overfishing:

Taking out of the sea more than natural population growth can sustain. Overfishing has a number of causes, the most ruthless being "chronic over capacity" of modern fishing fleets to effectively take far more fish than can be replaced.

Pace:

Two steps equal one pace. Often used in orienteering to assist with calculations on covering distances between stations.

Percolation:

The movement of water downward and radially through subsurface soil layers, usually continuing downward to ground water.

Permeability:

The ability of membranes, rock, or soil to allow water to pass.

Permits:

Legal documents issued by state and/or federal authorities containing a detailed description of the proposed activity and operating procedures as well as appropriate requirements and regulations.

Phosphate:

A nutrient that causes accelerated growth of plants and microorganisms if it is released into waterways. In coastal Georgia, phosphate values must stay below 0.03 part per million (ppm) to prevent excessive algae and plant growth.

Photosynthesis:

Photosynthesis is the process by which plants and phytoplankton utilize sunlight to convert water and carbon dioxide into a sugar and oxygen.

Phytoplankton:

Tiny plants such as diatoms, floating passively in the upper 300 meters of the ocean or to the depths of sunlight penetration. These organisms serve an important role as they are the basis of the food chain.

Plankton:

Microscopic or macroscopic plants and animals found in saltwater and freshwater that are unable to swim or move against a significant current; such as jellyfish and diatoms.

Point Source Pollution:

Obvious source of pollution that can be traced. Examples are industrial wastewater discharge, sewer outfall, and treatment plants.

Pollution:

Any substances in water, soil, or air that degrade the natural quality of the environment, offend the senses of sight, taste, or smell, or cause a health hazard. The usefulness of the natural resource is usually impaired by the presence of pollutants and contaminants.

Population Dynamics:

The change in abundance of a species due to available food, predation, or competition.

Population Estimate:

An approximate calculation of the number of individual organisms of the same species living within a particular area.

Productivity:

The amount of organic material formed in excess of that used for respiration. It represents food potentially available to consumers.

Public Hearing:

A public session in which participants have the right to voice concerns, give testimonies, or ask questions over a given proposal or project.

Regulations:

Rules or orders prescribed for management or government; rules of order prescribed by superior or competent authority relating to action on those under its control.

Restoration:

To return to its original or usable and functioning condition.

Run Off:

Rainfall that drains from an area as surface flow due to the land's inability to absorb to due solid or paved surfaces, ground saturation, or heavy rainfall.

Salinity:

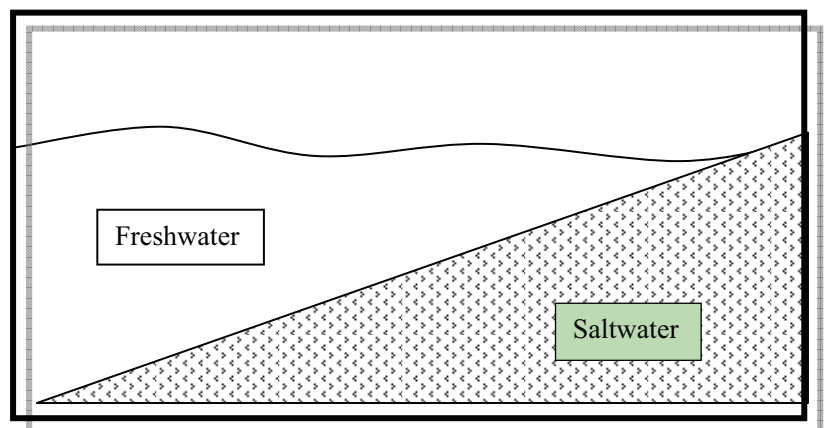
The amount of dissolved salts in a given volume of water usually expressed as parts per thousand (ppt).

Salt Marsh:

Areas of brackish, shallow water usually found in coastal areas and in deltas. There are also inland marshes in arid areas where the water has a high salt level because of evaporation. They are environmentally delicate areas, extremely vulnerable to pollution by industrial or agricultural chemicals, or to thermal pollution, which often results when river water has been used as the coolant in power stations and industrial plants.

Saltwater Wedge:

An estuary is defined as a location where the river meets the sea. At this meeting, or convergence, the waters form layers based on density differences created by the salinity values of the river and the sea. At the edge where the waters meet, a salt water wedge is formed as shown in Figure 1. The salt water wedge is either permanent or temporary. The wedge will remain in the water column until mixing occurs due to continued convergence, tidal cycles, winds, waves, or physical



underwater topography. In the wedge, the less salty/less dense upper water layer from the more salty/more dense bottom layer.

Semidiurnal Tide:

A tide characterized by two equally high tides and two low tides during a 24 hour time period. Georgia experiences a semidiurnal tide cycle.

Sewage:

Domestic or industrial waste added to the environment untreated.

Sound:

The deepest aquatic zone in an estuary. A sound is a large ocean inlet or deep bay.

South Atlantic Bight

The South Atlantic Bight is a region along the eastern continent of the United States and is known for its long, gently sloping land, other-wise called the continental shelf. In this part of the ocean, water depth is relatively shallow up to 100 miles off the Georgia coast. Due to this shallow water depth of the continental shelf, areas along the southeast have small waves that are susceptible to high storm surges. In deeper waters, the energy capable to produce a storm surge is absorbed in the deeper oceanic waters.

Spring Tide:

The maximum range of tides occurring when the moon is new or full; typically twice each month.

Stakeholder:

Any organization, governmental entity, or individual that has a stake in or may be impacted by a given approach to environmental regulation, pollution prevention, energy conservation, etc.

Stewardship:

Being responsible for one's own actions and caring for the land and its resources in hopes of preserving healthy ecosystems and organisms to pass on to future generations.

Storm Surge

Created by a hurricane or tropical storm causing seawater to penetrate inland where, without the storm, seawater would not enter. The storm's high winds travel across the surface of the ocean causing ocean water to "pile up" in a mound and water levels can increase up to 20 feet higher than normal and be up to 50 to 100 miles wide.

Subtidal:

The benthic tidal creek and oceanic environments that are always covered with water.

Sustainable:

An ecosystem characterization in which biodiversity, organism and resource renewability, and resource productivity are maintained over time.

Taxonomy:

The practice of classifying plants and animals according to their presumed natural relationships and stated characteristics.

Tides:

The periodic rise and fall of the sea level under the gravitational pull of the moon and the sun.

Toxin:

A chemical, physical, or biological agent that causes disease or some alteration of the normal structure and function of an organism. Onset of effects may be immediate or delayed, and impairments may be slight or severe.

Tributary:

The lower order or smaller stream that flows into another, typically larger, waterbody.

True North:

A navigational term referring to the actual North Pole. Compasses and maps must be delineated or altered to a specific location as true north differs from magnetic north.

Turbidity:

A cloudy condition in water due to suspended silt or organic matter.

Vertebrate:

Organisms with a backbone or spinal cord belonging to Phylum Chordata.

Water Balance:

The ratio between the water assimilated into the body and that lost from the body.

Watershed:

A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wetland:

Any number of tidal and nontidal areas characterized by saturated or nearly saturated soils most of the year that form an interface between terrestrial (land-based) and aquatic environments; include freshwater marshes around ponds and channels (rivers and streams), brackish and salt marshes; other common names include swamps and bogs.

Zooplankton:

Animals not capable to swim or move against a significant current for most or all of their lives; such as copepods and jellyfish. They typically float in the upper water column feeding on phytoplankton.

Sources for Further Information

Center for Oceanic Science Education Excellence
Georgia Department of Natural Resources
South Carolina Department of Natural Resources
University of Georgia Marine Extension: Shellfish Laboratory



Photo by Alan Power

Sources for Further Information

Coastal Habitats & Processes:

- GA DNR COASTAL CONNECTION Fact Sheets - www.knowtheconnection.com
Barrier Islands, Beach, Currents, Mud Flats, Salt Marshes, Sand Dunes, The Sound, Tides, Waves
- COSEE- Southeast – www.scseagrant.org/se-cosee/
Turning the Tide on Trash, Investigating the Ocean (Gulf Stream, Coral Bleaching, Upwelling, El Nino/La Nina, Algae Blooms, Coastal Waters), Georgia's Wetland Treasures,
- UGA MAREX Shellfish Laboratory - www.marex.uga.edu/shellfish/education.html
Grays Reef, Salt Marsh, Coastal Water Quality, Coastal Erosion, Whelk Fishery, Hurricanes, Hard Clam Fishery

General Animal Information:

- GA DNR COASTAL CONNECTION Fact Sheets - www.knowtheconnection.com
Beachcomber Guide, Boat Ramp Etiquette, Catch & Release, Fishing Methods
- COSEE- Southeast – www.scseagrant.org/se-cosee/
Sea Turtles in the South Atlantic Bight

KINGDOM ANIMALIA Sources:

Phylum Arthropoda:

- UGA MAREX Shellfish Laboratory - www.marex.uga.edu/shellfish/education.html
Horseshoe Crab, Hermit Crab, Spider Crab,

Phylum Chordata:

- GA DNR COASTAL CONNECTION Fact Sheets - www.knowtheconnection.com
Sea Turtles, Dolphins, Alligators, Manatees, Wood Storks, Oyster Catchers
- UGA MAREX Shellfish Laboratory - www.marex.uga.edu/shellfish/education.html
Bottlenose Dolphin, Coastal Birds, Whales of the South,

Phylum Echinodermata:

- UGA MAREX Shellfish Laboratory - www.marex.uga.edu/shellfish/education.html
Sea Star

Phylum Molluska:

- GA DNR COASTAL CONNECTION Fact Sheets - www.knowtheconnection.com
Whelks
- UGA MAREX Shellfish Laboratory - www.marex.uga.edu/shellfish/education.html
Knobbed Whelks, Channeled Whelks, Horse Conch, Lightning Whelks, Pear Whelks, Green Mussels, Atlantic Oyster Drill, Hard Clam, Eastern Oyster

KINGDOM PLANTAE Sources:

- GA DNR COASTAL CONNECTION Fact Sheets - www.knowtheconnection.com
Sea Oats
- Phytoplankton Monitoring Groups - www.chbr.noaa.gov/pmn/index.htm
Diatoms, Dinoflagellates, Harmful Algae Blooms

