Sound Experience
Curriculum Handbook

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Vision Statement

We envision a future where everyone values Puget Sound/Salish Sea and the world's oceans, and chooses to act as stewards of their treasured waters.

Mission Statement

Sound Experience sails the historic schooner *Adventuress* to educate, inspire and empower an inclusive community that works to improve our marine environment and celebrates our maritime heritage.

Values

- Transformative Education – changing our youth, our communities and our world
- Learning Organization – evolving for and with our people
- Living Sustainably – acting for our waterways
- Partnering – sharing our collective strengths
- Integrity – doing the right thing
- All Are Welcome

SOUND EXPERIENCE PHILOSOPHY OF EDUCATION

Education means 'to draw out'. It implies the process of awakening the inner world to its potential. Instruct means 'to pile upon'. When we pile upon, we do not honor the creative process, for we do not allow time and space for incubation, illumination, or the synthesis involved in creative intelligence. When we instruct, we merely provide facts and answers. Educating implies a drawing out, an active participation in creating intelligence, an awakening of inner thought processes.

- ***Chris Brewer and Don G. Campbell***

Rhythms of Learning: Creative Tools for Developing Lifelong Skills
1991, p. 202

Sound Experience programs offer a unique hybrid of styles and objectives. Our ultimate goal is to inspire participants to recognize Puget Sound as a fragile ecosystem, make connections between the Sound and the influence they have on it, and finally to take action in a positive manner.

While this philosophy may be similarly implemented from a shore-based facility, our use of *Adventuress* as an educational platform helps make the impact much more direct. We, as crew and participants, are stewards of *Adventuress*, just as we are stewards of our ecosystem. *Adventuress* has a limited quantity of resources to be managed and sails best when all aboard are working together toward a common goal. As such, the principles necessary to manage her responsibly are the same as those necessary to be stewards of our environment. Both are systems in which mismanagement becomes apparent to the system's inhabitants.

We strive to take an inductive approach to the learning process, in which as much of the lesson as possible is multi-faceted, integrated with other concepts, and student generated. Although the individual stations are differentiated in content, **the whole experience is the lesson**. As a result, nothing is done 'just because'. At times it is necessary to guide students toward the connections between seemingly unrelated activities, and at other times it is best to allow them to draw their own connections. Either way, the goal is to empower them to think outside the box, and find the interconnectedness of all things.

'Awe and wonder' are powerful tools, but they must be connected to action if they are to be effective beyond the individual. Because our program is based in awareness, and not advocacy, this is a complicated line to walk. In the end, when participants leave *Adventuress*, the action is up to them. It is therefore our role to help *them* make connections between the Sound, the role they play, and actions they can take. It is not our role to tell them how to be better citizens, what products to buy, or how to live. We can suggest alternatives, but as with anything, the discoveries *they make themselves* will be the most powerful to them as individuals, and the most likely to inspire them toward action.

ABOUT SOUND STUDIES

What is Sound Studies?

Sound Studies programs are three- or five-hour sails offered to school and youth groups. These programs occur primarily in the spring and fall. The age range starts at 3rd grade and runs through high school. They are sometimes adapted to college groups.

Who can participate in a Sound Studies program?

Schools and youth groups 3rd grade and older. Because of the short time-frame of these trips, the program varies little from trip to trip. The format is consistent, although the delivery may vary depending on age and background of the group.

Sound Studies Goals

Sound Studies are our most content-driven programs. As a result, the five stations of Sound Studies provide the basis and objectives for the environmental science curriculum in all other program models.

The goal of a Sound Studies program, as with all programs offered by Sound Experience, can be summarized in a single word: ***awareness***. The most effective way for us to have a lasting impact in this area is to strive to meet the following goals on every program:

Participants will:

- Leave with a heightened awareness of Puget Sound as a fragile ecosystem.
- Understand the concept of a whole system, and how *Adventuress* and the earth both illustrate this concept.
- Increased literacy of the natural systems in which they live.
- Recognize the interrelationships that exist between all life.
- Identify positive and negative impacts that they as individuals have on the Puget Sound ecosystem.
- Recognize their ability to take action by raising others' awareness and making responsible choices.
- Understand the necessity of cooperation as a course to action.

Sound Studies Program Themes

Teachers will pick one of the four themed program options for their day aboard. This will specify which stations are to be taught and how the program is framed. The themes are as follows:

Emerging Issues in the Salish Sea

Identify major environmental issues of the region and learn how we as a community can have an impact.

Teaching Stations: Plankton, Life Aboard Ship, Marine Debris, Nautical Skills, Ocean Acidification

Marine Trades
Learn about the importance of the marine trade industry and its impact in our region.
Teaching Stations: Life Aboard Ship, Marine Debris, Nautical Skills, Ocean Acidification, Mechanical Advantage

Marine Ecology
Discover a deeper understanding of the Salish Sea and its inhabitants.
Teaching Stations: Plankton, Marine Life, Life Aboard Ship, Nautical Skills, Ocean Acidification

Becoming a Mariner
Explore the many skills required to become a mariner on the Salish Sea
Teaching Stations: Marine Life, Life Aboard Ship, Nautical Skills, Navigation, Mechanical Advantage

ABOUT SOUND EXPLORATIONS

What is Sound Explorations?
Sound Explorations are 3+ day overnight sails offered to schools and youth groups. These programs occur throughout the sailing season, primarily in the spring. The age ranges from 5th grade through high school and occasionally into college.

Who can participate in a Sound Explorations program?
School and youth groups of up to 24 people can come aboard *Adventuress* for an overnight trip. As these programs allow for crew to get to know the individuals well, these programs tend to be more flexible in their structure and content.

Sound Explorations Goals
Sound Explorations programs are designed to educate students about the wonders of Puget Sound and ways they can help protect it. Our innovative, hands-on teaching strategies, conducted under sail on the waters of Puget Sound stimulate students to learn by making science real, accessible, and exciting.

Sound Experience uses a variety of developmentally appropriate strategies to meet the diverse learning needs of our participants. Within an experiential framework, Sound Experience utilizes hands-on learning, critical thinking skills, and large and small group interactions.

During the program, students work cooperatively to set *Adventuress'* sails. Students rotate through discovery stations that are a part of the chosen theme.

Key concepts that are woven through the stations are *environmental understanding*, *leadership*, and *stewardship*.

Participants will:

Environmental Understanding

- Understand that they are a part of the Puget Sound ecosystem.
- Understand the components of a healthy Puget Sound including energy flow, cycles, interrelationships and adaptations.
- Be introduced to the concept of a whole system; one which is self-contained. They will see parallels between Adventuress' system, the Puget Sound ecosystem and the planet earth.

Leadership

- Gain a greater appreciation of themselves and their abilities.
- Obtain skills and an increased feeling of responsibility to be part of the community.
- See parallels in actions taken on the ship and actions at home.

Stewardship

- Have an increased desire to contribute their efforts to preserving Puget Sound and acting on concern for others.
- Reflect on their role in the consumption of natural resources.
- Gain an appreciation for others and their ability to accept others' differences.

Sound Exploration Themes

Teachers or group leaders will pick one of the three themed program options for their overnight trip aboard. This will specify which stations are to be taught and how the program is framed. The themes are as follows:

Emerging Issues in the Salish Sea

Identify major environmental issues of the region and learn how we as a community can have an impact.
Teaching Stations: Plankton, Life Aboard Ship, Marine Debris, Nautical Skills, Ocean Acidification
Possible Activities: Marine Life, Microplastics research, Beach Clean Up/Restoration Project (4+ day trip)

Marine Trades

Learn about the importance of the marine trade industry and its impact in our region.
Teaching Stations: Life Aboard Ship, Marine Debris, Nautical Skills, Ocean Acidification, Mechanical Advantage
Possible Activities: Build a Boat to Float, Engineering Project

Marine Ecology

Discover a deeper understanding of the Salish Sea and its inhabitants.
Teaching Stations: Plankton, Marine Life, Life Aboard Ship, Nautical Skills, Ocean Acidification
Possible Activities: Plankton Races, Shore Hike (4+ day trip)

CURRICULUM

Curriculum Guidelines for Youth Programs
Programs are designed to educate students about the wonders of Puget Sound and ways they can help protect it. Our innovative, hands-on teaching strategies, conducted under sail on the waters of Puget Sound stimulate students to learn by making science real, accessible and exciting.

Sound Experience crew use a variety of developmentally appropriate strategies to meet the diverse learning needs of our participants. Within an experiential framework, Sound Experience utilizes hands-on learning activities, critical thinking skills, and large and small group interactions. We are interdisciplinary: not just science, but history, culture and art around the topics of the natural resources and conservation.

Key concepts that are woven through all stations are habitat, adaptations, interrelationships, cycles and human impact. Each station incorporates one or more of the seven Ocean Literacy Standards, which are correlated to the National Science Education Standards Science Content Standards. In addition to that, we align with Washington State K-12 Integrated Environmental and Sustainability Learning Standards.

Ocean Literacy Principles

1. The world has one ocean with many features
2. The ocean and life in the ocean shape the features of Earth
3. The ocean is a major influence on weather and climate
4. The ocean makes the Earth habitable
5. The ocean supports a great diversity of life and ecosystems
6. The ocean and humans are inextricably interconnected
7. The ocean is largely unexplored

Click HERE for more information about Ocean Literacy Standards

Click HERE for more information about Next Generation Science Standards. We are currently working on a documentation to show how our curriculum aligns with NGSS

PLANKTON STATION

Lesson Summary

The Plankton Lesson will provide students with an understanding of the definition of plankton, types of plankton found in Puget Sound waters, their place in the ocean ecosystem, their role in the food web, and their connection to environmental factors in the atmosphere and on land. Lesson activities will include plankton collection, observation of plankton with microscope-video system, identification of plankton types, and plankton “behavior”.

Educators will discuss connections to relevant Ocean Literacy Principals as well as other on-board lessons (e.g., Marine Life).

Ties to Ocean Literacy Principles 5: The ocean supports a great diversity of life and ecosystem

Outcomes & Learning Standards

Students will be able to:10-15 minute station:

- Define ‘plankton’
- Describe the two main plankton types (zooplankton, phytoplankton)
- Explain the differences between holoplankton and meroplankton
- Describe connections between the Plankton lesson and other lesson areas

15-30 minute station

- Give examples of phytoplankton and zooplankton
- Explain the role of phytoplankton in O_2 production and CO_2 absorption
- Explain the role of plankton in the food web
- Give examples of relevant Ocean Literacy principles

30+ minute station

- Explain concept of bio-accumulation
- Understand how eating lower on the food chain uses less energy

Lesson Vocabulary

plankton, phytoplankton, algae, diatom, silica, zooplankton, copepod, barnacle, crustacean, larvae, holoplankton, meroplankton, current, oxygen, carbon dioxide

Basic Description of Plankton Station

Assemble student group at aft deck area.