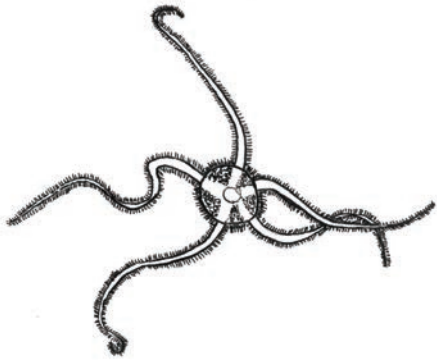
Wetland Classification Cards



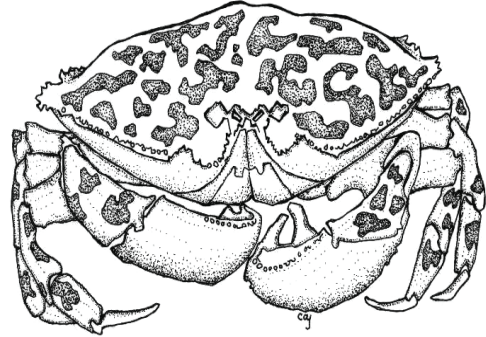
Photo by Angela Bliss

Wetland Classification Cards

Brittle Star



Calico Crab



Tunicate



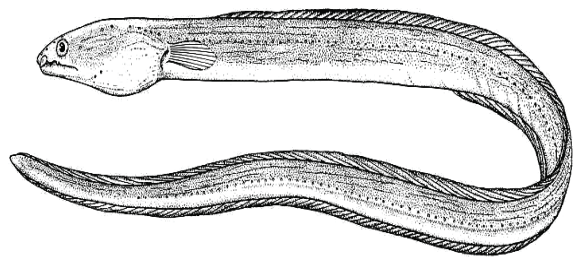
Sea Star



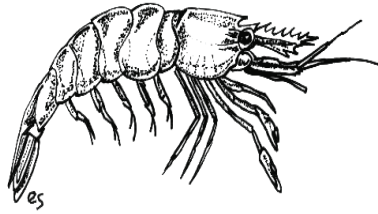
Skeleton Shrimp



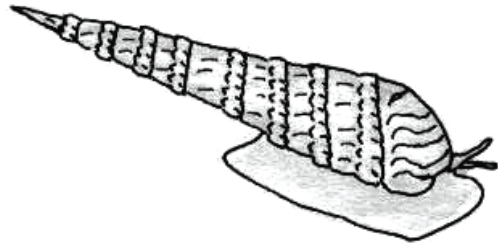
American Eel



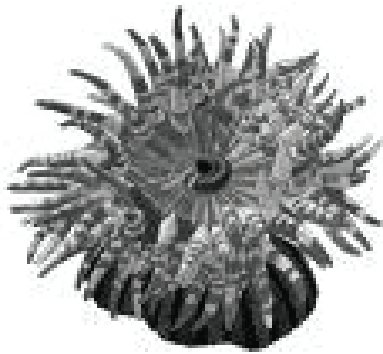
Grass Shrimp



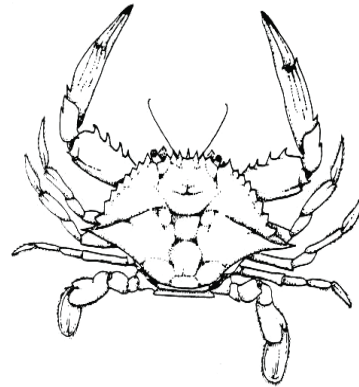
Auger Snail



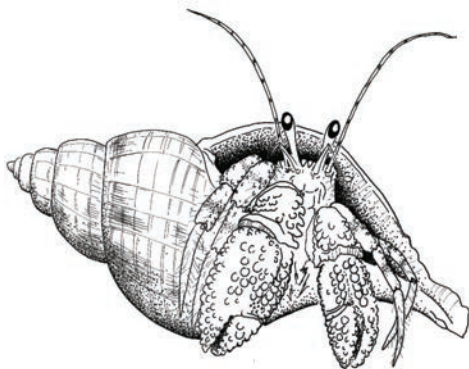
Anemone



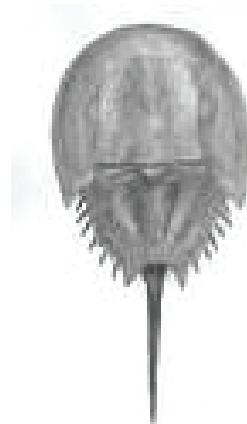
Blue Crab



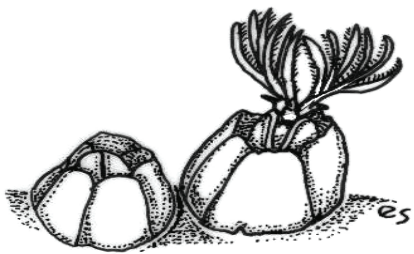
Hermit Crab



Horseshoe Crab



Acorn Barnacles



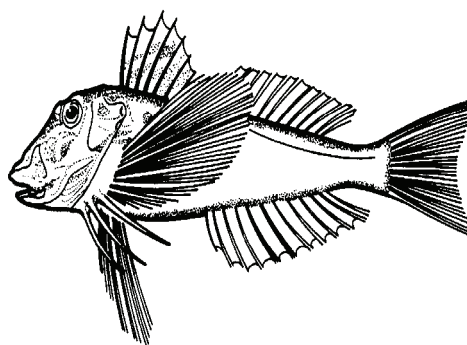
Mud Snail



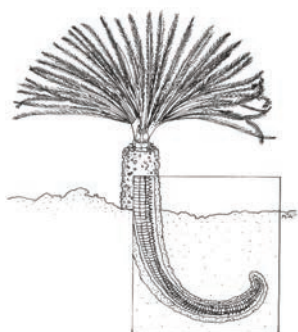
Ribbed Mussel



Sea Robin



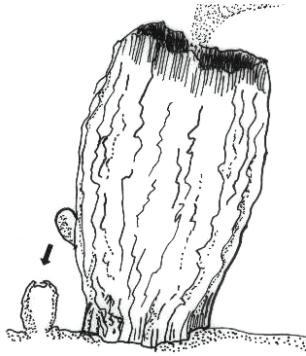
Fan Worm



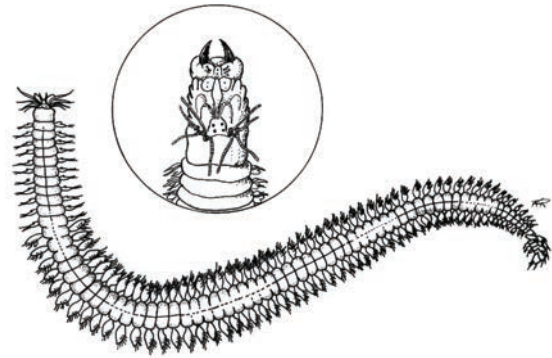
Eastern Oyster



Basket Sponge



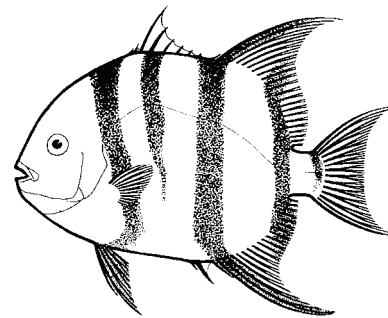
Polychaete Worm



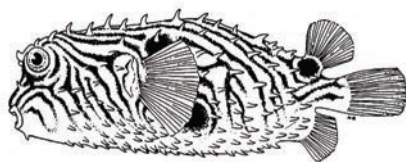
Oyster Drill Snail



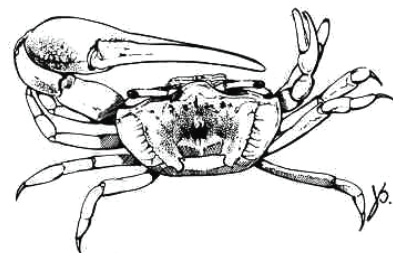
Atlantic Spadefish



Striped Burrfish



Fiddler Crab



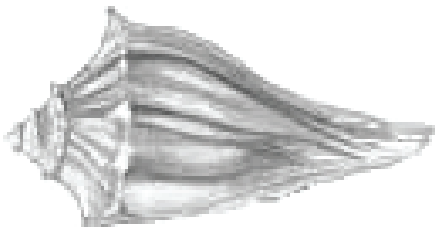
Sea Horse



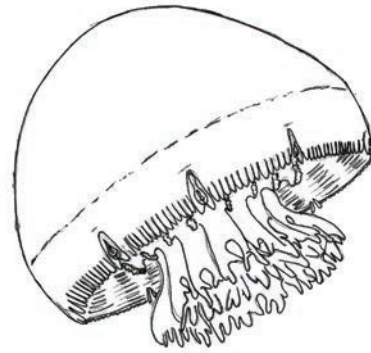
Finger Sponge



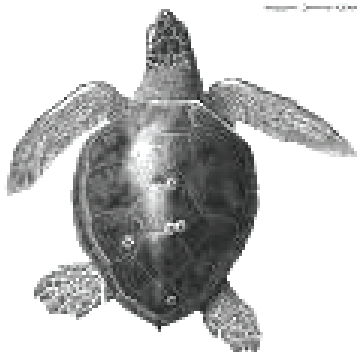
Knobbed Whelk



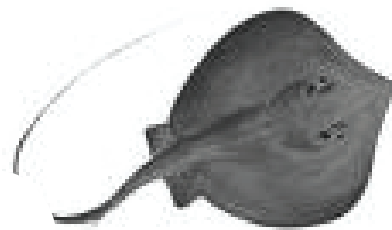
Cannon Ball Jelly



Loggerhead Sea Turtle



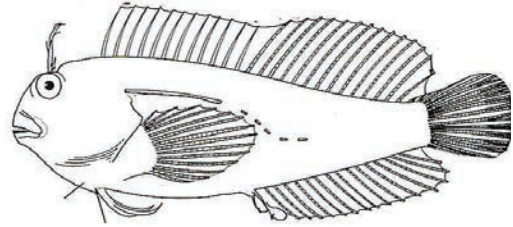
Atlantic Stingray



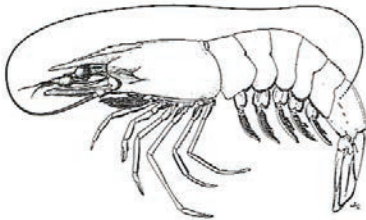
Atlantic Needlefish



Combtooth Blenny



White Shrimp



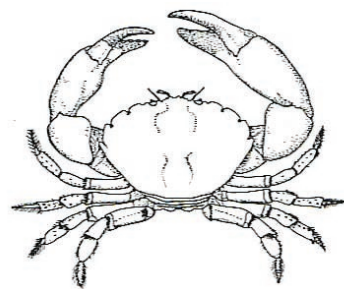
Red Drum



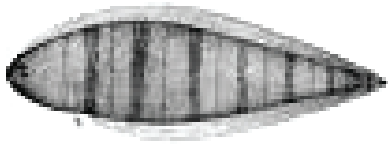
Oyster Toadfish



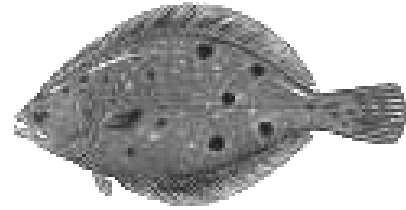
Stone Crab



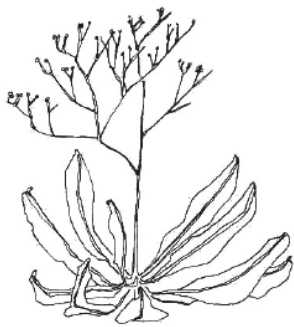
Tonguefish



Summer Flounder



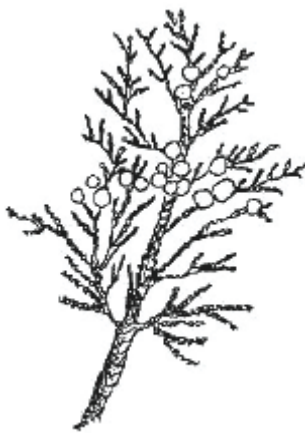
Marsh Lavender



White Mullet



Juniper



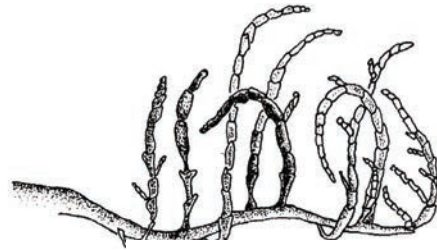
Marsh Aster



Spartina alterniflora



Glasswort



American Alligator



Diamondback Terrapin



Manatee



Bottlenose Dolphin



Belted Kingfisher



Marsh Wren



Cattle Egret



Great Blue Heron



Brown Pelican



Wood Stork



Evaluation



Photo by Patti Workover

EVALUATION

The UGA Coastal Adopt-A-Wetland program has aimed to create a valuable resource tool for coastal wetlands and water quality issues. Have you enjoyed this guide? We want to hear from you! Please submit feedback to let us know how this guide has impacted your classroom or lesson plans. All feedback is greatly appreciated.

1. Where did you acquire your copy of the AAW Curriculum Guide for Grades 3-12?
2. Has your knowledge or understanding of Georgia's coastal wetlands increased due to this curriculum guide?
3. What grade(s) do you teach? Which grade(s) did you facilitate AAW activities from this guide?
4. Would you classify your coastal wetland background as poor, fair, average, above average, or expert?
5. What activity (ies) were you able to facilitate to your students?
6. Do you feel that the Adopt-A-Wetland Curriculum Guide for Grades 3-12 assisted you in planning and implementing sound ecological activities?
7. Any comments or suggestions about your AAW workshop experience?

Thanks again for your time!

If you have any questions, please do not hesitate to contact:

Angela Bliss

acbliss@uga.edu or 912-598-2348 Ext 2



Fact Sheets

Includes:

Native Species Fact Sheets

Invasive Species Fact Sheets

Habitats, Processes, & Legislation Fact Sheets



Photo by Erica LeMoine

Crabs



Stone Crab



Male (left) and female (right) fiddler crabs



Blue Crab



Spider Crab

Stone Crab: *Menippe mercenaria*

Stone crabs can be found throughout the marsh zone. While similar to mud crabs, adult stone crabs can grow up to 13 cm in shell, or carapace, width while mud crabs can grow up to 5 cm. Stone crabs have large claws popular in the food industry, making these crabs commercially valuable. To prevent overharvesting or population decline of this species, only one claw can be collected from a stone crab at a time.

Fiddler Crab: *Uca* spp.

There are three species of fiddler crabs found along the coast of Georgia; sand, mud, and brackish water fiddler crabs. Most commonly seen are the mud fiddler crabs, *Uca pugnax*, which can grow up to 5 cm wide and have a blue carapace and light yellow to yellow claws. Fiddler crab gender is easily distinguishable as male crabs have one extremely large claw for defense and mating. Male crabs also construct chimneys of mud to assist in winning a mate while both genders create tunnel systems under the mud that aerate the marsh soil. Fiddler crabs are known as detritivores and eat dead or decaying plant and animal matter.

Blue Crab: *Callinectes sapidus*

Blue crabs are a commercially valuable species to the food industry and can easily be identified by their blue legs and large pair of claws. Scientifically, their name appropriately means “beautiful swimmer” as these crabs move swiftly through the water by utilizing a pair of flattened paddle-like swimmerets, as pictured to the left. A blue crab’s carapace is about 23 cm wide and they primarily feed on shellfish, but will scavenge and eat living and dead plant and animal matter throughout the marsh.

Spider Crab: *Libinia* spp.

Spiders crabs grow up to 10 cm in length and can be distinguished from other crab species due to the rounded carapace with protruding spines, spider-like legs, and long rostrum (nose). They can be found washed up on the beach in mats of bryozoa, clinging to oyster reefs in the intertidal zone, or scavenging around in waters up to 122 m in depth.

References & Photography Credits:

Georgia Tech - <http://gatech.edu>

Southeastern Regional Taxonomic Center/ South Carolina Department of Natural Resources - <http://www.dnr.sc.gov>

Smithsonian Marine Station at Fort Pierce - <http://www.sms.si.edu/IRLFieldGuide>

Texas Parks and Wildlife - <http://www.tpwd.state.tx.us/huntwild/wild/species/>



Public Service & Outreach
THE UNIVERSITY OF GEORGIA



Eastern Oyster

Scientific name:

Crassostrea virginica



Oysters have been harvested along Georgia's coast for many years.



A naturally occurring intertidal oyster reef bordered by a tidal creek and Spartina.

The eastern oyster, also known as the Atlantic oyster, grows up to lengths of 15 cm and is the most common oyster on the east coast as it ranges from the Gulf of St Lawrence to the Gulf of Mexico. In Georgia, this species generally lives intertidally in brackish waters where salinities range from five to 30 ppt (parts per thousand). Oysters are known as "keystone species" as the oyster reefs they create serve as an important habitat and food source for a variety of invertebrates and vertebrates; from whelks and sea stars to flounder and humans.



Cluster of eastern oysters.

Spawning occurs when the oysters release millions of eggs and sperm into the water when water temperatures warm around May triggering oysters to spawn. Spawning concludes in October. After the egg and sperm meet, the young larvae float around and eventually attach to hard submerged surfaces. These young oysters are known as spat and take about one year to reach sexual maturity. Old or discarded shell, dead trees and dock pilings serve as prime material to welcome spat which could ultimately begin an oyster reef. Without this hard substrate, spat cannot attach and oysters will not form.



Spat growing on discarded shell.

Oysters are filter feeders with the capability of greatly improving water quality. For instance, a 7 cm oyster can siphon approximately 190 L of water per day, filtering the basic diet of plankton accompanied by water impurities such as sediment, toxins, and pollutants.

References & Photography Credits:

- Chesapeake Bay Program- http://www.chesapeakebay.net/american_oyster.htm
- Franklin Institute - <http://www.fi.edu/fellows/owens/estuary/oysters/facts.html>
- University of Michigan, Museum of Zoology - <http://animaldiversity.ummz.umich.edu>
- University of Georgia Marine Extension- <http://www.marex.uga.edu/shellfish>



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Diamondback Terrapins

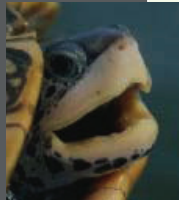
The diamondback terrapin is the only turtle in the US that lives its entire life exclusively in the coastal salt marshes from Massachusetts to the Gulf Coast of Texas.

Coloration of the skin and shell varies greatly throughout this species. The terrapins' soft skin varies from gray with black speckles to solid black while the terrapins' shell varies from shades of brown to green.

An unmistakable characteristic of this turtle is the terrapins' large lip-like beak that seems to greet you with a smile.

The size of adult terrapins indicates the gender; female terrapins can grow up to 18 cm while male terrapins typically grow up to 10.5 cm.

Terrapins feed on periwinkle snails, fiddler crabs, marsh plants and fish.

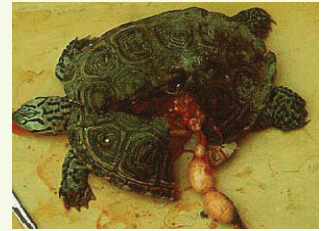


Diamondback Dangers

Historically, diamondback terrapins have been adversely affected by human activity. Terrapin populations were almost hunted to extinction in the late 1800's as they were the main ingredient in turtle soup. Surviving an episode of near extinction, diamondback terrapins reoperated around the 1960's only to face two new threats; vehicle strikes and crab traps.

Vehicle Strikes

With increased coastal visitation and human migration to coastal communities, diamondback terrapins are having to navigate treacherous routes while avoiding speeding traffic during their summer nesting season. As pictured to the right, this female terrapin searching for a hammock nesting site, was struck by a vehicle. With no chance of survival for this adult, her eggs will be collected and incubated in hopes of rearing viable offspring. If any eggs hatch, the hatchlings are returned to the marsh near where their mother was found. Many programs, often referred to as "head start" programs, exist along the terrapin range and are able to return many of these reared hatchlings to the wild.



Female killed on the road.

Crab Traps

Commercial and recreational crab traps are heavily utilized throughout the range of diamondback terrapins. These traps along with abandoned or entangled crab traps, known as ghost traps, cause accidental drownings to thousands of juvenile and adult diamondback terrapins each year. Many facilities from New Jersey to Georgia are conducting research on methods to reduce diamondback terrapin death from crab traps. By testing bycatch reduction devices (BRDs), pictured to the right, scientists are trying to reduce the size of trap entrances without negatively effecting crab catch. By establishing the necessary size and orientation of BRDs placed in the openings of crabs traps, larger terrapins would be dissuaded from entering.

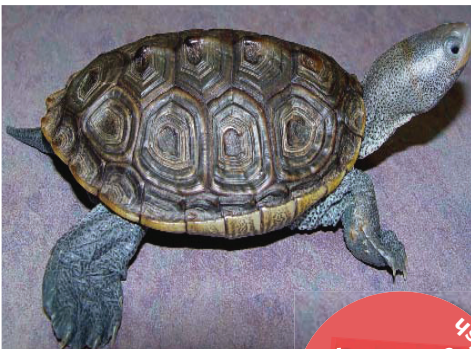


Live terrapins rescued from a crab trap.



BRD installed on a crab trap.

An adult male diamondback terrapin



References & Photography Credits:

University of Delaware, Marine Studies- <http://www.ocean.udel.edu/kiosk/terrapi.html>

Wetlands Institute- <http://www.terrapi.conservaion.org>

University of Georgia- http://www.uga.edu/srel/FactSheets/diamondback_terrapi.htm



Public Service & Outreach
THE UNIVERSITY OF GEORGIA



MAREX
The University of Georgia Marine Extension Service

Nudibranchs



Dendronotidae: *Dendronotus frondosus*



Dorididae: *Hypselodoris edenticulata*



Aeolidiidae: *Aeolidia papillosa*



Dendrodorididae: *Dendrodoris warta*

Classified in Phylum Mollusca, nudibranchs are colorful snails without shells that grow up to 7 cm and creep throughout tidal creek and oyster reefs or along the ocean's bottom. Nudibranchs are carnivorous and feed on soft corals, gorgonians, tunicates, sponges, hydroids, and anemones. As nudibranch literally means "naked gill", these mollusks move with their exposed gills displayed on their backs like feathery costumes. For defense, these slow-moving creatures utilize colors to either elude predation or warn predators of their toxic or distasteful flavor. The nudibranchs' nonpalatable characteristic is derived from stored toxins from previously eaten meals such as anemones and hydroids.

Below are four common families found on Georgia's coast:

Dendronotidae

Dendronotidae have several feathery gills on each side on the back and a cup-like sheath around the tentacles on the head. The tentacles are believed to be sensory organs used to find food and seek a mate. Some species, like *D. frondosus* pictured at the top left, have radula-like teeth as it will prey on soft corals and gorgonians (sea whips).

Dorididae

Characterized by a pair of tentacles on top of the head and feathery gills on the rear of their back, Dorididae, such as *H. edenticulata* pictured at the left, are beautiful fluid specimens to observe at locations like Gray's Reef National Marine Sanctuary off Georgia's coast where they feed on tunicates and sponges.

Aeolidiidae

These nudibranchs are covered with numerous finger-like appendages which are for gas exchange and sometimes defense. Aeolidiidae, such as *A. papillosa* pictured to the left, feed primarily on sea anemones and store the anemones' venom to utilize in defense.

Dendrodorididae

Warty sea slugs, *D. warta*, are members of the Dendrodorididae family and can be found on oyster reefs along Georgia's coast and offshore on Gray's Reef. As pictured to the right, the warty sea slug can typically be found grazing on sponges.

References & Photography Credits:

Animal Library - <http://www.saltcorner.com/sections/zoo/inverts/molluscs/nudibranchs/nudibranchs.htm>

National Oceanic and Atmospheric Administration Photo Library- <http://www.photolib.noaa.gov/>

Opisthobranchs of the Sunshine Coast- <http://www.nudibranch.com.au/>

Ocean Link- <http://oceanlink.island.net/oinfo/oinfo.html>

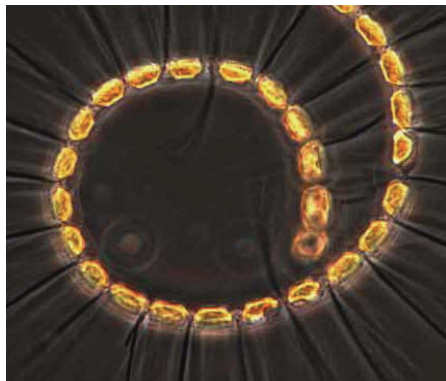
Sea Slug Forum- <http://www.seaslugforum.net/>



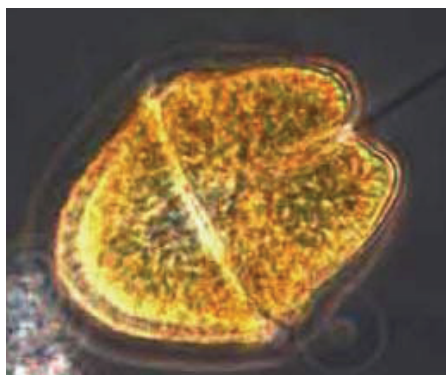
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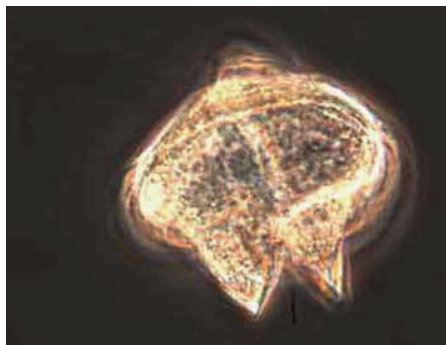
Phytoplankton



Chaetoceros chain



Akashiwo sp.