1. Hook: At the beginning of the lesson, ask some of the following questions to engage students and stimulate their curiosity and readiness for learning:

- "Who has heard of 'plankton'?"
- "What is it?"
- "Have any of you ever seen plankton?"
- "Have any of you ever EATEN plankton?"

2. Building Background Information (BBK)
    - What are plankton? – organisms that drift in the current
    - 2 main types of plankton – zooplankton (animal) and phytoplankton (plant-like)
    - 2 sub-types of zooplankton – holoplankton (plankton throughout their life cycle, i.e. copepod) and meroplankton (plankton during their juvenile stages and later develop into adult forms, i.e. sea stars, barnacles, crabs, etc.)

3. Guided Practice
    - Briefly describe the components of the plankton net and the collection process.
    - Attach (two points of attachment!) net line to life line.
    - A student will ask the captain or mate for permission to deploy the plankton net.
    - Students (2 - 4) will lower the net and feed out the line.
    - While the plankton net is overboard, ask students what they think we might catch. This conversation can lead to a discussion of the different types of plankton – phytoplankton and zooplankton.
    - After approximately two minutes, ask two or three students to pull in the net and, under the direction of the educator, unscrew the collection "bucket" and transfer sample to plastic container. Make sure to involve different students for each activity.
    - Lead the group to the deck house. ***NOTE: For shorter lessons or prior to using the microscope, you can give students the small loupes to make their own observations of the sample.
    - Prior to viewing the sample, review relevant concepts/information:
        - What are plankton? – organisms that drift in the current
        - 2 main types of plankton – zooplankton (animal) and phytoplankton (plant-like)
        - 2 sub-types of zooplankton – holoplankton (plankton throughout their life cycle, i.e. copepod) and meroplankton (plankton during their juvenile stages and later develop into adult forms, i.e. sea stars, barnacles, crabs, etc.)

- Educator will demonstrate using eye dropper or small scoop to transfer specimens to petri dish(es). Specimens can be collected "randomly" or visually "hunted"/captured.
- Note: it is helpful to put just one or two drops onto the petri dish to allow for easier focusing with the microscope
- Place sample dish on microscope platform and adjust lighting/magnification/focus as necessary. Begin with low magnification and zoom in to better view specific organisms.

4. Application Synthesis

- Distribute/utilize plankton I.D. sheets to facilitate discussion.
- Students will observe plankton on the monitor. Ask students to describe their observations. Ask facilitating questions (e.g. "What is the most interesting thing you noticed?", "Which are zooplankton, which are phytoplankton, and why do you think so?", "What's it doing?").
- Identify specific plankton being viewed and describe important/interesting characteristics (e.g., movement, eating/defense behavior, reproduction strategies, place in food web). Have students use plankton info cards to share characteristics of different types of plankton
- Identify a variety of specimens to demonstrate plankton diversity.
- Discuss vital role of phytoplankton in O_2 production and CO_2 absorption.

5. Reflection/Process/Action At the conclusion of the lesson, a variety of questions, riddles, and/or games are used to assess student learning and increase the likelihood of successful "take home" messages. Some examples or suggestions:

- What are plankton?
- What is the difference between phytoplankton and zooplankton?
- What are two types of plankton we saw today?
    - e.g., plankton definition; main groups of plankton; holoplankton vs meroplankton, importance of phytoplankton in the food web, examples of zooplankton and phytoplankton.
- Challenge students to answer some of the following questions or come up with your own creative questions to provoke critical thinking:
    - "What role do plankton play in the ocean ecosystem?"
    - "What do plankton give us that we use every day?"
    - "What would happen if there were a die off of plankton? How about a bloom?

- Lead, "THANK YOU PHYTOPLANKTON!", so the whole boat can hear it!

Plankton Background Information and Resources

For a brief description of plankton and their role in the environment, watch the following videos:
http://ed.ted.com/lessons/the-secret-life-of-plankton
http://www.oceanicresearch.org/education/films/plankton_qt.htm

For in-depth information about plankton studies in Puget Sound read pages 42-47 of the Puget Sound Marine Waters overview

Vocabulary

Trophic Level**:** A group of organisms that occupy the same position in a food chain

Plankton: Small organisms that float or drift in bodies of fresh and salt water. Plankton is a primary food source for many animals, and consists of bacteria, protozoans, certain algae, cnidarians, tiny crustaceans, and many other organisms

Phytoplankton: Plankton consisting of free-floating algae, protists, and cyanobacteria. Phytoplankton form the beginning of the food chain for aquatic animals and fix large amounts of carbon, which otherwise would be released as carbon dioxide.

Zooplankton: Plankton that consists of tiny animals and of microorganisms once classified as animals such as dinoflagellates and other protozoans

Holoplankton**:** Plankton that remains free-swimming throughout all stages of its life cycle

Meroplankton**:** Any of various organisms that spend part of their life cycle, usually the larval or egg stages, as plankton

Photosynthesis**:** The process in green plants and certain other organisms by which carbohydrates are synthesized from carbon dioxide and water using light as an energy source. Most forms of photosynthesis release oxygen as a byproduct

Producer**:** A photosynthetic green plant or chemosynthetic bacterium, constituting the first trophic level in a food chain

Food Chain**:** A succession of organisms in an ecological community that constitutes a continuation of food energy from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member

Energy

Energy, though it can be an abstract concept, is vital to all life forms. Humans receive their energy supply by eating foods, processing the sugars in these foods, and storing this energy in their cells as ATP. When humans have a deficiency of these sugars, they begin burning other, less efficient forms of stored energy, such as fats and proteins.

Where did the energy come from, and where does it go?

There is nothing on earth that creates energy itself. The earth receives solar energy from the sun. As this energy is radiated through the atmosphere and to organisms on the earth, plants and plant-like organisms use the solar energy to transform carbon dioxide and water to sugars through photosynthesis. Once these sugars are produced, they may be stored to sustain the survival of the plants. Hence the term we use for these plants: ‘producers’, since they produce sugars. Fortunately for us, a byproduct of this process is oxygen

Energy Transfer

Just as the plants require sugars to sustain themselves, other organisms require sugars to store as energy. Animal organisms cannot produce sugars as plants do, so they must consume other organisms to receive their energy. As a plant grows, it is not 100% efficient, and much of the energy it produces is lost. Only about 10% of the energy produced is available to the consumer. As a result, when an organism comes along to eat a plant, it does not receive 100% of the energy it requires to survive. Furthermore, the consumer is not 100% efficient either, so much energy is lost in the form of heat and as its body performs other actions. By way of analogy, in order to receive the minimum amount of energy necessary for it to survive, the consumer must eat about 10 plants to receive the same amount of energy that 1 plant received from the sun. The consumers that eat the producers are called 'primary consumers' because they are the first level of consumers.

Many organisms in the animal kingdom exist by consuming other animals. If one organism eats another organism, which in turn had eaten a plant, then this organism is called a secondary consumer. Just as in the previous case, the secondary consumer is only about 10% efficient, and must eat the equivalent of 10 primary consumers in order to receive the minimum amount of energy necessary for its survival. So, thinking back, the secondary consumer has eaten 10 primary consumers, each of which has consumed 10 plants. Therefore for a secondary consumer to receive the minimal amount of energy necessary for its survival, it must consume the equivalent of 10 primary consumers or 100 plants.

This process continues up the food chain, with transfer of energy moving in a linear direction. The energy is either transferred to organisms in higher trophic levels, or it is lost through motion as heat. Energy cannot, therefore, be recycled or re-used, only transferred or dissipated.

Plankton

At first glance, a cup of ocean water may look like it does not have any living things in it. However, looking through a microscope would reveal an incredible world teeming with life. These tiny organisms called plankton drift with the currents, wind, and waves. Although most plankton are tiny, some plankton, such as jellyfish, can be quite large. All plankton are weak swimmers. Some plankton spend their whole lives drifting, and some are only plankton in the early stages of their lives. These organisms then metamorphose into their adult form and might live on the ocean bottom (mussels, crabs, and seastars) or swim in the open ocean (fish and squid). Plant-like plankton that get its energy from the sunlight are called phytoplankton. Phytoplankton need sunlight in order to make their own food, so they must stay within the sunlit area of the surface – usually the top 100 meters. Animal-like plankton are called zooplankton. Zooplankton depend on phytoplankton for food, so they must stay near the surface, too. Plankton avoid sinking by having high surface area and/or low density. Flattened bodies and appendages, spines, and other body projections slow sinking by adding surface area without increasing density. Some plankton resist sinking by forming chains, or they store oil, which increases their buoyancy. Plankton are critically important to the health of the ocean. The vast majority of marine organisms depend on phytoplankton-based food chains. In addition, phytoplankton, along with photosynthesizing bacteria, produce much of the oxygen in the atmosphere. .

Phytoplankton are microscopic, free-floating, photosynthetic plant-like organisms in aquatic environments. They rely on the sun in order to make their food. Phytoplankton are integral to the health of all organisms in the marine environment and on land. They provide much of the oxygen in water that fish and marine invertebrates need in order to breathe. They also provide a substantial amount of the oxygen that animals, including humans, breathe on land. The millions of species of phytoplankton form the base of the marine food web. Phytoplankton, like plants, require nutrients to help them photosynthesize. When too many nutrients get into the water from fertilizer, pesticides, or soap (phosphates), phytoplankton population explosions occur. These plankton blooms can lead to oxygen depletion in part of the ocean and to large-scale growth of toxic plankton. Both of these scenarios are extremely harmful to animals living in the affected areas and to other animals who depend on those animals as a food source, including people. Members of the phytoplankton include diatoms and dinoflagellates. Diatoms have beautiful silica dioxide (glass) skeletons; dinoflagellates are responsible for the bioluminescence visible at night and "red tides."

Zooplankton are animals that live in the ocean and other aquatic habitats and are distributed or moved by the currents. Some zooplankton remain plankton throughout their entire lives; other zooplankton metamorphose into nonplankton animals as they get older. Most zooplankton are microscopic, or at least very small. Some, such as jellies or chains of salps, can be quite large. Many zooplankton consume phytoplankton or other zooplankton. Zooplankton, in turn, are consumed by very small nonplankton animals or by much larger animals, such as whales. Most major marine animal groups are represented in the zooplankton. Crustaceans are the most numerous and include copepods, krill, amphipods, and crab, barnacle, and fish larvae. Jellyfish (phylum Cnidaria) and comb jellies (phylum Ctenophora) are also members of this group.

The abundance of phytoplankton and zooplankton in Puget Sound is critical to the survival of other organisms that feed on higher trophic levels. It can take millions of plankters to make a single meal for an organism such as salmon or an orca whale.

Plankton densities vary greatly for different regions of the world's oceans. Low densities of plankton in mid-oceanic areas result in extremely clear, deep blue waters. The majority of marine productivity occurs in polar and coastal areas where upwelling ocean waters and input from rivers provide high nutrient levels. High plankton densities in these areas result in greener waters and low visibility. Plankton productivity also varies with season, temperature, water depth, water movement, and many other factors.