Protoperodinium sp.

Phytoplankton are photosynthesizing organisms that are transported through fresh, brackish, and salt water by currents and tidal movement. Although microscopic organisms, phytoplankton serve as the base of the global food web by serving as food to numerous species of fish such as mullet and anchovies. In addition, the photosynthesizing plankton produce half of the Earth's oxygen supply which makes them essential for aquatic and terrestrial organisms. Two types of phytoplankton commonly encountered on Georgia's coast are diatoms and dinoflagellates.

Diatoms

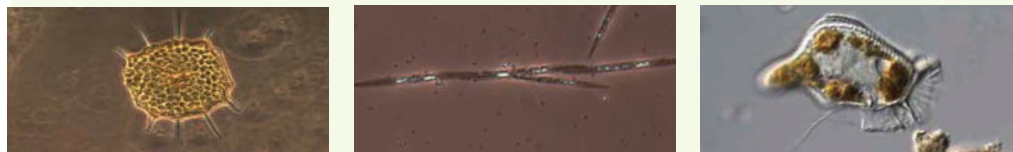
There are over 20,000 species of diatoms, such as *Chaetoceros* (top left), *Odontella* (below left) and *Pseudonitzschia* (below middle). Due to the high silica content of these organisms' outer membrane, diatoms are responsible for production of diatomaceous earth which is utilized as abrasives in toothpaste or as filtering medium for swimming pools.

Dinoflagellates

Utilizing whip-like tails to maneuver through the water column, dinoflagellates species like *Akashiwo* (left), *Protoperidinium* (bottom left), and *Dinophysis* (below left) are capable of producing toxins and causing harmful algal blooms in favorable conditions.

Harmful Algal Blooms

Caused by increased nutrients, harmful algal blooms cause environmental problems with fish kills or gill lacerations, red tides, or increased oxygen consumption from decomposing bacteria once algal bloom subsides. Human and mammalian health is affected as well from HABs, in forms of gastrointestinal problems, respiratory distress, and death. Effects of these blooms and information on the responsible species can be found by visiting the Phytoplankton Monitoring Network (www.chbr.oaa.gov/PMN).



Odontella, Pseudonitzschia chain, and Dinophysis sp.

References & Photography Credits:

Chesapeake Bay Program- <http://www.chesapeakebay.net/info/plankton.cfm>

Indiana University, Biology Department- <http://www.indiana.edu>

NASA Earth Observatory- <http://earthobservatory.nasa.gov/Library/Phytoplankton/>

Phytoplankton Monitoring Network- <http://www.chbr.noaa.gov/PMN>

Rhode Island Sea Grant- <http://seagrant.gso.uri.edu/factsheets/phytoplankton>

Southeastern Regional Taxonomic Center/South Carolina Department of Natural Resources- <http://www.dnr.sc.gov>



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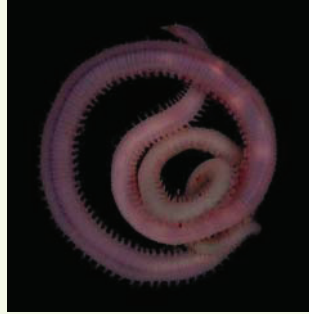


Polychaetes

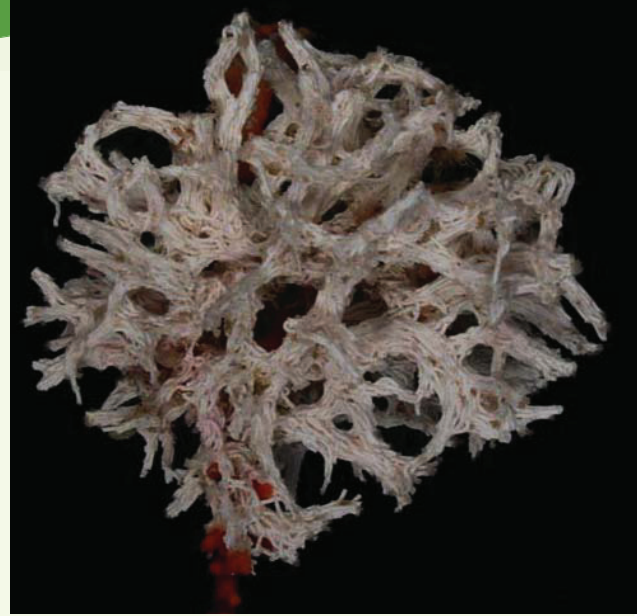
Polychaetes belong to the Phylum Annelida and are segmented worms with bristly leg-like protrusions, called parapodia. The name "polychaete" means "many hairs"; which is fitting as these worms are often times referred to as bristleworms. Many species of polychaetes have common names such as clam worms, fire worms, blood worms, fan worms and tube worms.

With approximately 10,000 species on record, polychaetes can be sessile or free living marine organisms and can be found at a variety of water depths and water temperatures. These organisms have well developed eyes, antennae, and sensory type organs which assist in catching their diet of small invertebrates and plankton.

Worm tubes from Gray's Reef



Bloodworm polychaete (*Glycera americana*)



Adaptations

Sessile or Seditary: Many species of polychaete worms are able to permanently adhere themselves to structures by hook-like protrusions. After attachment, the sessile polychaetes create tubular homes out of sand, mud or mucus; such as the cluster of worm tubes from Gray's Reef as pictured above on the right. Sessile polychaetes eat microscopic particles and plankton found drifting in the water's current. Large feathery crowns of fringed tentacles from a fan worm polychaete, pictured at the right, assist with catching food that drifts by.

Free-living: Actively preying and scavenging on invertebrates such as oysters, free-living polychaetes move throughout the benthic and nektonic communities of oceans and tidal creeks. Polychaetes, such as bloodworms (pictured above), clam worms, and bristleworms (pictured to the left) can be found on oyster reefs, in or on abandoned shells or burrowed in the sand or mud.



Fan Worm



Bristleworm polychaete (*Lepidonotus sublevis*)

References & Photography Credits:

Animal Diversity Web- <http://animaldiversity.unmz.umich.edu>

Southeastern Regional Taxonomic Center/South Carolina Department of Natural Resources- <http://www.dnr.sc.gov>

University of Georgia Marine Extension, Shellfish Laboratory- <http://marex.uga.edu/shellfish>



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Native species

Shrimp

Approximately 90% of shrimp sold in the United States are imported from Latin American and Asian countries. The remaining 10% comes from the southeastern United States.



The University of Georgia's Georgia Bulldog

Shrimp are omnivores and eat plankton, worms, and plants. Emerging from eggs held on the legs of the female parent, young shrimp are temporarily planktonic and drift through the water until growing large enough to sink to the bottom where they can grow up to 28 cm. Throughout their lifespan, shrimp are consumed by many organisms in the oceanic, estuarine, and terrestrial food webs.

One of the main shrimp consumers are humans; making Georgia's shrimp industry a major constituent to coastal economics. Three important shrimp species can be found in brackish and oceanic waters along the coast of Georgia; white shrimp (top left), brown shrimp (left), and pink shrimp (bottom left). Competition between the shrimp species is minimal as white, brown, and pink shrimp have slightly different preferences for salinity, water temperature, dissolved oxygen, and water depth.

These three shrimp species are captured by shrimping vessels dredging the bottom of inlets and sounds during the shrimp season. In efforts to have a more efficient and sustainable shrimping industry, research programs are constantly underway to reduce bycatch loads and monitor health of shrimp populations. The R/V Georgia Bulldog (above), stationed at the UGA Marine Extension office in Brunswick, has conducted numerous experiments and trials on shrimping gear to reduce bycatch. The first TED (turtle excluder device) was created by a local Georgia shrimper to decrease bycatch and prevent destruction of gear by heavy trawls of jellies. As TEDs proved successful in reducing other bycatch, such as sea turtles, many federal state and private parties have worked collectively to produce the best method of TED installation and design.



White Shrimp:
Litopenaeus setiferus



Brown Shrimp:
Farfantepenaeus aztecus



Pink Shrimp:
Farfantepenaeus duorarum

References & Photography Credits:

Oceans Alive- <http://www.oceansalive.org/eat.cfm>

National Marine Fisheries- www.sefspanamalab.noaa.gov/docs/White_Shrimp.doc

North Carolina DNR- <http://www.ncfisheries.net/kids/3shrimp.htm>

Fish a Wildlife Service, Biological Report

http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-090.pdf

National Marine Fisheries Service- <http://www.nmfs.noaa.gov/fishwatch>

University of Georgia, Georgia Bulldog- http://www.uga.edu/marine_advisory/gabulldog.html



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Snails



Periwinkle Snails



Eastern Mud Snail



Common Marsh Snails



Atlantic Oyster Drill

Periwinkle Snail: *Littorina irrorata*

Periwinkle snails are generally found on living *Spartina* grasses and graze on planktonic organisms and algae found on the grass stalks. Periwinkle snails can be found throughout the marsh, intertidally and often subtidally, as they migrate up and down the grass stalks in rhythm with tidal fluctuations. Periwinkle snails grow up to 5 cm and, although they can range in colors, can be identified by their small spiral ridges.

Eastern Mud Snail: *Ilyanassa obsoletus*

The eastern mud snail has a dark brown shell with 5-6 whorls and is decorated with small beaded lines. It can grow up to 2.5 cm in length and is often found in masses burrowing on mudflats at low tide. Mud snails feed on plankton, detritus, and small worms.

Common Marsh Snail: *Melampus bidentatus*

Similar to the eastern mud snails, the common marsh snails are grazers of decaying *Spartina* and other plant matter. Growing up to 2 cm long, marsh snails are typically found along or above the high tide line around heavy amounts of vegetative debris making trails with their bodies as they move through the mud.

Atlantic Oyster Drill: *Urosalpinx cinerea*

Atlantic oyster drills grow up to 2.5 cm long and are usually gray, yellowish-white, or purple. They inhabit oyster beds and intertidal rocky bottoms up to 7.6 m in depth. They are predatory snails feeding primarily on the eastern oyster. They use a drill-like organ, known as a radula, to drill a tiny hole in their prey while secreting sulfuric acid to dissolve the mollusk's shell and expedite the drilling process. Once the hole is complete, the oyster drill uses its tiny tongue-like proboscis to feed.

References & Photography Credits:

Exotic Species of San Francisco Bay- http://exoticguide.org/species_list.html

Chesapeake Bay Program- <http://www.chesapeakebay.net/baybio.htm>

Clark University- www.clarku.edu/departments/biology/biol201/2002/MChmielewski

Southeastern Regional Taxonomic Center/South Carolina Department of Natural Resources- <http://www.dnr.sc.gov>

University of Georgia, Steve Newell- <http://newell.myweb.uga.edu>



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Tunicates

Tunicates are classified in Phylum Chordata, along with birds, fish and mammals, due to the initial presence of a dorsal nerve cord and notochord. Further classified into subphylum Urochordata, meaning "false nerve cord", the larva tunicate tadpole loses any sign of a nervous system once it reaches the sessile adult form.

As interesting as their development phases, tunicates are diverse in form and color. Tunicate species vary from solitary to colonial and can live in tidal creeks to coral reefs to the open ocean. A few native tunicates found in Georgia are small translucent sea squirts, fleshy pink or peach colored sea pork, and various shades of hard encrusting tunicates.

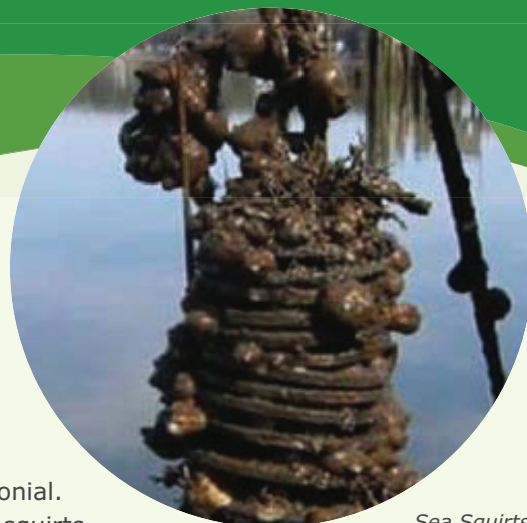
Anatomy: As their name suggests, tunicates are typically encapsulated in a leathery tunic or sac made primarily of cellulose that provides structure and protection.

Depending on the species, tunicates can be solitary or colonial. Solitary tunicates, such as sea squirts which are pictured at the right, grow on submerged structures such as these Hester Dendy sampling plates. Sea squirts also can be found growing on boat hulls and undersides of docks.

Colonial tunicates, such as sea pork (below right) and encrusting tunicates (left), are clusters of individual tunicates known as zooids, housed within the protective colorful tunics.

Feeding: Tunicates are filter feeders and feed by drawing water through the incurrent siphon, filtering out incoming plankton, and expelling the filtered water back into the ocean via the excurrent siphon. The siphons, pictured below on the left, are easily visible in the solitary species but not in the colonial species.

Reproduction: Tunicates are generally hermaphroditic, but they do not self fertilize. During breeding season, they release sperm into the water and bring in other sperm to fertilize their eggs. Initially, the planktonic tunicate larvae float in the water quickly settling on hard submerged surfaces where they develop into adult tunicate form.



Sea Squirts



Encrusting tunicate



Sea squirt siphons



Sea pork

References & Photography Credits:

Earth Life Web- <http://www.earthlife.net/inverts/ascidiacea.html>

National Oceanic and Atmospheric Administration Photo Library- <http://www.photolib.noaa.gov/>

Southeastern Regional Taxonomic Center/South Carolina Department of Natural Resources- <http://www.dnr.sc.gov>

The University of Georgia, Marine Extension- <http://marex.uga.edu/shellfish>



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Wetland Birds



Brown Pelican

Pelecanus occidentalis

These birds grow up to 1 m long with a 2 m wingspan! Brown pelicans are distinguishable due to their long bill with a pouch and yellow crown on the heads of mature adults. Brown pelicans dive into tidal creeks, sounds, and the ocean for fish. Other than in flight, these birds can be seen sitting on pilings and docks.



Double-crested Cormorant

Phalacrocorax auritus

Cormorants are approximately 69 cm long with a 1.3 m wingspan and have an obvious orange throat patch that stands out from their black body. They are excellent fishing birds and will dive and swim to catch dinner. Similar to the Anhingas, their freshwater cousins, double-crested cormorants inhabit brackish and salt water areas.

Great Blue Heron

Ardea herodias

This heron is easy to recognize in flight because of their streamline profile that extends 1 m in length and hosting a 1.8 m wingspan. While on land, these tall majestic birds have a grayish blue body and white head with black stripes above the eyes. They hunt by remaining motionless along the water's edge



and waiting for prey, such as fish and crabs, to come within striking distance. Great blue herons can be found around fresh, brackish, and salt water habitats.

Great Egret

Ardea alba

Great egrets are almost 1 m long and are solid white with a yellow bill and black legs. On land, the great egrets' stark white color makes them easy to locate amongst the brown or green marsh grasses and during breeding season, one can see their long white plumes of feathers on their backs.



Great egrets are closely related to herons and inhabit waters of varying salinities where they hunt by slowly stalking prey, such as fish and crabs, in shallow water.

Belted Kingfisher

Ceryle alcyon



Belted kingfishers can grow up to 30 cm long and have a large dark blue head, dark blue back, a white belly, and a white stripe around their necks. Belted kingfishers are excellent fishing birds and can easily be spotted on power lines waiting to dive for fish and capture any other small creatures in the water.

References & Photography Credits:

Fairfax County Public Schools- <http://www.fcps.edu/StratfordLandingES/>

National Park Service- <http://www.nps.gov>

Sapelo Island National Estuarine Research Reserve- <http://www.sapelonerr.org/>



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Aquatic Invasive Species

AIS Definition

An Aquatic Invasive Species (AIS) is any freshwater or marine species that is not native to an ecosystem and whose introduction does or is likely to cause economic, human health, or environmental harm

AIS Characteristics

- High reproductive rates
- Broad diets
- Wide environmental tolerances
- Long lived
- Habitat generalists
- Gregarious
- Associated with humans



<http://www2.dpi.qld.gov.au/extra/aquaticinvaders/>

What are some of the problems that can be caused when AIS are introduced?

- Fouling of boats, docks, water intake pipes, and other objects in the water
- Competition with native species
- Reduced water quality (lowered dissolved oxygen levels, increased pH, or decreased light levels)
- Decreased biodiversity in the ecosystem



Photo credit: Jeff Schardt, Florida D.E.P.

What can I do to prevent the spread of AIS?

- Thoroughly clean and empty all boating equipment, including trailers, bilges, and live wells, when moving between bodies of water
- Never dispose of unwanted aquarium plants or animals in local waters
- Use only local live bait when fishing
- Landscape using native plants
- Educate yourself and others about invasive species in your area
- Report any AIS sightings

Have You Seen Me?

Forms are available on our website: <http://www.marex.uga.edu/shellfish>

Want to learn more about invasive species?

Check out the following websites:

- www.invasivespeciesinfo.gov
- www.invasive.org
- nas.er.usgs.gov
- www.sgnis.org/kids
- www.protectyourwaters.net
- www.habitattitude.net



STOP AQUATIC HITCHHIKERS!

Prevent the transport of nuisance species. Clean all recreational equipment.

www.ProtectYourWaters.net



Who should I contact if I find an AIS?

Shellfish Research Laboratory
 UGA Marine Extension Service
 20 Ocean Science Circle
 Savannah, GA 31411
 Phone: (912) 598-2348
 Fax: (912) 598-2399



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Australian Tubeworm

Scientific Name:
Ficopomatus enigmaticus
(Fauvel, 1923)

Habitat: Low intertidal to shallow subtidal areas attached to hard surfaces, prefers brackish water

Origin: Native to the southern hemisphere (Indian Ocean), possibly Australia, and has been introduced to many regions including Europe, Japan, and areas of the United States (Hawaii, California, Texas, and the Chesapeake Bay)

Suspected pathway of introduction: Hull fouling



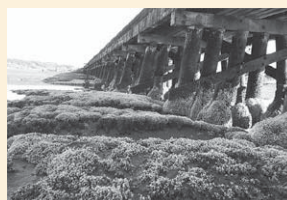
Photo credit: Leslie Harris, NHMLAC
www.californiabiota.com

Description and similar species:

These polychaete worms build and live in upright white calcareous tubes that have distinctive collar-like rings at irregular intervals and are about 2 mm in diameter. Tubes that are older tend to darken to a gold or brown color; however, the areas around the rings and by the flared opening remain white. The worm itself is about 2 cm long, including the operculum, which is the protective "stopper" the worm pulls into the opening of the tube when startled.



Photo credit: Luis A Solorzano
www.californiabiota.com



2001©Wasson, MBARI

Facts and potential impact:

Ficopomatus enigmaticus can occur as a single tube or as a large, dense reef-like mass. In one Argentinean location, this species formed circular reefs up to 7 m in diameter and 0.5 m deep. Heavy settlement and growth of this species has caused significant economic problems in both the Netherlands and New Zealand, and similar problems are feared

if the fouling species were to become established in Georgia. The first sighting of this species in Georgia occurred in Brunswick, where the species was found attached to intertidal oysters on a piling structure. To feed, *F. enigmaticus* sends its branching gill plumes out of its tube. The gill plumes then move around in the water, capturing small food particles to pass down to the mouth. Competition with native species for food and space is another potential impact.

Selected References:

- Cohen, Andrew N. 2005. Guide to the exotic species of San Francisco Bay. San Francisco Estuary Institute, Oakland, CA. Retrieved 8/8/2007. http://www.exoticguide.org/species_pages/f_enigmaticus.html
- Read, Geoffrey B. and Dennis P. Gordon. 1991. Adventive occurrence of the fouling serpulid *Ficopomatus enigmaticus* (Polychaeta) in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 25: 269-273.



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Invasive species

Charrua Mussel

Scientific Name:
Mytella charruana
(d'Orbigny, 1846)

Habitat: Typically mudflats or shallow lagoon areas, attached to submerged hard surfaces

Origin: Eastern coast of South America (Venezuela to Argentina) and the eastern Pacific Ocean (from Mexico to El Salvador, plus the Galapagos Islands)

Suspected pathway of introduction: Ballast water

Description and similar species:

In shape, this species resembles the edible blue mussel (*Mytilus edulis*). Charrua mussels are brown, light green, yellow, or black in color and can be uniform or banded. This mussel can be distinguished from native mussels because it lacks distinct exterior ribs or ridges and the interior of the shell is normally iridescent purple.



Photo credit: Marcy Mitchell, UGA MAREX

Facts and potential impact:

Mytella charruana is a member of the Mytilidae family, one that includes our native ribbed, scorched, hooked, lateral, and horse mussel species, plus another non-indigenous species, the green mussel. Charrua mussels have been reported at maximum lengths of 45 mm, with a salinity tolerance between 14 and 41



Photo credit: Alan Power, UGA MAREX

ppt. This species was first reported in Jacksonville, Florida in 1986 and in Liberty County, Georgia in 2006. Dense colonies of these mussels have been observed on floating docks and boat hulls, presenting economical costs associated with cleaning and maintenance efforts. These mussels also have the potential to compete with native shellfish species for space and food.

Selected References:

- Benson, Amy. 2007. *Mytella charruana*. USGS nonindigenous aquatic species database, Gainesville, FL. Retrieved 8/2/2007. <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=106>
- Boudreaux, Michelle L. and Linda J. Walters. 2006. *Mytella charruana* (Bivalvia: Mytilidae): a new, invasive bivalve in Mosquito Lagoon, Florida. *Nautilus* 120(1): 34-36.



Photo credit: Marcy Mitchell, UGA MAREX



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Invasive species

Green Mussel

Scientific name:
Perna viridis
(Linnaeus 1758)

Habitat: Coastal waters (less than 10 m), typically attached to hard structures like dock pilings

Origin: Indo-Pacific region of Asia

Suspected pathway of introduction: Ballast water



Photo credit: Marcy Mitchell, UGA MAREX.

Description and similar species:

The outer shell layer is bright green, especially in juveniles. The shell may be mostly brown in adults, with green occurring near the shell margins. Adults can reach 150 mm in length. Green mussels are often confused with other members of the *Perna* genus, particularly the green-lipped mussel from New Zealand (*P. canaliculus*). Members of the *Perna* genus lack ribs or ridges and therefore are not easily confused with many of our native mussel species (e.g. ribbed, scorched, hooked).



Photo credit: Amy Benson, USGS

Facts and potential impact: The optimal salinity and temperature tolerances of the green mussel are 27-33 ppt and 26-32°C. Specimens located in Georgia are predominantly subtidal, with some reports of the mussels occurring on the lower intertidal portion of beach jetties. The green mussel was first introduced to the United States in Tampa Bay in 1999, where it has caused significant fouling resulting in economical and ecological impacts. In Tampa, dense colonies developed on bridge pilings, piers, and navigation structures, and even smothered out intertidal oyster reefs (*Crassostrea virginica*). It is thought that a greater tidal range in Georgia is preventing the mussel from thriving in the intertidal zone here, thereby protecting oyster resources. Mortalities associated with cold winter spells have also helped to keep the mussel populations in inshore waters under control. However, warmer offshore currents help populations on buoys to persist through the winter season and there are concerns that the species will establish populations at Gray's Reef National Marine Sanctuary, one of the largest nearshore sandstone reefs in the southeastern United States.