Additional Activities

Food Chains: For longer stations, a discussion on food chains can occur while the net is collecting plankton. This conversation can use props such as canvases and deck chalk.

Imagine, it is dinner time. For dinner, we are going to have a one pound salmon. Will the salmon fill you up? Possibly. Will it be enough to keep you full for the rest of the week? No, so tomorrow we are going to have to eat another. Why doesn't it keep us full? The energy it provides is enough to keep us going for a short time, but the more active we are, the more energy we will use. We must replenish that supply. Even if we were to sit in a room all day, doing nothing but breathing and blinking, the energy our body would use would make us hungry at the end of the day. We lose a lot of it just in our bodily functions, and we lose a lot as heat. So we would have to eat a salmon, or the equivalent, every day to keep full, plus probably something else for breakfast and lunch.

Now move down the food chain. What did the salmon eat? Can the salmon live off one pound of fish? No, it has to eat about 10 pounds of small fish in order to be a healthy one pound salmon.

The small fish can live off the zooplankton. But can it eat a pound of zooplankton and be big enough to feed the salmon? No. In order to feed the salmon, it must eat 10 pounds of zooplankton. So do the math: we ate one pound of salmon, who ate 10 pounds of small fish, which each ate 10 pounds of zooplankton. That’s 100 pounds of zooplankton to make the one pound salmon. How much phytoplankton did it take to feed the zooplankton? Again, about 10 pounds. So doing the same math, it took about 1,000 pounds of phytoplankton to provide us with one pound of salmon.

The reason behind the numbers, as mentioned in the background section, is that our bodies are inefficient systems and 80-90% of the energy each organism consumes is lost, leaving only about 10% available to each new trophic level. Of course, pounds are just used as a form of measurement to which participants can relate.

Think about the marine food chain. How many plankton are in the sample they are looking at? How many are in the ocean? Discuss the “bottom-rung” position of the food chain and why plankton are so important to other organisms at other levels of the hierarchy and therefore the ocean ecosystem at a variety of scales.

Observation: Have participants examine the water samples under the microscope. Sketch the organisms seen on white-boards or scrap paper. Which kinds of organisms are the most common? What else do we find besides plankton?

What do the different body types seen among the plankton in the sample suggest about what kind of plankton they are? What sorts of adaptations do they have that work towards camouflage, floatation/buoyancy, predator/prey relations, etc.?

Matching Game: Play the match larval and adult form game (laminated cards) to emphasize how many different organisms are plankton at some phase of their life.

Plankton Races: Build a plankton model from a variety of materials. The goal is to have a model that sinks very slowly or maintains neutral buoyancy but does not float at the surface of the water. Test the models in the aquarium so that sinking rates can be easily observed.

Concepts and Connections

Plankton can be a difficult station to teach, primarily because there is so much information that can be presented. The educator, then, has the responsibility of providing a relevant lesson that engages, but does not overwhelm the students. It is up to the educator to be selective in what they cover, and in determining what will have the most meaning to the students. The reality of it is that in a 15 minute Sound Studies station, many of these concepts will not be presented.

It is important to note that each group comes with varying levels of knowledge of plankton. Groups who know very little will need to spend more time on understanding the basics, while those with background knowledge can get more in-depth with their learning.

A question that is often asked aboard *Adventuress* is why we are vegetarian. While the storage space issue is one to which people can quickly relate, the idea of lessening environmental impact by eating lower on the food chain can be relatively abstract. This station provides the perfect opportunity to illustrate what that means.

NOTES:
MARINE LIFE STATION

Lesson Summary

The Marine Life lesson will provide students with an understanding of the diversity of marine life and their habitats in the Puget Sound. Discussion of adaptation will help students appreciate the processes that determine the variety and viability of our local marine life forms. The lesson will combine discussion of marine life topics and observation of the surrounding environment.

Educators will make connections to relevant Ocean Literacy principles as well as other on-board lessons (e.g., Plankton, Marine Debris)

Ties to Ocean Literacy Principles 5: The ocean supports a great diversity of life and ecosystems

Outcomes & Learning Standards
Students will be able to:

10-15 minute station:

- Describe different marine habitats
- Identify prominent species in the Salish Sea and which habitat they inhabit
- Explain what physical adaptations allow the animals to live in their habitat

15-30 minute station:

- Explore the water quality of the immediate area
- Hypothesize what pollutants may be entering the surrounding waters and from where
- Discuss the effects of various water pollutants on marine species of the Salish Sea

Lesson Vocabulary
habitat, adaptation, intertidal zone, open water (pelagic) zone, sandy bottom (benthic) zone, river

Materials

Relief map of Puget Sound and/or chart, binoculars, whiteboards and pens or paper and pencils, marine animal representations (whale teeth, baleen, shells, fish, etc.), refractometer, pH meter, thermometer

Basic Description of Marine Life Station

1. Hook

   Hand out binoculars or pass out the contents of the marine life bag.

2. BBK

   Ask the students what are some animals they know of that live in the Salish Sea? Ask the students to look out and around at the surrounding waters and land using their eyeballs and binoculars. Do you see any animals? What do you notice about the shoreline? What animals do you think live here?

3. Guided Practice

Option 1 : Individually or in groups, have the students draw a map of what they see. Ask them to look carefully and include any buildings they see, how the land differs (sand vs. rock), how wide the body of water is we are sailing on, if there are other boats present, etc.

- For longer stations, have the students note other characteristics of the immediate area such as the depth, temperature, salinity, pH
- Share the maps and identify different physical areas shown (intertidal, pelagic - open water, benthic - sandy bottom, river). Define with students the term *habitat* and make the connection that the before mentioned different physical areas are separate habitats even though they are all connected by the one big ocean.
- Take out the relief map and/or charts and ask students to point to some of the habitats discussed earlier.

Option2: Pass out items representing the *intertidal zone* (clam/mussel shells, sea urchin shells, sea star, snail shells), *pelagic zone* (whale teeth, baleen, sea otter pelt/skull, representation of a salmon), *benthic/stream zones* (representation of flat fish and salmon). Discuss what each student's animal is and why they chose to place it in that spot.

- Discuss what aspects of each animal allow it to live and thrive in its specific habitat, what physical *adaptations* does it have? Define adaptation with the students.

- For longer stations, ask the students to look back at their drawn maps and think about water pollution. If there was pollution entering these waters, what would it be and where would it be coming from? Add representations of the pollution and the path it took to enter the Salish Sea to their maps. Discuss what the students think this pollution may do to the habitats and the animals in the area.

4. Assessment/Check for Understanding
   - What does habitat mean? What is your habitat? What are some different marine habitats?
   - What does adaptation mean? What are some of your physical adaptations?
   - If you could have any of the adaptations of the marine animals we discussed today, what would it be and why?

Background Information and Resources

Vocabulary

Habitat: the natural environment where an organism lives
Intertidal zone: the area between the highest tide and the lowest tide (either rocky or sandy)
Benthic zone: the sandy bottom; benthic organisms are those living on or buried in the bottom
Pelagic zone: the water column away from the bottom
Estuary: a semi-enclosed area where freshwater and seawater meet and mix
Adaptation: a characteristic that enhances the survival of an organism

Mussels: these bivalves (two-shelled creature) live in the rocky intertidal zone attached by incredibly strong strings called byssal threads to a hard surface such as rocks or docks. They are filter feeders and are eaten by many animals from sea stars to humans.
Clams: these bivalves live in the sandy intertidal zone, but not on the rocks, under the sand. Both clams and mussels have a muscular "foot" that they can push outside their shell, and clams use this foot to dig themselves down into the sediment. Clams are filter feeders.
Sea Urchins: these relatives of the sea star live in both the rocky intertidal and sandy bottom habitats. Urchins use their spines and tube feet to travel around the rocks and sand in search of algae which they eat with their 5-part jaw.
Limpets: these snails hide in the shady spots of the intertidal zone licking up the algae and diatoms off the rocks with their extra sharp tongue (called a radula)
Barnacles: this shelled creature lives on hard surfaces in the rocky intertidal zone with its head cemented to the surface and its feet free to swipe through the water to catch tiny things to eat
Flatfish (flounder, halibut, etc): these fish spend their adult lives laying either on their right or left side and swimming that way along the sandy bottom. When they are young, however, they swim upright like other fish with one eyeball on either side of their head (normal). As they mature, either the left or the right eyeball (dependent mostly on the species) will start to migrate over to meet the other eyeball on the opposite side of the head so when the fish swims

sideways both eyes will be out of the sand and available. They are carnivores eating creatures such as crabs, fish, worms and shrimp.

Salmon: young salmon hatch in freshwater streams and as they grow they travel out to the salty open ocean. Once the salmon mature, they will travel back to the freshwater rivers and streams and swim against the current for hundreds of miles until they reach a spot to spawn. This life pattern of starting in freshwater but spending most of their time at sea is called anadromous. While the salmon are in the ocean they eat krill, herring and anchovies. To avoid being eaten themselves, salmon camouflage through countershading; seen from above, the salmon's dark and spotted topside looks like the deep ocean, whereas seen from below, the light underbelly looks like the surface of the water.

Orca whales: these toothed dolphins inhabit the water column, some staying in the Puget Sound (resident orcas), some traveling throughout the Sound and into the open ocean (transient orcas) and others staying strictly off the coast in the open ocean (offshore orcas). They grow to an average of 28ft long (as big as a school bus!), calves being born at 7ft long, and to a mature weight of 8 tons. The resident orcas feed on fish such as salmon, the transient feed on marine mammals such as seals, and the offshore feed on schooling fish and possibly marine mammals and sharks. Orcas travel in groups called pods. One pod is made of smaller subpods of a mature female and her young. More than one pod together is called a superpod.

Gray whales: these baleen whales inhabit the open ocean spending the winters in the cold northern Arctic waters and migrating south to spend the winters in warm Mexican waters. They spend the summer eating small pill-bug like creatures called amphipods that live in the sediment close to shore. The stored body fat from eating all summer helps them through the winter when there is not much food.

Sources

http://www.idahoforests.org/critter1.htm

http://www.pugetsoundsealife.com/puget_sound_sea_life/Common_Plants_and_Animals.html

"Whales and other Marine Mammals of Washington and Oregon" by Tamara Eder

"American Cetacean Society Field Guide to the Orca" by David G. Gordon and Chuck Flaherty

"Marine Biology" 7th Edition by Peter Castro and Michael E. Huber

"Evolution" 2nd Edition by Douglas J. Futuyma

Habitat and Adaptation

An adaptation is an inherited characteristic in a species that helps the species survive and reproduce. An adaptation may be a structure (such as teeth or a fin) or an internal process (such as photosynthesis). Inherited behaviors that aid in survival, such as migration behaviors, are also adaptations. Many people misunderstand the concept of adaptation and think that an individual organism either decides to adapt or adapts over the course of a few months or years. In fact, adaptations are the result of evolution in a species, not in an individual organism, usually over many generations. Certain genetic changes result in characteristics that enable organisms to survive and reproduce and, thus, to pass on genetic changes to future generations. Those changes eventually become adaptations of the species. The everyday use of the word *adapt* may actually engender misconceptions. We often say that a person has adapted to a situation, such as a new job. This connotation can be problematic for students when they begin to learn about the adaptations that organisms have that enable those organisms to survive in their habitats. That is why it is important to emphasize that when we discuss the adaptations of particular species, we are referring to the adaptations of the group of organisms, not just the individual organism. Many people think of adaptations only as body parts. However, a behavior can also be an adaptation. To be considered an adaptation, a behavior must help the members of the species survive or reproduce. It must also be coded in the organism's genes and not be a learned behavior. It is important to remember that not all behaviors are adaptations, and those that are adaptations apply to the species as a whole, not to a new behavior of an individual organism.

The adaptations a species has are closely connected to the habitat, or environment where an organism or ecological community normally lives or occurs, in which it lives. Some marine animals, such as sea stars, have suction cup-like tube feet that help them hang on tightly even when subjected to crashing waves at the rocky shore. Because all adaptations benefit a species' survival, adaptations are directly related to the conditions in the habitat in which the species live.

Other adaptations include adaptations for movement, for feeding, and to avoid being eaten.

Ecosystem**:** a system involving the interactions between a community of living organisms in a particular area and its nonliving environment

Marine Invertebrates of Puget Sound
(As typically seen by *Adventuress*)

There are thousands of species of marine invertebrates found in Puget Sound. Many have developed some form of an exoskeleton (i.e. crabs) or shells (i.e. clams), but others have not (i.e. anemones). Some live in deeper waters, those seen aboard *Adventuress* are found in the *intertidal zone*. Marine invertebrates found in the intertidal zone must be able to adapt to being exposed and out of the water for a long duration of time and waves pounding on the shore.

The intertidal zone can be divided into three subzones – high tide zone, middle tide zone, and low tide zone. The high tide zone is only covered by water at extremely high tides, spending much of its time as terrestrial habitats. Some barnacles can survive this environment, but most marine invertebrates cannot be out of the water for this duration of time. The middle tide zone is regularly exposed and submerged by average tides. Crabs, ochre sea stars, barnacles, anemones, and many more invertebrates can be found in the middle tide zone. The low tide zone is only exposed to air at extreme low tides. Marine invertebrates including sea cucumbers, sunflower stars, and other softer invertebrates that are not protected from the harsh intertidal environment are found in this zone. Creatures in this zone can grow larger in size as they have more access to energy (plankton). Being so close to the shore and wave action they are protected from larger predators such as fish.

Fun Invertebrate Facts

Invertebrates often found on shore hikes and on the docks include:

- *Sea Stars*: Sea stars have radial symmetry rather than more commonly seen bilateral symmetry. The tips of each arm have an eye which allows the sea star to see light and dark and detect movement. They have a hydraulic water vascular system that helps them move in the water. Many species of sea stars will eat by everting a stomach (they have multiple) from their bodies, partially digest the food externally, then bring it to their next stomach inside their body to complete digestion. Sea stars are part of the pylum *echinodermata*. Other species in this phylum include sea cucumbers, sea anemones, and sand dollars, all of which have radial symmetry.
- *Whelks*: Whelks eat mostly bivalves, and will use the edge of their shells to pry open the bivalve. A whelk may also drill a hole with its radula through the shell of a bivalve to access the soft tissue inside. Whelks are part of the phylum *mollusca*.
- *Limpets*: Limpets eat algae that forms on rocks. A limpet will spend its day grazing around a rock, but will always go back to the same spot. The limpet will form a small depression in the rock, allowing it to have a tighter fit for its shell therefore preventing it from drying out during low tide. Limpets are part of the phylum *mollusca*.
- *Crabs*: To tell the difference between a male and female crab, look at its underside – crabs have a ‘tail’ that has been folded under the body. If this is shaped like a triangle, the crab is male. If it is rounded the crab is female. Crabs are part of the phylum *arthropoda*.
- *Nudibranchs*: Some nudibranchs feed on anemone tentacles and are immune to their stinging cells. In fact, they can then process the stinging cells and use them for their own defense! Most nudibranchs absorb oxygen through cerata, or unusual appendages on their backs. Nudibranchs are part of the phylum *mollusca*. Approximately 23% of all named marine organisms fall into the phylum *mollusca*.
- *Anemones*: Anemones have stinging cells called cnidarian used for defense. They can reproduce both sexually or asexually. Some can live up to 60 years. Anemones are part of the phylum *cnidaria*, related to jellyfish.
- *Barnacles*: Barnacles are free-floating as juveniles, then will attach themselves to a surface where they will remain the rest of their lives. They attach themselves to the surface with a gland that secretes a cement-like substance on their head, and use their modified legs as filters for food. They are a part of the phylum *arthropoda*, related to lobsters and crabs.

Additional Activities

Puget Sound Habitat: Puget Sound is one that is incredibly productive. There are estuarine waters, cold, constant water rich in nutrients because of tidal circulation. This provides a thriving, healthy environment for a diverse range of species. Pin marine life ID cards to the back of each participant. Each person must figure out who they are by asking yes or no questions pertaining to the animal/plants food, water, shelter, space.

Adding up the Puget Sound and San Juan shoreline, it totals over 2,354 miles of marine shores providing many types of habitats for animals to live within. Each marine animal, with its own adaptations, lives within the habitat best suited for them.

***Diversity of Life in Puget Sound*:** Review phylums of marine life (see background info) and their typical characteristics. After listing the phylums and an example of an animal in each, have participants brainstorm typical characteristics in small groups. Have participants, in small groups or individually, pick one creature and find out as much as possible regarding that creature.

Creature Features! To get students to continue to think about how animals develop adaptations to help them survive in their habitat, have them individually or in pairs invent their own marine invertebrate. The can draw their creature on deck with chalk. Questions to guide their thinking:

- Where in the intertidal zone does this critter live?
- What and how does it eat?
- How does it protect itself from predators?
- What ecological niche does it fill?

The web of life. Have each participant say their creature and its environment, then grab on to a string. Do this with everyone in the circle, creating a web where everyone is connected. Read Chief Seattle's quote: All things are connected.

Concepts and Connections

There is a connection between *Adventuress* as a habitat for her crew and Puget Sound as a habitat for its organisms. Just as we need to take care of *Adventuress* in order to have a safe and productive habitat in which to live, we must recognize the need to value the Sound as a habitat for far more organisms that we can count. The theme is the same as that of the Watershed station in that we are all inhabitants of overlapping and diverse habitats, and as a result the actions or inactions we take have far greater effects than we can see.

NOTES:

OCEAN ACIDIFICATION STATION

Lesson Summary

The Ocean Acidification lesson will help students understand the process of ocean acidification, its causes, and its increasingly damaging impact on marine life. Students will be empowered to identify and change aspects of their daily behavior that contribute to ocean acidification.

Educators will discuss connections to Ocean Literacy principles as well as other on-board lessons (e.g., Plankton, Marine Life, Marine Debris).

Ties to Ocean Literacy Principles 1, 5, 6: The Earth has one ocean big with many features. The ocean supports a great diversity of life and ecosystems. The ocean and humans are inextricably connected

Outcomes & Learning Standards

Students will be able to:

10-15 minute station:

- Describe the ocean acidification process
- Identify at least 2 sources of CO2 pollution
- Describe the harmful effects of ocean acidification on marine life (adult and planktonic forms)

15-30 minute station:

- Explain to concept of pH and the influence of added CO2
- Give examples of how to decrease ocean acidification by reducing CO2 polluting emissions

Lesson Vocabulary

acid, pH, ocean acidification, CO_2, calcium carbonate, exoskeleton, emissions, pollution, ecosystem, fossil fuel

Basic Description of Ocean Acidification Station

1. Hook

Show students pieces of an egg and/or sea shell in a jar of water. Then show pieces of an egg and/or sea shell in a jar of vinegar. What are the differences? What has caused these changes? Lead into a discussion of what ocean acidification is.

2. BBK
   - Define/Discuss ocean acidification.
3. Guided Practice
   - Guide students' participation in the "CO2 in Water" demonstration, using pH test kit(s).
     - Place about 1 cup of Sound water into a suitable container.
     - Using an eye dropper, fill the pH Test Kit test tube with 5ml (to the line) of Sound water.
     - Add three drops of pH test solution to the test tube. Keep the dropper bottle completely vertical to assure drop-size uniformity.
     - Cap the test tube and invert tube several times to mix solution (use participant volunteer).
     - Read the test result by comparing the color of the solution to the pH card. Confirm participants groups' pH reading. Assure sufficient light to evaluate sample's pH level (use flashlight if necessary).
     - Retain the sample.
     - Have 2-3 participants *take turns* blowing (not too vigorously!), through straws (they each get *their own*!), into the water container (approx. one-minute total time).
     - Using a second test tube, repeat steps 2 through 5 (promptly begin second pH test).
     - Allow participants to compare the pH readings and sample colors.
     - Facilitate discussion of how exhaled CO_2 lowered the pH level (acidification) of the second sample.
4. Application/Synthesis
   - Connect these acidification findings (carbolic acid creation) with the damaging impact on marine animals with calcium carbonate exoskeletons (shellfish examples). Refer back to egg and/or sea shell in vinegar.
   - Help students identify specific sources of CO_2 polluting emissions.
   - Facilitate student "brainstorming" to identify behavioral changes they can make to reduce CO_2 emissions.
5. Reflection/Process/Action

Check for understanding by asking some of the following questions:

- Why is Ocean Acidification a problem for the marine life of the ocean?
- What are some things that are causing the lowering of the pH of Puget Sound and the ocean?

- What are some things we might be able to do as a community to diminish human impact on the changing pH of the oceans? What is something that your class can do?

Background Information and Resources

Watch the following documentary, ‘Acid Test’:
http://www.youtube.com/watch?v=5cqCvcX7buo
Or for a condensed summary of the documentary ‘Acid Test’:
http://vimeo.com/channels/savetheocean%0a
Watch the following video demonstrating change in pH in water when CO2 is added:
http://www.noaa.gov/video/administrator/acidification/index.html

Read pages 36-42 of the Puget Sound Marine Waters overview for an explanation of how Ocean Acidificationhttp://www.psp.wa.gov/downloads/psemp/PSmarinewaters_2011_overview.pdf

pH

pH is a measure of the acidity or alkalinity (basicity) of a solution. It is measured on a logarithmic scale of 0-14. Seven is considered neutral, neither acidic nor basic. The neutral zone is where most plants and animals like to live. The lower the pH value, the more acidic the sample is, the higher the pH value, the more basic the sample is. Being a logarithmic scale, there is a tenfold change for every unit-change on the scale. For example, a substance with a pH of 6 is ten times as acidic as a substance with the pH level of 7. Just as with dissolved oxygen, marine organisms have a range of pH they can live in. A changing pH can affect the health and diversity of these organisms.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

very acidic neutral very basic

Seawater tends to be slightly basic due to the presence of dissolved salts (pH=8). Freshwater pH is often closer to 7. Humans can affect the pH of water in the marine environment. Acid rain, or acid precipitation, which includes acid snowfall, snowmelt, and acid fog, is an example. Acid precipitation occurs when air pollutants mix with moisture in the air and eventually fall to the earth as acid. The two primary sources of acid precipitation are sulfuric acid resulting from sulfur dioxide emissions from coal and oil-fired power plants, and nitric acid, resulting from nitrogen oxide emissions from automobiles.