Selected References:

Baker, Patrick, Jon Fajans, Shirley M. Baker and Derek Bergquist. 2006. Green mussels in Florida, USA: Review of trends and research. *World Aquaculture* 37(4): 43-48, 65-67.

Power, Alan J., Randal L. Walker, Karen Payne and Dorset Hurley. 2004. First occurrence of the nonindigenous green mussel, *Perna viridis* (Linnaeus, 1758) in coastal Georgia, United States. *Journal of Shellfish Research* 23(3): 741-744.



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Green Porcelain Crab

Scientific name:

Petrolisthes armatus
(Gibbes, 1850)

Habitat: Rock rubble or oyster reefs in shallow intertidal or subtidal areas

Origin: Historic range includes both Pacific and Atlantic: eastern Pacific from the Gulf of California to Peru; western Atlantic from Florida through the Gulf of Mexico to Brazil, including Bermuda, the West Indies, and the Caribbean; eastern Atlantic in tropical western Africa

Suspected pathway of introduction: Native transplant, possibly from ballast water and/or cultured shellfish transport

Description and similar species:

These crabs are extremely flat and small (max 11-15 mm carapace width). The chelae (claws) are also flattened. Adults are typically orange-brown to dark brown, while the juveniles have a somewhat lighter, speckled appearance. While they superficially resemble other porcelain crabs; mature specimens of both sexes have bright blue coloration on their mouthparts.



Photo credit: SERTC/SC DNR



Photo credit: Angela Bliss, UGA MAREX

Facts and potential impact: Green porcelain crabs are filter feeders, using feathery arm-like structures to sweep plankton into their mouths. The flattened bodies of these crabs make it ideal for them to hide between the oyster shells on an oyster reef. While camouflage and body shape are their most useful form of protection, they can also readily drop an appendage, such as a claw or leg, to distract a predator and escape. The impact of this non-indigenous crab on the local oyster reef ecosystems is inconclusive. Possible threats include feeding on native shellfish and crab larvae, competition with resident crabs and fish for space on the reef, and food competition with other filter feeding natives.

Selected References:

- Hollebone, Amanda L. 2006. An invasive crab in the South Atlantic Bight: friend or foe? (Doctoral dissertation, Georgia Institute of Technology, 11 April 2006). SMARTech: Scholarly Materials and Research at Georgia Tech. Retrieved 8/8/2007. <http://etd.gatech.edu/theses/available/etd-04092006-121221/>
- Knott, David M. and Rachael A. King. Petrolisthes armatus – an introduced species in the South Atlantic Bight? Retrieved 8/8/2007. <http://www.dnr.sc.gov/marine/sertc/P%20armatus%20SOM.pdf>



Photo credit: Alan Power, UGA MAREX



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Island Apple Snail

Scientific name:

Pomacea insularum
(d'Orbigny, 1835)

Habitat: Freshwater

Origin: South America

Suspected pathway of

introduction: Deliberate and accidental releases by aquarium hobbyists. In the aquarium trade they are sometimes sold as the "Golden Apple Snail" or "Mystery Snail"

Description and similar

species: The island apple snail is now the largest non-marine snail in the southeastern United States and is the most common apple snail found in Georgia. It can be distinguished from the native Florida apple snail (*Pomacea paludosa*) by the deep groove (channel) between the whorls of the shell. Shells are 70-100 mm high as adults and are highly variable in color, from olive brown to yellowish brown, often with darker bands and blotches. Gold and albino color forms are popular in the aquarium trade.

Facts and potential impact:

This snail feeds aggressively on many types of aquatic and terrestrial plants. Apple snails were introduced to Taiwan and Hawaii for human consumption and have since spread rapidly, becoming a serious rice and taro pest. While not yet a rice pest in the continental US, there is concern that this apple snail may out-compete native snails for food. In areas where they are eaten, undercooking can lead to parasite infections (e.g. rat lung parasite). This species has great potential to continue to spread throughout coastal Georgia. Apple snails, in general, have a lung in addition to their gills, allowing them to survive considerable time out of water and to migrate between water bodies. In addition, this species has a lower tolerance for cold temperatures than the Florida apple snail.



Photo credit: Bill Frank



Egg mass clusters of *P. insularum* (Photo credit: Bill Frank)

Apple snails lay their egg clusters on solid objects above the water line. It is normally the presence of these masses that alert individuals to their presence. The island apple snail lays thousands of

eggs in clusters that are initially bright pink or red in color. After time, the eggs fade to a lighter pink or even white color. The native Florida apple snail also lays pale pink to white clusters, but the eggs are larger in diameter and each cluster typically averages only 30 eggs.



Selected References:

Howells, R.G. 2000. Applesnails (*Pomacea*) in U.S. waters. Retrieved 8/1/2007. www.cdfa.ca.gov/phpps/ppd/Entomology/Snails/Applesnailidentification2.pdf

Ghesquiere, S. 2005. Apple snails. Retrieved 8/1/2007. www.applesnail.net

Rawlings, T.A., Hayes, K.A., Cowie, R.H., and Collins, T.M. 2007. The identity, distribution, and impacts of non-native apple snails in the continental United States. *BMC Evolutionary Biology* 7: 97.



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Invasive species

Red Lionfish

Scientific name:

Pterois volitans

(Linnaeus, 1758)

Habitat: Sand, coral, and live bottom substrates from about 10 to 55 m in depth (some sources indicate a greater maximum depth)

Origin: Indo-Pacific

Suspected pathway of introduction: Aquarium trade and human release.

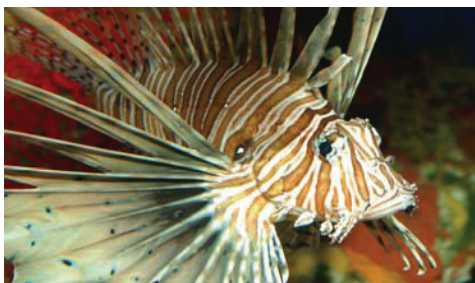


Photo credit: Peggy Sloan, North Carolina Aquarium at Fort Fisher

Description and similar species:

Lionfish are members of the Scorpaenidae family (Scorpionfishes).

Therefore, they share some characteristics with other members of this family, such as a large head and long, extravagant fins that contain venomous spines. Their body is typically white or cream with vertical red to reddish-brown stripes. They normally

have large tentacles over their eyes and the membranes of their fins (particularly the dorsal, caudal, and anal fins) are often spotted. The red lionfish (*Pterois volitans*) is very similar and closely related to another member of its genus, the devil firefish (*Pterois miles*).

The red lionfish and devil firefish are largely separated by differences in number of fin spines or rays and also coloration.



Photo credit: Peggy Sloan, North Carolina Aquarium at Fort Fisher

Facts and potential impact: While the red lionfish is utilized as a food fish in some areas of its native range, in the U.S. it is most commonly known as a valuable aquarium fish. The first documented introduction of red lionfish on the east coast came when Hurricane Andrew swept across Florida in 1992. The hurricane destroyed a large marine aquarium and released six lionfish into the water. These fish were seen alive nearby several days later. Since then, several lionfish have been captured or seen along the east coast, some as far north as New York. Adult red lionfish have no known predators and hunt small fish, shrimp, and crabs. The juvenile stage of this fish swims continuously in open water, which may account for its spread along the coast. As of September 2007, red lionfish have been documented and photographed at Gray's Reef National Marine Sanctuary off the Georgia coast.

Selected References:

Robins, Robert H. 2007. Red lionfish. Ichthyology at the Florida Museum of Natural History website. Retrieved 8/3/2007. <http://128.227.186.212/fish/Gallery/Descript/RedLionfish/RLionfish.html>

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Schofield, Pamela J. and Pam L. Fuller. 2007. *Pterois volitans/miles*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Retrieved 8/3/07. <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=963>



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Invasive species

Titan Acorn Barnacle

Scientific name:
Megabalanus
coccopoma
(Darwin, 1854)

Habitat: Shallow water attached to hard substrate, may survive in lowest intertidal range, most likely to be found in high salinity waters

Origin: Native to the eastern Pacific Ocean from Mexico to Ecuador, but reported in Brazil, Texas, Louisiana, as well as a northern expansion of its Pacific range in California

Suspected pathway of introduction: Hull fouling

Description and similar species:

Megabalanus coccopoma can grow very large (> 5 cm in diameter and height) and has a conspicuous pink color with six triangular plates. It may be distinguished from *M. tintinnabulum (antilensis)* which also occurs occasionally in Georgia by its globulo-conical shell and a circular to ovate aperture. Additionally, if the plates are removed the scutum is noted to be wider than higher.



Photo: *M. coccopoma* scutum right and shell above, Marcy Mitchell, UGA MAREX.



Facts and potential impact:

Research on *M. coccopoma* indicates that the planktonic larvae prefer to settle on disturbed or recently cleaned surfaces. The barnacle can also grow rapidly and attain a large size. Significant settlement and growth of the barnacle on structures including boat hulls, buoys, and fishing gear presents economic problems associated with reduced fuel efficiency and increased cleaning and maintenance efforts. Competition with native filter-feeding species for space and food is an environmental concern.



Photo: Left and above, Fran Lapolla, UGA MAREX.



Selected References:
Henry, D.P. & McLaughlin, P.A. 1986. The Recent species of *Megabalanus* (Cirripedia: Balanomorpha) with special emphasis on *Balanus tintinnabulum* (Linnaeus) sensu lato. Zoologische Verhandelingen (235): 1-69.
Newman, William A. and Ronald R. McConnaughey. 1987. A tropical eastern Pacific barnacle, *Megabalanus coccopoma* (Darwin), in Southern California, following El Niño 1982-83. Pacific Science 41: 31-36.
Perreault, Ray T. 2004. An exotic tropical barnacle, *Megabalanus coccopoma* (Darwin, 184), in Louisiana: its probable arrival and environmental implications. Proceedings of the Louisiana Academy of Sciences 66: 13-16.



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Invasive species

Alligatorweed

Scientific name:

Alternanthera philoxeroides
(Mart. Griseb.)

Habitat: Can tolerate a variety of habitats but typically roots in wet soils or shallow water and grows out into waterways; can also grow terrestrially (differs somewhat in form when growing on land)

Origin: South America

Description: The elliptic, non-succulent leaves occur in opposite pairs and are shiny with a dark green color. When growing aquatically, this plant has hollow stems to assist with floating. The flowers are silvery-white, small, and papery and occur in short, headlike spikes.

Facts and impact:

Alligatorweed grows out into waterways, forming dense floating mats that expand across the surface of the water. These mats can cause many ecological problems including but not limited to: displacing native vegetation, clogging waterways, and damaging water quality by restricting oxygen and increasing sedimentation. While usually found in freshwater habitats, the plants can tolerate brackish water conditions (up to 10% salt by volume). When growing on land, the plant has smaller, tougher leaves; and the stems are almost solid, having little to none of the hollowness seen in their aquatic counterparts. Alligatorweed normally spreads through vegetative fragments, since seeds are not common and usually not viable.



Photos credit: Chris Evans, River to River CWMA, Bugwood.org

Water Hyacinth



Scientific name:

Eichhornia crassipes
(Mart. Solms)

Habitat: All types of freshwater: lakes, ponds, rivers, marshes, and other types of wetland habitats

Origin: South America

Description and similar species: Water hyacinth has thick, waxy leaves that are oval or broadly elliptical in shape. The stalks (petioles) of the plant are spongy and sometimes inflated. The lavender flowers are showy with six petals; the uppermost one has a yellow patch on it. The roots are dark and feathery. When not flowering, water hyacinth can be confused with frog's-bit (*Limnobium spongia*); however, a comparison of the stalks and roots can show the difference. Frog's-bit has stalks that are thin and firm, unlike the spongy petioles of water hyacinth. Also, the roots of frog's-bit are whitish and can easily be distinguished from the dark roots of water hyacinth. Photo at left: Wilfredo Robles, Mississippi State University, Bugwood.org.