In the marine environment, acid rain is not as big of a problem. As the pH of the ocean is slightly basic, it tends to neutralize acid rain. However, acid rain can cause great damage in freshwater rivers or ponds close by. Although nitric acid may not affect the ocean’s pH, nitrogen itself creates a problem. Nitrogen acts as a very effective fertilizer, stimulating plant and algae growth. This nitrification can lead to hypoxic conditions.

NOTES:

LIFE ABOARD SHIP STATION

Lesson Summary

The Life Aboard station will use the unique concept of living aboard a tallship to engage participant in a discussion of conservation. It takes place below-deck and uses Adventuress to illustrate what a person really needs to subsist, identifying essential needs and exploring the implications of misusing resources. In this station we use Adventuress as a metaphor of Earth, a closed system.

Educators will discuss connections to relevant Ocean Literacy principles (e.g., Plankton, Marine Debris)

Ties to Ocean Literacy Principles 6: The ocean and humans are inextricably connected

Outcomes & Learning Standards

Students will be able to:

10-15 minute station:

- define the difference between a closed and open system
- identify essential resources for living aboard
- discuss repercussions of overusing *Adventuress'* resources

15-30 minute station:

- distinguish between systems and subsystems aboard *Adventuress*
- compare similarities of the closed system of *Adventuress* to the much larger closed system, Earth
- assess the implications of misusing Earth's resources within their schools and communities

Lesson Vocabulary

Systems, Subsystems, Open and Closed Systems, Inputs and Outputs, Matter, Energy

For higher grade levels: Positive and Negative Feedback.

Basic Description of Life Aboard Station

The rotation starts in the foc'sle and proceeds aft. Participants may be over 'awed' by the inside of the ship and you will need to answer questions or tell a quick story from time to time to sate curiosity. This is a time for them to explore and touch some things, but keep them together and safe.

In this station you also have the opportunity to tie themes together from other stations so watch for moments for when you can tie it to watersheds, for instance.

1. Hook

Start by telling them that this ship sailed half way around the world and ask them how they think the people survived. Look for answers that question food and water storage. Ask them if they know how we strung a cord all the way out here for electricity and move their thoughts toward the answer of batteries. Get them talking about how they would live on a boat.*Remember, this is a walking tour in which you must look for your teachable moments.*

2. BBK
   - As you begin to explain that we carry everything we use, introduce the concept of closed-vs-open system.
3. Guided Practice
   - Here you can identify inputs and outputs of our Adventuress system. Subsystems can be defined as you begin walk through the ship and actually look at sinks and heads, etc.
   - Ask them why we don't have showers or baths or baseboard heaters. Start them thinking about resource use and how people may act differently with their resources aboard then on land, and why. Ask about what happens if you use resources up too quickly in a closed system.
   - As they start to get a bigger picture of how the ship functions as a closed system bring the conversation to comparing our systems to Earth. Ask them to identify usable resources from the hanging globe (you have to hang it first).

4. Application/Synthesis
   - Scavenger hunt or other activity

5. Reflection/Process/Action
   - Can students name either systems or subsystems from their communities that use resources?
   - How would their overuse affect those communities or the Earth?
   - Can they infer way in which they can impact those effects?

Background Information and Resources

Vocabulary

System: A group of interacting parts that form a whole

Subsystem: A system within a greater system that can be defined by definite boundaries (e.g., fresh water, battery bank).

***Closed System*:** System in which energy (but not matter) is exchanged between the system and its environment

Inputs and outputs: Anything that goes into or comes out of a system

Matter: Physical substance

Energy: (e.g., sunlight, electricity)

Positive Feedback: Process in which the output of a system increases the disturbance to a system (e.g., global warming causes Earth's ice caps to melt, reflecting less energy to space increasing temperatures).

Negative Feedback: Process in which the output of a system reduces the disturbance to a system. (e.g., body overheats, it produces sweat the cools the body by evaporation).
Open System**:** System in which energy and matter are exchanged between the system and its environment

A closed system is one that must sustain itself, with no input or output of matter from outside sources. Essentially the Earth is a closed system, as the resources we have on our planet (water, minerals, oil, potential food supply, etc) are constant. Though they may be altered over time and take many forms, the amount we have is the same we have always had, and will always have. We cannot create more clean air or water. We must therefore find ways to use our resources wisely or minimize the impact we have when we do use them.

Along similar lines, when *Adventuress* leaves the dock for an overnight trip, she functions as a closed system. This means that the vessel must be fully stocked with food, supplies, fuel, and water. Our goal is to make it through a trip without having to return to shore to restock unnecessarily, and as such, have no input of resources from the world outside *Adventuress*. By the same token, we have no output until we end a voyage and return to dock. It is then that we must offload our waste, compost, sewage, and recycling.

Online:

Earth as a closed system:
http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/ecosystem/ecosystem.html
Ocean Literacy: http://oceanliteracy.wp2.coexploration.org/?page_id=1527#p6_alignss

Additional Possible Activities:

1. Resource Scavenger Hunt - Have students find necessary resources for life aboard ship and compare to resource use on land.
2. Brainstorm ways that we use resources, consciously and unconsciously, at home and in our communities.
3. Tour below decks to see how crewmembers live onboard *Adventuress*.
4. Plan an overnight trip aboard *Adventuress* and determine how long we could survive with the resources we have aboard

Concepts and Connections

This station is the 'glue' that connects so many of the ecological concepts we study to *Adventuress* as a learning platform. It is also the station in which we have the potential for the most direct impact in motivating the participants to take action when they leave the ship. Most participants are surprised at the number of similarities they find between systems on *Adventuress* and those at home, especially when compared to their initial impressions of how foreign the vessel seems.

The concepts of resource management in this station can be connected to other stations by discussing:

- What role does how we manage or squander our resources play in the survival of other organisms?

- What choices can we make toward managing our resources responsibly?
- What is the next step, once we have taken action to manage our own resources responsibly?

MARINE DEBRIS STATION

Lesson Summary

The Marine Debris station will provide students with an understanding of the definition of marine debris, the pervasiveness of plastics within marine debris, the various “life-spans” of marine debris, the potential environmental impacts of oceanic plastic pollution and ways to reduce everyday plastic usage.

Educators will discuss connections to relevant Ocean Literacy Principles as well as other on-board lessons (Plankton, Ocean Acidification, Marine life)

Ties to Ocean Literacy Principles 5, 6: The ocean supports a great diversity of life and ecosystems. The ocean and humans are inextricably connected

Outcomes & Learning Standards

Students will be able to:

10-15 minute station:

- Define ‘marine debris’
- Recognize the pervasiveness of plastics within marine debris
- Identify the “Debris Decomposition Timeline”
- Illustrate ways to reduce the everyday use of plastic/contain plastic pollution before it reaches the ocean
- Recognize that plastic is both good and bad

15-30 minute station:

- Give examples of items used everyday that contain plastic
- Explain the difference between mineralization of debris vs. degradation of plastics

30+ minute station

- Summarize the citizen science conducted on-board and how it is assessing the plastic pollution situation
- Use a ‘manta-net’, or microplastics tow
- Distinguish between microplastics, nanoplastics, and macroplastics

Materials and Equipment

- Marine Debris samples (cigarette butt, plastic bottle, glass bottle, aluminum can, apple core/orange peel, newspaper)
- Marine Debris Commonly Found list

- Marine Debris Decomposition Rate list
- (for longer station) – Microplastics tow equipment

Lesson Vocabulary

Marine debris, degrade, decompose, adsorb, nurdle, photodegrade, biodegrade

Basic Description of Marine Debris Station

1. Hook:
   - Hand out the cigarette butts, plastic bottle, glass bottle, can, newspaper and fruit to the students. Ask the students to identify the objects in their hands and brainstorm places they see these objects in their everyday life.
   - Inform the students that these items represent some of the most commonly found trash items on beach clean-ups. Discuss possible ways the trash ends up on the beach.
   - Work together with the students to define marine debris.
   - Possible questions: Do you see any marine debris out on the water right now? Are there marine debris out there right now that we may not be able to see?

2. BBK
   - Introduce vocabulary and concepts such as marine debris, microplastics, nurdles,
3. Guided Practice
   - Ask the students holding the objects to line themselves up in order from which object they think is the most commonly found on beach clean-ups to the object that is least commonly found. Correct if necessary when they are finished and discuss the outcome (for longer station, can turn this into a bit of an initiative in which students organize themselves without speaking, with a few students blindfolded, only allowing one or two people to speak, etc…)

	Commonly Found			**Decomposition Rate**	
1	Cigarettes and Cigarette Filters	52,907,756	**1**	Beverage Bottles (Glass)	1 million years
2	Beverage Bottles (Plastic)	9,549,156	**2**	Beverage Bottles (Plastic)	450 years
3	Beverage Bottles (Glass)	7,062,199	**3**	Beverage Cans	80-200 years

4	Beverage Cans	6,753,260	**4**	Cigarettes and Cigarette Filters	1-15 years
5	Apple core/orange peel	N/A	**5**	Apple core/orange peel	2 months
6	Newspaper	N/A	**6**	Newspaper	6 weeks

- Now ask students to re-arrange themselves in a line from the object that takes the longest to decompose to the object that takes the least amount of time to decompose. Correct if necessary and discuss the results.
- During the discussion, define with the students the difference between *degrade* and *biodegrade*. Make the point that plastics are not biodegradable because the tiny bacteria and critters that break down the other objects do not recognize the molecular structure of plastics and thereby cannot break them apart. Plastics can be degraded by sun and wave action, but these tinier and tinier pieces release harmful toxins as they fall apart.

4. Application/Synthesis:
   - Think Pair Share activities
   - Ask what does this make you think? How does it make you feel? How are these marine debris potentially effecting the creatures of the Salish Sea? How are the marine debris getting into to water and onto the beach in the first place? Are plastics good or bad? What do you use every day that is made out of plastic/has plastic in or on it?
   - What are some ways we can help keep plastic and other trash out of the ocean? What are some ways to reduce our daily plastic usage?
   - For a longer station: Have students break into groups or pairs and give them the task of brainstorming a collective action idea that would positively impact the plastic problem. They could focus on cleaning up plastic from the ocean, from beaches, ways to reduce the amount of plastic getting into the ocean, alternative materials than plastic for society to use, etc. Have the students think about what they want to do, who they will get to participate, how they will convince the people to participate, who they need to talk to for logistics, etc. For older students give more parameters
   -

5. Reflection/Process/Action

Discuss the following questions to check for participant understanding:

- Where do we find marine debris? Where does it come from?
- What is the most surprising thing you've learned today?
- What is one thing a group of people can do to help reduce the impact on our oceans?

Background Information and Resources

Vocabulary
Degrade: to break down or deteriorate chemically
Biodegrade: capable of being decomposed by bacteria or other living organisms resulting in elements that can be reused in the environment
Decompose: decay; break down or cause to break down into component elements or simpler constituents that can be reused in the environment
Marine Debris: marine debris is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes
Adsorb: to hold (a gas, liquid, or dissolved substance) on a surface in a condensed layer
Nurdle: a very small pellet of plastic that serves as raw material in the manufacture of plastic products.
Photodegrade: be decomposed by the action of light, especially sunlight

NOAA RESOURCES – MARINE DEBRIS
Top 10 Debris Items from Turning the Tide on Trash NOAA curriculum. Source
http://act.oceanconservancy.org/pdf/Marine_Debris_2011_Report_OC.pdf
Commonly Found Items on Shoreline Clean-Ups

Item	**25 Year Total**
Cigarettes and Cigarette Filters	52,907,756
Food Wrapper and Containers	14,766,533
Caps, lids	13,585,425
Cups/Plates/Utensils	10,112,038
Beverage Bottles (Plastic)	9,549,156
Bags (Plastic)	7,825, 319
Beverage Bottles (Glass)	7,062,199
Beverage Cans	6,753,260
Straws/Stirrers	6,263,453
Rope	3,251,948
Total	**132,077,087**

Decomposition Rate for commonly found items:

Glass Bottle	1 million years
Monofilament Fishing Line	600 yrs
Plastic Beverage Bottles	450 yrs
Disposable diapers	450 yrs
Aluminum Can	80-200yrs
Foamed Plastic Buoy	80yrs
Foamed Plastic Cups	50yrs
Rubber-Boot Sole	50-80yrs
Tin Cans	50yrs
Leather	50yrs
Nylon Fabric	30-40yrs
Plastic Film Container	20-30yrs
Plastic Bag	10-20yrs
Cigarette Butt	1-5yrs
Wool Sock	1-5yrs
Plywood	1-3yrs
Waxed Milk Carton	3 months
Apple Core	2 months
Newspaper	6 weeks
Orange or Banana Peel	2-5 weeks
Paper Towel	2-4 weeks

- US National Park Service; Mote Marine Lab, Sarasota, FL

http://coastalcare.org/2009/11/plastic-pollution/

Turning the Tide on Trash NOAA (Summarized information- please click HERE for a link to original information)

- "Abandoned fishing nets and related gear, plastic tarps, and other debris can smother and crush sensitive coral reef and seagrass ecosystems and their benthic (bottom- dwelling) species. Each year, thousands of marine animals are caught in, strangled by, or ingest various forms of debris. Medical and personal hygiene-related debris, including syringes and broken glass, pose obvious dangers to barefooted beach-goers when it washes ashore. Coastal communities lose revenue when littered beaches must be closed or cleaned up, and the fishing industry must absorb the annual costs to replace or repair vessels and gear damaged by floating and abandoned debris."

- "*Marine debris* – is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. It can enter the environment either directly through human action or indirectly when blown or washed out to sea via rivers, streams, and storm drains."
- Marine debris is a form of marine pollution. Other examples of marine pollution are sewage, gasoline, toxic chemicals, fertilizer, animal wastes, etc.
- Some marine debris are buoyant and some are not
- Buoyant objects are more likely to become marine debris because they are easily carried by wind and waves.
- Plastic and some types of rubber are the most buoyant kinds of debris while others that initially float such as wood become water-logged over time and sink. There is the possibility that buoyant marine debris may sink if they are covered in a biofilm of living organisms.
- "An object is *degradable* if natural forces cause it to be broken down into smaller pieces. In nature, materials are typically broken down through a process known as *biodegradation*."
- *Biodegradation* is the process in which organisms such as bacteria and fungi decompose (break down) a material into compounds that can be reused in the environment (ex. Nutrients).
- " 'Degradation' means decay, and the 'bio' prefix means that the dacay is carried out by a huge assortment of bacteria, fungi, insects, worms, and other organisms that eat dead material and recycle it into new forms." (Environmental Inquiry, Cornell University and Penn State University http://ei.cornell.edu/biodeg/)
- As plastics fall apart, they release potentially toxic chemicals such as bishpenol A (BPA) and PS oligomer. This is a concern because these pollutants can negatively affect animals by disrupting hormone functioning and reproductive systems. http://phys.org/news169927772.html
- "Natural materials are usually more biodegradable than synthetic materials."
- Materials that are resistant to degradation are plastic, glass, synthetic fabrics, and metal.
- "Some plastics can break down into small pieces when exposed to sunlight, a process called *photodegradation*."
- "Some materials can break down due to chemical interactions (for example, rust on steel), and other breakdown due to physical forces, including erosion or weathering, where the material actually falls apart into smaller pieces."
- *Persistent debris* – debris that does not easily degrade and remains in the environment for a long time (ex. Plastics and synthetic rubber)
- Glass, foamed plastic, and metal are considered less persistent because even though they do not biodegrade, they can be broken down into smaller pieces by wave action or chemical interactions.

Main sources of marine debris:

- Beachgoers
- Food packaging, beverage containers, cigarette butts, toys, Frisbees, discarded fishing line and nets
- Improper disposal of trash on land
- Trash can be carried to the oceans by wind or the watershed
- Storm water sewers (storm water runoff) and combined sewer overflow
- Some storm water runs through independent storm sewers that empty directly into a nearby water source, other storm water combines with sewage wastewater from homes and business. This combined sewage and storm runoff flows through a treatments plant that separates the solid waste material and water
- When there is too much added stormwater for the sewage plants to handle, the over flow is dumped into a nearby waterway, including the untreated sewage and solid waste.
- Ships and other vessels
- According to MARPOL (an international treaty controlling marine pollution from ships) Annex V (referring to trash), it is illegal to put any type of trash into the water from a vessel that is on a US lake, river, or in coastal waters up to three miles offshore."
- Some ships dump trash because of limited space, they do not know about the law, or they don't care. Trash is also accidentally blown or washed overboard.
- *Derelict fishing gear* – abandoned or lost nets and other fishing gear
- Industrial facilities
- Production scraps, flawed products, and packing material disposed of improperly
- Finished products lost during transport
- *Plastic resin pellets* – pre-production plastic pellets (nurdles) are often lost as they are transported from the facility that produced the pellets to the facility that will use the pellets to make products
- Waste disposal activities
- Trash can be lost during collection or transportation, and can be blown or washed away from disposable facilities
- Offshore oil and gas platforms
- Drill pipes and drill pipe protectors, hard hats, gloves, 55-gallon storage drums, everyday trash items

- Tracing the source of marine debris is very difficult
- The primary threats that marine debris poses to marine wildlife are entanglement and ingestion.
- Entanglement can cause wounds that lead to infections or loss of limbs, strangulation, choking, suffocation, impair an animal's ability to move
- Ingestion can lead to choking, starvation, malnutrition
- "A conservative estimate is that more than 100,000 marine mammals die every year from entanglement or ingestion of marine debris."
- Plastic bags have been found in many sea turtles' stomachs with the theory that the turtles mistake the bags for sea jellies

- “Thousands of seabirds are thought to die from entanglement or ingestion each year.”
- *Bioaccumulation* – the accumulation of plastics up the food chain from prey to predator.
- *Biomagnification* – the concentration of pollutants as they move from one feeding level to another

Affects of Marine Debris on Humans:

- Loss of money in tourist areas when the beach is covered in debris, very expensive to clean beaches, loss of money through loss of fishing gear, boat damage from marine debris, fishing industries may be financially hurt by decreases in fish and crustation populations because of lost traps
- Potential injury to humans walking on the beach, entanglement while diving, health hazards of contaminated debris

Ways to produce less plastic waste:

- Reuse materials, use reusable items, reduce the amount of packaging that is used, use fabric bags instead of plastic, buy products with less packaging, carry water in reusable bottles, use cloth napkins and kitchen towels rather than disposable paper products
- “Marine debris can only be truly managed by changing the behavior that causes it to enter the environment.”
- Dispose of trash properly, tightly secure it in bags and trash cans, cover truckloads going to the landfill

Fun Facts:

- ITW Hi-Cone, the world’s largest manufacturer of six-pack holders, changed in 1988 to create their ring carriers out of photodegradable plastic to reduce the risk of marine animal entanglement
- “According to the US Environmental Protection Agency (EPA) in 2010, US residents, businesses, and institutions produced more than 250 million tons of municipal solid waste, which is almost 5 pounds of waster per person per day. At 28.5%, paper and paperboard made up the largest component of generated solid waste.”
- “In 2010, about 34% of trash in the United States was recycled or composted, up from 16% in 1990. Almost all of the rest was buried in landfills (54%) or burned (12%)”

Videos:

https://www.ted.com/talks/capt_charles_moore_on_the_seas_of_plastic
http://www.youtube.com/watch?v=DHg291KeFls

More info:
http://www.sciencedirect.com/science/article/pii/S0025326X02002205

Daily Water Use Quantities

Taking a bath: 30-40 gallons
Flushing a toilet: 3-5 gallons
Cooking 3 meals: 8 gallons
Shower: 5 gallons/minute
Shaving/brushing teeth & letting the water run: 3 gallons
Washing a car: 30-40 gallons
Cleaning a house: 8 gallons

Washing dishes (3 meals): 10 gallons
Washing clothes: 20-30 gallons
Watering the lawn: 30-40 gallons

Additional Marine Debris Activities

Map A Raindrop
Divide participants into 3 small groups. Give each group deck chalk. Each group will map the path a raindrop takes from when it lands until it flows to Puget Sound.
Group 1: Raindrop lands on Mount Rainier (or Baker, Olympus, etc. depending on port).
Group 2: Raindrop lands on an upstream farm
Group 3: Raindrop lands in the city

Questions to think about:
What kind of surface did the raindrop land upon? How long does it stay where it landed? Where does it go next? What kind of terrain does it go through? What kind of pollutants might it meet? What kinds of debris might it pick up along its path to Puget Sound?

Have each group share their raindrop's path with the rest of the group.

Microplastics Net
Participate in Citizen Science activity of collecting a microplastics sample. See complete instructions on how to deploy the 'Manta Net' and collect sample in Microplastics folder on boat. Use Marine Debris curriculum to develop an understanding of why we are collecting samples for researchers at UW Tacoma / Center for Urban Waters.