Facts and impact: In areas of the United States such as Florida, water hyacinth has been present for 100 years, and has caused significant problems for water management. The plant forms dense, free-floating mats of vegetation that can drastically alter the habitat for aquatic invertebrates and other plants. The mats restrict the light that would be needed for these organisms to survive. Also, water hyacinth depletes oxygen levels in the water, particularly near the center of the mats. This oxygen depletion can cause many problems for fish and invertebrates living in the water beneath this plant.



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Invasive species

Hydrilla

Scientific name:

Hydrilla verticillata
(L.f. Royle)

Habitat: Flowing or still freshwater systems: lakes, ponds, rivers, reservoirs, ditches, canals, etc.; can tolerate salinity levels up to 9-10 ppt

Origin: Warmer regions of Asia

Description: Hydrilla is a rooted, submersed perennial herb that has long, slender branching stems. The small, pointed leaves are in whorls of 3-8 with reddish midribs. The margins of the leaves are slightly toothed or serrated.



Above, Hydrilla mass has formed on the propeller of an outboard boat motor. Photo credit: Wilfredo Robles, Mississippi State University, Bugwood.org.

Facts and impact:

This aggressive and competitive plant can quickly grow from depths of 20 ft (sometimes deeper in clear water) to form dense mats at the surface. Once a popular aquarium plant, hydrilla first appeared in Florida in the 1950s. There are two populations present in the eastern U.S., an all female dioecious type that is found mainly from Florida up to South Carolina and a monoecious type that can be found north of South Carolina. The southern population survives over winter as a perennial, while the northern population relies on its tubers. Both populations commonly reproduce by potato-like tubers and ¼ inch compact buds called turions. Fragments of the plant can also be spread by boating, fishing, and waterfowl. Hydrilla is easily able to out-compete native aquatic vegetation because it has the ability to photosynthesize at lower light intensities (1% of full sunlight), allowing it to grow at greater depths and photosynthesize for a larger portion of the day. The large mats it produces raise pH, decrease oxygen levels, and impact the weight and size of sport fish. Synonym: Water thyme



Photo credit: Raghavan Charudattan, University of Florida, Bugwood.org



UGA1624028
Photo credit: Raghavan Charudattan, University of Florida, Bugwood.org

Selected web references for many invasive plants:

Invasive and Exotic Species – www.invasive.org

USGS Nonindigenous Aquatic Species Database – <http://nas.er.usgs.gov>

Center for Aquatic and Invasive Plants: University of Florida, IFAS –

<http://plants.ifas.ufl.edu/photos.html>



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Invasive species

Marsh Dewflower



Photo: Linda Lee, University of South Carolina, Bugwood.org

Scientific name:

Murdannia keisak
(Hassk. Hand.-Maz.)

Habitat: Roots in damp soil by water edges; found around ponds, lake, slow-moving streams, freshwater and tidal marshes, and other wetlands; often growing emerged

Origin: Eastern Asia

Description and similar species:

Marsh dewflower's succulent stems root at the nodes, and grow prostrate along the ground, eventually ascending to 18 inches. The lanceolate (lance-shaped) leaves are alternate, clasp the stem at the base of the leaf, and grow up to 3 inches.

Marsh dewflower has pink to purple flowers with three petals. The flowers are normally solitary, although they sometimes grow in small clusters of 2-4 flowers. Marsh dewflower is not a true dayflower (true dayflowers are in the genus *Commelina*), and therefore it lacks a modified leaf called a spathe around the flower.

Facts and impact: Marsh dewflower was first seen in the United States growing in cultivated rice patties in South Carolina in 1935. Since then, this annual, emergent plant has spread into the piedmont and coastal plain regions of the southeastern United States. The aggressive growth of this plant allows it to out-compete native plants. As with many other invasive aquatic plants, marsh dewflower forms dense mats in the water, causing both ecologic and economic problems. Marsh dewflower is primarily spread by seeds that are dispersed by wildlife; however, fragments of the plant can also be spread in the water, especially during flooding. Synonyms: Marsh (swamp) dayflower, Asian dayflower, Asian spiderwort, wartremoving herb

Giant Salvinia



Scientific name:

Salvinia molesta
(D.S. Mitchell)

Habitat: Wide range of freshwater aquatic habitats including lakes, ponds, slow moving rivers, canals, etc.

Origin: South America

Description and similar species:

Giant salvinia is a rootless floating aquatic fern with horizontal stems and leaves in whorls of three (two floating and one submerged). The floating leaves vary in color from green to gold to brown and are covered in rows of white arching hairs that

join at the top to form a cage. These cages resemble egg beaters and are easily seen with a hand lens. Some closely related neo-tropical species also have egg beater type hairs (*S. auriculata*, *S. biloba*, and *S. herzogii*) and differentiation of the species is normally dependant on sporocarps (fruiting bodies of the plant).

Facts and impact: Using its leaves to float, giant salvinia is able to form long chains and can quickly form thick mats that cover the water surface. Salvinia is able to reproduce rapidly, doubling in as little as a week in natural conditions. The mats that are formed block light to any plants living below the surface. In addition, oxygen levels in the water drop because the mat blocks atmospheric oxygen from entering into the water. Decaying parts of the plant also fall to the bottom and begin to decay; using what little oxygen is present. Like many other aquatic pest plants, giant salvinia can clog water intake pipes and affect recreational boating and fishing. Synonyms: Aquarium watermoss, Kariba weed, African payal, water fern



Photo: Troy Evans, Bugwood.org

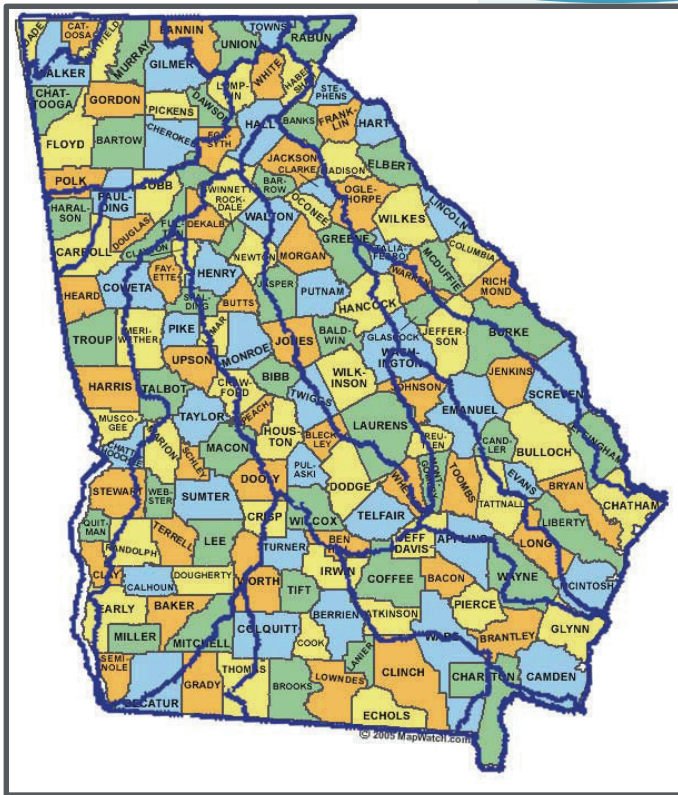


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Counties and Watersheds



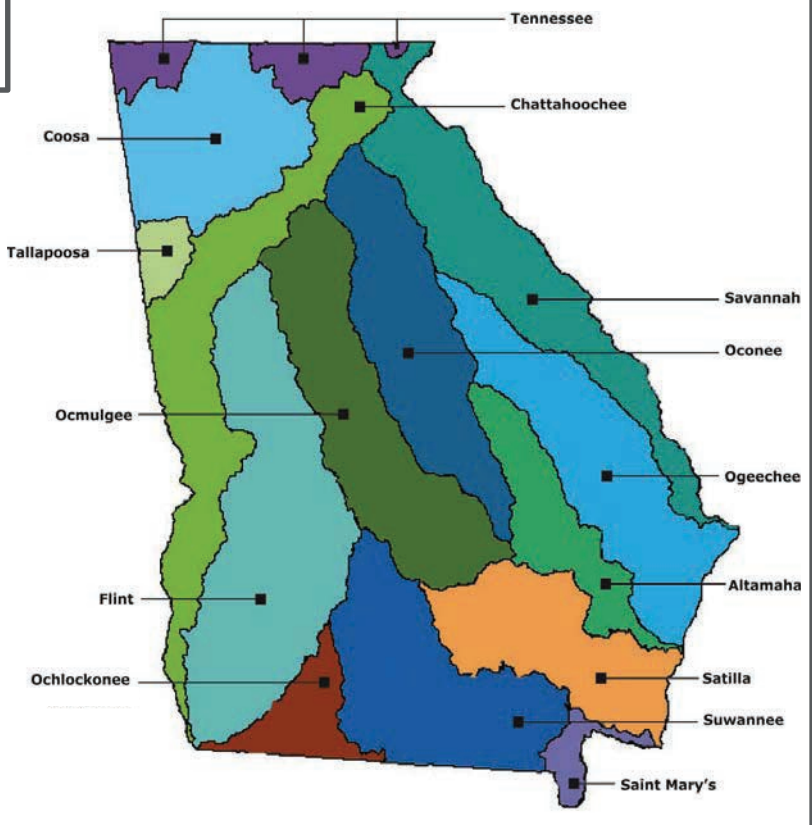
The map above shows each of the 159 counties in Georgia. The blue outlines represent the borders of Georgia's 14 major watersheds.

The map to the right depicts the 14 major watersheds located in Georgia. In which watershed do you live?

What is a Watershed?

Watersheds are divisions or regions that come in random shapes and sizes. As watersheds are dictated by geographical features such as mountain ranges and rivers, they tend to cross state and national boundaries. Due to the connectedness of watersheds, it is important to work along fellow communities, states, or countries as all of the water contained within a watershed flows the same direction eventually ending up in one of the earth's oceans. Pollution or overconsumption by those communities upstream can greatly affect water quality and water availability to the communities downstream.

In Georgia, there are 14 major watersheds (Tennessee, Chatahoochee, Coosa, Tallapoosa, Savannah, Oconee, Ocmulgee, Ogeechee, Altamaha, Flint, Satilla, Ochlockonee, Suwanee, and St Marys).



References and Photo Credits:

Skidaway Institute of Oceanography
<http://www.ski.o.peachnet.edu/>

US Census Bureau - http://quickfacts.census.gov/qfd/maps/georgia_map.html

US EPA - <http://www.epa.gov/owow/watershed/>



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Marsh Zones



Sound

Georgia Marsh Zones (from Ocean to Mainland):

A **sound** is the deepest zone of the saltwater marsh and is distinguishable as a large aquatic inlet or deep bay protected by barrier islands and influenced by tides and storm surges. Examples situated along Georgia's coast include Ossabaw Sound, Wassaw Sound and Doboy Sound.

Tidal creeks vary in width, depth, and length. These naturally channelized marsh areas experience drastic changes in water depths and salinities due to tidal variation, rainfall events, and storm surges. Tidal creeks can be lined with oyster reefs, mud, or *Spartina*. Various birds, such as mergansers and buffleheads, frequent these creeks along with sea turtles and dolphins.

Moving to higher elevated parts of the marsh, the **low marsh** is typically dominated by salt tolerant marsh grass (*Spartina*). Many vertebrate and invertebrate species such as stone crabs and diamondback terrapins frequent this zone to prey on the periwinkle snails and Atlantic ribbed mussels. The low marsh zone provides habitat for many bird species such as the marsh wren and the red-winged blackbird.

Often times, **mud flats**, can be exposed within tidal creeks and the low marsh zone at low tides to reveal a plethora of mud snails, fiddler crabs, and tube worms that are predated on by egrets, herons, and diamondback terrapins.

The **high marsh** is the next zone and, as its name implies, it is higher in elevation than the low marsh. The high marsh has sandier soils and more access to freshwater run-off after rainfall events. Plants that grow in the high marsh zones include sea lavender, sea oxeye daisy, and black needlerush. Only covered by a spring high tide, the exposed soil of the high marsh is subject to evaporation and areas of very high salinity, known as "**salt pans**", develop. Salt pan soil is so saline that it prevents all plant growth and appears as sandy patches as seen in the picture at the bottom left.