Concepts and Connections

This station is in many ways similar to the Life Aboard station in that it examines a concept through the lens of resource management. It is also a key station to specifically connect participants to the role they play for Puget Sound. The ultimate goal is to help them discover that the first step toward action in protecting Puget Sound is to be aware of the role they play, for good or ill, and then to decide to take action based upon that awareness. Action need not be complex; it can be as simple as managing the resources (water) that we use at home, much as is illustrated in the Life Aboard station.

Connections may also be made to the Marine Life station because both stations explore the concept of where we live and our responsibilities toward that area.

NOTES:

NAUTICAL SKILLS

Lesson Summary

This station is intended to allow the watch groups to learn by working together, with a focus on cooperative actions, and feel the responsibility of steering Adventuress. As this is a very weather dependent station it is important to have many optional activities. Optional activities include: knot tying, sail setting and striking, navigation, sail theory and the ability to explain the mechanics of tacking and gybing. When appropriate, focusing on the more physical tasks is encouraged, as this is the only station participants really get to use their bodies.

This plan focuses on the overall cooperative and communicative elements of the Nautical Skills station. See alternate lesson plan for explanation and preparation of the Navigation Lesson and associated outcomes.

Educators will discuss connections to relevant Ocean Literacy Principles with a focus on current and historic exploration as well as technological advents.

Ties to Ocean Literacy Principles 7: The ocean is largely unexplored

Outcomes & Learning Standards

Participants will:

1. Identify tasks which need to be accomplished to successfully sail *Adventuress* and, with the guidance of the watch leader, take action
2. Each take responsibility for steering *Adventuress*
3. Recognize the necessity of cooperation to accomplish a task

Basic Description of Nautical Skills Station

This is a very dynamic station. Weather is critical in what you do for this station. If there is no wind you can focus on navigation, setting and striking the jib and knot tying. If there is wind you can focus on sail theory and sail handling. You should always rotate participants through the helm.

1. Hook

Set the stage. Discuss how you are now the watch on deck responsible for the safe handling of the ship – sail handling, navigation, steering. Ask participants to make a weather observation, see if they know where they are generally.

2. BBK
3. Guided Practice
   - First Rotation – Setting the staysail. Participants work with Watch leader, Spare Deckhand and Chief Mate to set the staysail. Discuss the mechanics of setting sail and identify key elements in controlling the set, i.e. halyard, sheet, downhaul and associated commands.

   - Second and third rotations – focus on navigation. If the group requested knot tying this is the time for it. Cooperation again is a focus as you discuss and explore the tasks at hand. See *Navigation 1 Lesson Plan* for more in-depth information about how to teach this subject.
   - Fourth and Fifth rotations – focus on striking various sail with similar concentration on cooperative actions.
4. Application/Synthesis

5. Reflection/Process/Action

This is often a very rapid fire station, with participants rotating through the helm and others hauling lines or doing some piece of navigation. In-line assessment is best, asking the questions as you go. Even simple questions like, “When I say, ‘two, six’ what do you say?” or “Why does a compass point north?” or “Let’s see your best knot.”

Background Information

It’s rare that you will get to any topic in depth during this station. Basic knowledge in all of these areas will suffice, but more knowledge gives you better flexibility and adds richness to your rotations. The crew handbook is a very good starting reference. Remember, this is a gaff-rigged ship and even for someone who has sailed this will be fairly new information. If in doubt turn to the ‘spare deckhand’ and ‘chief mate’ who will be on deck and can support you very well as you are getting this station down.

The basic nautical skills taught at the nautical skills station include; knots, navigation, setting and striking sails and sailing of *Adventuress* (including furling, tacking sails and coiling lines).

Sail and Line Handling: Any rope on a sailing vessel that has a purpose is called a line**.** The lines that pull up the sail are the halyards (after the term haul yard). The port halyards are the throat halyards and the starboard halyards are the peak halyards. The lines that tend the sail relative to the boat are the sheets. The sheets correspond to the sail; main sheet, fore sheet, staysail sheet and jib sheets (the jib has two sheets). The main sail and foresail each have lifts which connect to the boom, these need to be tended when *Adventuress* tacks.

Most of the above lines are belayed to a pin. This is done by creating figure eight turns around the belay pin. Be sure to ask the First or Second Mate for help with this if you are unfamiliar.

Setting sails is simply the raising of the sails. Most commonly the jib and staysail are set by a nautical skills group. Once the daisy chain or square knots (in the case of the jib) are untied you need people to haul on the halyard, pay out the downhaul and tend the sheet. In order to strike sail (take down the sail) you need to centerline the sail by pulling in on the sheet, ease the halyard and pull on the downhaul. There are several ways to furl the headsails; most commonly take a big fold at the foot of the sail, then dump the sails into the fold and wrap the foot over the top with the seam underneath the sail by the boom. Complete the furl with a daisy chain using the downhaul for the staysail, and tie the lines on the jib with slippery square knots. Again, please ask the Mate to show you if you have never done this and remember to wear lifejackets if you are forward of the lifelines.

Most coiling begins with making a working coil. Most of the lines on *Adventuress* are a right hand lay and should be coiled in a clockwise manner. A working coil is a quick, loose coil that works out many of the kinks. After being made up, the working coil lines are either hung or coiled on deck. To hang a coil grab a bite from the working end (near the belay pin) and put it through the coil and hang it on the pin. There are lots of ways to coil line on deck. The ballentine coil is a quick circular coil and the tub coil is a neat and tidy circular coil. Be sure to check with the First or Second Mate if these coils are unfamiliar.

Knots: Basic sailing knots include the bowline, clove hitch, stopper knot and reef (or square) knot. The bowline is used to make a loop in the end of a rope and is called the “king of knots” because it can be readily untied. The clove hitch is used to tie fenders onto the life lines for docking, and other various uses. The stopper knot is often put on the end of lines, so that they don’t accidentally slip through blocks. The reef knot is used to tie the reef tendrils on the main and fore sail while shortening sail. Please refer to Ashley’s Book of Knots for more information.

NOTES:

NAVIGATION

Lesson Summary

This is a focus on teaching the principles of inland navigation beginning with personal observation and advancing to the use of common marine navigational tools. The lesson is used to develop personal observational skills through navigation, fundamental use of navigation equipment and as a way of generating metaphoric connections to the concept of, “know where you are to be able to plan where you are going”.

Educators will discuss connections to relevant Ocean Literacy Principles with a focus on current and historic exploration as well as technological advents.

Ties to Ocean Literacy Principles 7: The ocean is largely unexplored

Outcomes

Participants will:
10-15 minute station:

- Define and interpret the symbols and language on a navigational chart
- Define terms ‘longitude’ and ‘latitude’
- Differentiate charts from maps

15-30 minute station:

- Understand how to use tools of navigation
- Read a chart and determine location accurately using navigation tools

30+ minute station:

- Identify the difference between magnetic and true north
- Explore the importance of always knowing where you are to be better able to decide where you must go next

Lesson Vocabulary

Chart, Compass Rose, Buoy, Marker, Longitude, Latitude, Magnetic North, True North, Range, Bearing, LOP (Line of Position), Triangulation,

Educators need to familiarize themselves with Chart #1 – a catalog explaining chart symbology.

Basic Description of Navigation Station

Here is the narrative describing the learning progression and activities included to successfully complete your learning objectives. This progression is intended as a road map for creating concrete activities focused on the diverse learning and teaching opportunities available aboard Adventuress.

1. Hook

Begin by asking participants if they know where they are right now. Tell them to look around and see if they can figure it out. Have them try to point on the chart where they think that is. After they each have made a choice tell them that you are going to show them how to figure out precisely where they are and figure out who is right. Begin by telling them that the better they understand a chart the easier it is to know where you are.

2. BBK

- Have students compare nautical chart to local map. Brainstorm similarities and differences.

- Gather around the chart…. Point out chart basics: water colors, soundings, land/water, hydrography, contour lines, fathoms vs. feet, compass rose, aids to navigation. Ask them to tell you what all the colors on a chart mean. Then start asking what the symbols and numbers could mean. Point out symbols of particular significance to where you are and ask them if they can find them in the "real world". Introduce the concept of lat/long positioning. Discuss the importance of knowing where you started to more easily determine where you are going.

- *At this time, students will begin rotating through the helm in singles or in pairs. You will need to incorporate this rotation into your lesson – rotating students through concepts 2-5 in smaller groups.

3. Guided Practice
   - (Optional) Using Chart #1, figure out what the symbols are and how to read them.

   - Begin talking about natural ranges and see if participants can find or anticipate any ranges.
   - Introduce use of Hand Held Compass:
4. Application/Synthesis
   - (Suggested Activity if you have time.) Have a group of 4 students each pick a cardinal direction, N, S, W, E. Have the students then, back to back, form the compass directions using their body and pointing to their direction… all together to form an accurate compass. Draw out connection between cardinal points and degrees in a compass. This is a time to talk about the difference between magnetic and true north. Depending on time you may introduce compass effects in many number of ways. (**This is the first stop point)**

   - Introduce parallel rules and the use of the compass rose. Have students begin plotting a Line Of Position (LOP) from objects they identify. Assign roles: shooting bearings, logging bearings, plotting LOP's. **(This is a second stop point)**

   - Introduce triangulation and have them plot their position

5. Reflection/Process/Action
   - Each participant practice taking a bearing with a compass.
   - Observe participants accuracy with LOP's
   - Ask why this idea of knowing where you are and where you are going is a good skill in life and onboard.
   - If Chart#1 is used have a contest to see who or what team can figure out chart symbols faster
   - Have a shout it out race to see who can repeat the most terms they learned or location place names.

Background Information and Resources

Before beginning the lesson Educators should have a good understanding of which chart symbols reflect what can be seen on the water and know how to use parallel rules and compass in relationship with the compass rose. Basic plotting skills are a must and good understanding of the Lesson Vocabulary.

Navigation is the art of knowing where you are and where you are going. Mariners use charts (as opposed to maps) to read the lay of the land, aids to navigation and lines of position to determine where they are and their course of direction.

Charts have an incredible amount of information on them. Soundings are the depths of the ocean and are marked in either fathoms (six feet) or feet. Aids to navigation appear as symbols on the chart that disclose information as to what buoys look like, how far the light can be seen from and whether they have bells or horns. All of this information is detailed in the Chart No. 1 Book put out by NOAA and located in the chart desk in the deckhouse. Charts have compass roses on them. There are two circles in the compass rose, one reads relative to true north and one reads relative to magnetic north. The magnetic circle is most often used because all of the readings relative to land and the chart, taken with a compass, are magnetic.