The **hammock**, which is also known as a maritime forest, is the most inland edge of the marsh and is typically untouched by normal high tide events. The freshwater from rainfall events allows for several tree species to thrive, such as live oaks, palmettos, and yaupon holly. Due to the higher elevation and beautiful scenery, hammocks are the most developed marsh zone.



Tidal creek and mud flat



Low marsh



High marsh, salt pan, and hammock

References & Photography Credits:

Sapelo Island National Estuarine Research Reserve - www.sapelonerr.org/
University of Georgia - <http://www.marex.uga.edu/shellfish>



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Oyster Reefs

Oyster reefs, also referred to as oyster bars, are intertidally submerged habitats found in near shore areas and estuaries along the coast. Created by the accumulation of spat (young oysters) growing on established oysters, oyster reefs create an important habitat within the Georgia's coastal wetlands, both ecologically and economically.



Ecologic Importance

Oyster reefs serve important ecological roles in coastal ecosystems:

- Protect various marsh zones from shoreline erosion caused by tidal action and storm surges.
- Improve water quality and clarity by filtering estuarine waters of pollutants and excessive nutrients.
- Provide a hard substrate in the estuaries for oyster larvae and various planktonic organisms to settle and thrive.
- Provide spawning, breeding, feeding, and nursery habitat for commercial and recreational wetland species such as clams, mussels, whelks, and sheepshead, blue crabs, and shrimp.



Economic Importance

In the early 1900's, Georgia commercially produced more oysters than any other state, but today Georgia's oyster harvests have drastically declined to a few thousands pounds due to:

- Coastal development and deteriorating water quality
- Over-harvesting and lack of hard substrate to which spat can attach
- Disease

G.E. R.G.I.A.

(Generating Enhanced Oyster Reefs in Georgia's Inshore Areas)

Due to the oysters' importance in maintaining a healthy coastal ecosystem, the UGA Marine Extension Service coordinates a community based oyster restoration program. Companies, communities and individuals can donate oyster shell from an oyster roast that can be utilized to build new oyster reefs along Georgia's coast.

For more information on the GEORGIA project or to donate used oyster shell for restoration projects, please visit <http://www.uga.edu/gotshell> or call 912-598-2348 ext 3.

References and Photography Credits:

Fort Pierce Smithsonian Marine Station - http://www.sms.si.edu/IRLspec/Oyster_reef.htm

University of Georgia Marine Extension - <http://www.marex.uga.edu/shellfish>



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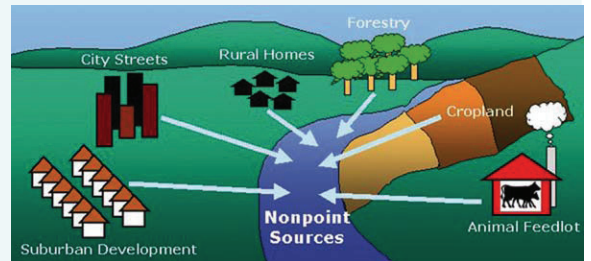


Non-point Source Pollution

Non-point source pollution, unlike point source pollution, comes from many diffuse sources and is difficult to regulate or permit. Whether it comes from cars, pets, yards, or wildlife, non-point source is the leading cause of poor water quality in coastal wetlands. Non-point source pollution enters coastal waters through rainfall events and runoff. With increasing coastal populations and development, there is great concern on preventing non-point source pollution.

Sources of Non-point Source Pollution

- Excess fertilizers, herbicides, and insecticides from residential areas
- Excess nutrients from animal wastes and fertilizers from agricultural areas
- Oil, grease, and toxic chemicals from vehicles and marine vessels
- Sediment eroded away from improperly utilized land
- Salts from irrigation practices
- Acidic leaching from abandoned mines
- Bacteria from livestock waste, pet waste, and faulty septic systems.



Effects of Non-point Source Pollution

- Closed recreation areas and beaches due to *Enterococci* and *E. coli* levels
- Detergents from washing the car increases nitrate levels which promotes plant and algal growth
- Tainted seafood due to algal blooms from excess nutrients
- Oily film or foul smelling wetlands from leaking boats and cars
- Sick or declining bird populations due to improperly used bug sprays
- Fish dying from sediment clogged gills
- Aquatic invertebrates fleeing or dying due to increased salt levels

WE ALL CAN PREVENT NON-POINT SOURCE POLLUTION!

- Keep litter and debris out of the environment and out of storm drains
- Apply garden chemicals at the proper time and in the proper dose
- Dispose of used oil, antifreeze, paints, and other chemicals properly.
- Control soil erosion by planting ground cover or utilizing silt fences
- Have your septic system inspected and pumped at least every 3-5 years
- Pick up pet waste and dispose of properly in the garbage
- Participate in coastal and local clean up events



References and Photography Credits:

Clean Water Campaign - <http://www.cleanwatercampaign.com>

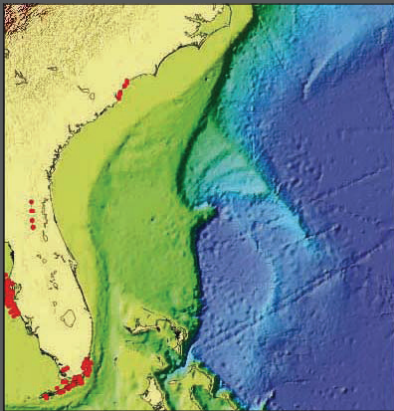
U.S. Environmental Protection Agency website - <http://www.epa.gov/owow/nps>



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Tides



The Georgia coast experiences a semi-diurnal tidal cycle with two high tides and two low tides that are similar in highs and lows respectively throughout a lunar day or approximate 24 hour period. From this, we can extrapolate that a high tide event occurs approximately every 12 hours with a low tide occurring in between each high tide. Therefore, if a high tide occurs at 6:00am, a low tide will follow around noon, followed by a high tide around 6:00pm and another low tide around midnight.

Not all coasts experience the same tidal variation or the same tidal cycle; for instance, Seattle, Washington, located in the Pacific Northwest experiences a mixed semi-diurnal tidal cycle in that their daily high tides and low tides come in pairs, but not of equal heights. A third type of tidal cycle is experienced in the Gulf of Mexico and is known as a diurnal tidal cycle with only one high tide and one low tide throughout each day.



Other than tidal cycle, Georgia experiences a great tidal variation throughout each month with high tides and low tides differing by up to nine feet in one 24 hour period! Not as drastic as the more commonly known Bay of Fundy in Canada, but Georgia experiences the highest tidal variation on the East Coast due to its location in the Georgia Bight or South Atlantic Bight, pictured at the top left. Due to low lying elevation, the shallow continental shelf, and the GA bight, flood tide events funnel onto Georgia's coast filling in coastal estuaries and saltmarshes. The height of the highest tide can be estimated by a glance into the night's sky to look at the moon! Gravitational relationships between the sun, moon, and earth are the driving force of the tide types and heights. Below, are two types of tides commonly experienced and the gravitational relationships:



SPRING tides, middle left, occur when the Sun and Moon are lined up and jointly pull on the same location of the Earth. With joint efforts, the Earth's oceans are essentially pulled from areas creating extremely low tides while other parts of the oceans experience extremely high tides. Spring tides, or bulge tides, occur on Georgia's coast during full and new moons.

NEAP tides, bottom left, occur during waxing and waning moon phases such as crescents and half moons. Tide variation during these moon phases are not as notable as the tide heights occurring during spring tides; for instance, marsh grasses are not completely inundated with water nor are mud flats totally exposed. Remember that "NEAP" means the tides are "nearly even as possible."

References and Photography Credits:

National Oceanic and Atmospheric Agency - <http://tidesandcurrents.noaa.gov/> and http://oceanservice.noaa.gov/education/kits/tides/media/supp_tide07a.html

Georgia Encyclopedia, Georgia Coast Geology - <http://www.georgiaencyclopedia.org>

Seaclock - <http://www.seaclock.com/anglais/forwhat.htm>



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Clean Water Act



The Clean Water Act (CWA) was established in 1977 by the US Environmental Protection Agency (EPA) and is called the cornerstone of surface water quality protection. This act was set forth to regulate pollution discharged into United State's waters to protect wildlife, recreation, and surface water quality.

The CWA sets standards for industrial wastewater discharge and sets water quality standards. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit was obtained from EPA. The CWA also recognized the need for planning to address the critical problems posed to water quality by non-point source pollution; such as toxic surface run-off and storm sewer systems

Shore Protection Act

Established in 1992 by the Georgia Department of Natural Resources, the Shore Protection Act protects and manages Georgia's shoreline including sand dunes, beaches, sandbars, and shoals.



Sand dunes, offshore sand bars, and shoals are easily disturbed by human and natural actions which can either harm or inhibit their natural development. Valuable resources, these sand structures offer great habitat and coastal protection from high tides and storm surges. To protect these, the Shore Protection Act regulates beach renourishment, groins, jetties, rock revetments, and sand dune crossovers on a permit basis, while the Act prevents boat basins, docks, marinas, and boat ramps in these areas.

The Shore Protection Act also states that these inshore and offshore sand structures are additionally protected as they are actively participants in the sand sharing system of the Georgia coast and Eastern Seaboard. If sand is removed from the sand sharing system, then coastal areas within the network are effected.

For instance, sand from Hilton Head, South Carolina, migrates southward along the shore via the longshore current and comes to rest on Tybee Island's north end. Over time, the sand from Tybee Island's north end migrates down the coast until it reaches Little Tybee Island's north end. This southerly movement continues. The sand sharing system ultimately means that sand can travel from the northern reaches of Maine to the tip of the Florida Keys. At any point that sand is removed from the system, such as settlement into dredged rivers or inlets, an island or coastal area south of that point can be greatly effected with decreased amounts sand from the natural renourishment process of the sand sharing system.

References & Photo Credits:

Environmental Protection Agency - <http://www.epa.gov/>

Georgia Department of Natural Resources - <http://crd.dnr.state.ga.us>



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Marshlands Protection Act

Marshlands and estuaries along Georgia's coast provide vital resources for terrestrial and aquatic organisms from birds to sea turtles to humans. Beyond immediate resources such as oxygen, food supplies, and protective habitats, marshes also provide a buffer zone that shelters inland areas from storm surge impacts.

Written in 1970 and ammended in 1992, the Coastal Marshlands Protection Act states that Georgia's 700,000 acres of coastal marshlands are vital natural resources that provide:

- Habitat and food for many terrestrial and aquatic species
- Protective areas or nurseries for economically important fish and shellfish species
- Flood and storm surge buffers for coastal communities
- Filtration of pollutants

Estuarine areas protected under the Marshlands Protection Act extend from the water's edge to 5.6 feet above mean tide level; which includes intertidal areas, tidal water bottoms, and mudflats.

This Act has aimed to protect these coastal areas by implementing a permitting process to control development and use of these ecologically important marshland areas. For those wanting to build structures like community docks and marinas, conduct dredging or channel deepening, or fill areas, a permit must be obtained. Permits and the permitting system are under the jurisdiction of the Coastal Marshlands Protection Committee and administered by Georgia's Department of Resources Coastal Resources Division.

The Coastal Marshlands Protection Committee has the authority to evaluate proposed developments then grant or deny the proposals based on the development's environmental impacts and its impact on public interest. This Act states that projects cannot do harm or alter the natural flow of navigational waters, projects cannot increase erosion in marshland areas, nor can projects interfere or negatively impact marine life or wildlife conservation efforts.

Further information can be obtained by contacting GA DNR's Coastal Resources Division at www.dnr.state.ga.us/dnr/coastal.

References & Photography Credits:

Georgia DNR Coastal Resources Division - <http://www.dnr.state.ga.us>
University of Georgia - <http://www.marex.uga.edu/shellfish>



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