Navigation tools include dividers, parallel rulers and a hand held compass. Dividers are used for measuring nautical miles (1.15 statute/land miles). A nautical mile is one minute of latitude and is marked on the east and west edges of the chart. Parallel rulers are used to walk bearings from lines of position on a chart to the compass rose or vice versa. A compass is used to find out the line of position from a marker in true life. Parallel rulers used in conjunction with a compass allow you to choose three distinguishable points on land or aids to navigation. Take three bearings relative to you, and then use the parallels to record those lines on the chart and establish a small triangular area where you were when you took the compass readings. This is called triangulation.

Triangulation is establishing your position by intersecting three lines of position (LOPs) taken at the same time on three different known objects. You may have already figured out that two intersecting LOPs would be logically sufficient: your position is where they cross. Two bearings will cross somewhere, even if you make a mistake in one or both. Three bearings will make a triangle (since total point accuracy is very difficult) and the size of that triangle gives you immediate feedback on the quality of your work. Consider a two LOP intersection to be an estimated position.

The Method:

- Choose three visible objects that you can positively identify, and that are neither close to each other, nor completely opposite each other from where you are looking. Buoys, lighthouses, mountaintops, and tangents (edges) of islands work well.
- On a space on the chart you won't need to refer to, make a table listing those points.
- Take the bearings as quickly as you can, and immediately write down the time over the table.
- Draw out the LOPs on the chart, erase markings except for the neighborhood of the intersection and mark your fix with the time of the bearings. The mark should be in the middle of the triangle.

References

Books:

Chapman Piloting & Seamanship (Onboard)

Dutton's Nautical Navigation (Onboard)

The American Practical Navigator: Bowditch (Onboard)

Online:

http://www.paddlinglight.com/articles/navigation-fixes-and-triangulation/

Ocean Literacy - http://oceanliteracy.wp2.coexploration.org/?page_id=1530

NOTES:

Mechanical Advantage

Lesson Summary

Students will develop an understanding of Mechanical Advantage and how different systems such as pulleys, levers, wedges, and screws work to help ship-board systems function. Lesson activities will include use of a block and tackle and an inclined plane system, and identifying different simple machines used to work *Adventuress*.

Outcomes & Learning Standards

Students will be able to:

10-15 minute station:

- Understand that simple machines allow us to use less force through mechanical advantage
- Be able to identify simple machines onboard Adventuress and what purpose they serve

15-30 minute station:

- Compute the ratio of force to distance on various simple machines

- Understand that work = force x distance

Materials and Equipment

Handy billy, bag of weights, turnbuckle, marlin spike, ramp

Lesson Vocabulary

Work = force x distance, Block and tackle, Incline Plane, Screw, Lever

Basic Description of Mechanical Advantage Station

1. Hook:
   - Have one student on the working end of the handy billy, 4 on the tail end – play 'tug of war'. Was it hard or easy for the solo person to haul the 4 others? Why? What forces are at play?
   - Who wants to play tug of war? Why is that side always winning?

2. BBK
   - After everyone has had a turn with the handy billy, ask what is a task we completed earlier today with a system very similar to the handy billy? (raised the sails) how did the system help us raise the sails?
   - Discuss the concept of increased distance = less force needed to lift an object (do work).
     - With lifting the sails, the increased distance is the increased length of line. This system is called a *simple machine* and gives us increased *mechanical advantage* which makes our job easier
   - Talk about a few other simple machines;
     - ask has anyone heard of an incline plane? How do people moving big heavy objects into trucks make it easier on themselves? (use a ramp). Now think about a screw, what does it look like? Would you believe that a screw is an incline plane wrapped around a nail?
   - For a longer station: use a piece of wood propped up on a deck box as an incline plane and ask students to first lift up a bag of weights to the deck box then push it up the ramp to the deck box, which was easier? Then use that same bag of weights attached to a turnbuckle (an example of a screw) and ask some students to hold the turnbuckle as others tighten it to lift the weights. What would make this process easier? Use a marlin spike in the turnbuckle and introduce it as a lever.
   - For older students and longer stations: Introduce the equation W = F x d. Talk about each of the variables
   - What other kinds of simple machines do you know of?

3. Guided Practice
4. Application/Synthesis

5. Reflection/Process/Action

- Where do you see simple machines on the ship?
- Where do you see simple machines on land?
- What could you use simple machines for in your everyday life?

Background Information and Resources

Vocabulary

Simple machines: machines that make moving objects easier for us by allowing us to push or pull over a greater distance; increased distance = less force used
Mechanical advantage: the number of times the input force is multiplied by use of a simple machine
Pulley (block and tackle): A pulley is a simple machine that uses grooved wheels and a rope to raise, lower or move a load.
Incline plane (ramp): An inclined plane is a slanting surface connecting a lower level to a higher level.
Screw: A screw is an inclined plane wrapped around a pole which holds things together or lifts materials.
Lever: A lever is a stiff bar that rests on a support called a fulcrum which lifts or moves loads.
Wedge: A wedge is an object with at least one slanting side ending in a sharp edge, which cuts material apart.
Wheel and axle: A wheel with a rod, called an axle, through its center lifts or moves loads.
Work: the measure of force applied over a distance, calculated by W=Fxd, where W is work measured in Joules, F is force measured in Newtons, and d is distance measured in meters

Places mechanical advantage occur on the ship:

- A lever for the on deck bilge pump
- Levers to propel Ay-a-she (oars)
- Turnbuckles to tension the shrouds
- Block and tackle systems attached to various places of all sails
- The wheel as a lever/wheel and axle (different from a tiller at a lever) and the worm gear as an incline plane

https://www.youtube.com/watch?v=HEsH1iA20GM
longer version https://www.youtube.com/watch?v=o9tXgUu7fXQ
https://www.khanacademy.org/science/physics/work-and-energy/mechanical-advantage/v/introduction-to-mechanical-advantage

References

http://www.mikids.com/Smachines.htm
http://www.learnnc.org/lp/editions/work-power-machines/7518

NOTES:

ADDITIONAL EDUCATION BACKGROUND INFORMATION

MARINE MAMMALS OF PUGET SOUND

The story of the marine mammals of Puget Sound begins with the origins of marine mammals themselves, for there are none which are unique to this area, and there are few which have not lived here at some time. Indeed, the return of mammals to a marine way of life 20 to 60 million years ago could well have been in a place or places topographically similar to Puget Sound, where inshore and inland waters are alternately stirred by winds and tides and radiated by the sun.

Eighty million years ago the marine food chain was capped by large predatory fishes, reptiles, and marine birds that were ancestors of loons, grebes, and pelicans. At that time mammals dominated the food webs on land, but they had not yet ventured into the sea. Imagine, for a moment, that you are a hairy and hungry creature on the shore of waters that teem with life. On land, there is intense competition for the food resources and hungry carnivorous beasts that may consider you their next meal. There is a tremendous advantage for you to wade into the water - perhaps a little bit at a time - to enjoy the food and protection it offers. Over millennia, the creatures that possessed the inclination and anatomy to do so eventually became adapted primarily to the water and rarely came out on land. Some of them eventually lost all need for legs to walk upon, and never again returned to land. Some groups of these, mammals - desmostylians, cetotheres, and sirenians - appeared and disappeared with the ages, while others have remained as part of a continuously evolving scenario of marine creatures in the waters of Puget Sound.

The Cetaceans - Whales, Dolphins, and Porpoises
Among the very first marine mammals were the whales, dolphins and porpoises of the order *Cetacea*. They evolved very rapidly once the initial step was made into the water. It is not known precisely when or where this step took place, or even whether more than one type of land creature concurrently accomplished this feat. What is known from fossil evidence, however, is that 55 million years ago there were primitive, completely aquatic cetaceans living in all marine waters of the world, and some were venturing into major rivers and lakes.

At that time the entire Pacific Northwest was under water and Puget Sound was only a deep trench. But there were no doubt similar inshore habitats wherein some cetaceans evolved specialized roles, while others tended toward the open seas. Among the cetacea that now occur in Puget Sound are species of both suborders: Odontoceti, the “toothed” whales, and Mysticeti, the baleen whales. The names are derived from the Greek words for teeth, *odontos*; moustache, *mystax*; and whale, *ketos*.

Mysticetes feed on small schooling fishes and invertebrates, which they filter from the water through hundreds of baleen plates-parallel ridges of cornified epithelium with a fringed inner edge-that grow from the roof of the mouth. This anatomical specialty permits them to feed on organisms very close to the primary production level in the sea. Typically, seasonal “blooms” of their prey species-such as krill-occur in the high latitudes during spring and summer. Most mysticete whales therefore migrate to feeding areas when food is available, and migrate to temperate or tropical regions in the winter to breed and calve.

The mysticete cetaceans are taxonomically divided into three families comprising nine species, which are differentiated by anatomy and physical characteristics. The family Balaenidae includes the right whales and bowhead whales, which have a high arched rostrum and no dorsal fin. The Balaenopteridae family - called rorquals - includes the finner whales and humpbacks, which have a dorsal fin and numerous pleats of skin on the throat. The family Eschrichtiidae has only one living member, the gray whale, which has a slightly arched rostrum and no dorsal fin. All three families are represented in the Pacific Northwest, but due to extensive whaling in the past some species are very rare. Only the latter two families are represented in Puget Sound at present.

The odontocete cetaceans are taxonomically divided into six families comprising approximately 68 different species. The family Physeteridae includes the sperm whale, which only have functional teeth on the lower jaw. Ziphiidae, the beaked whales, have dentition that is characteristically reduced to two or four functional teeth on the lower jaw.

Monodontidae, the narwhal and beluga whales, are unique in that they have completely adapted to the arctic environment. Delphinidae are the marine dolphins, of wide variety and description including pilot whales and killer whales. Phocoenidae are the porpoises, which have spade shaped teeth and characteristically blunt foreheads. There have been occurrences of all these families except Platanistidae in Puget Sound, but at the present time only the Delphinidae and Phocoenidae are regularly found here.

Pinnipedia - The Fin-footed Mammals
Long, long after cetaceans had evolved to be the supreme creatures of the sea, several other surges of land mammals headed toward the water, perhaps to avoid competition and predation on land, or perhaps to exploit an amphibious niche that the cetaceans had passed quickly through. Whatever the reason, about 20 million years ago some of these carnivorous mammals ventured into the marine environment. They evolved paddle-shaped feet for mobility in water, but still retained the ability to move about on land. These creatures are the fin-footed mammals - seals, sea lions, and walruses - of the order Pinnipedia (from the Latin pinna meaning feather and pes meaning foot). Pinnipeds are found in all oceans and seas of the world and even in freshwater lakes. Several of these species presently inhabit the marine waters of Puget Sound, and others have lived here in the past.

The order Pinnipedia is composed of three families of carnivorous mammals: the Odobenidae, whose sole surviving representative is the walrus; the Phocidae, which are the true seals; and the Otarriidae, the eared seals, sea lions and fur seals. Among this trio, sea lions are distinguished from seals by physical characteristics and behavioral traits, and walruses are easily distinguished by their tusks. Sea lions have external ear pinnae, their front flippers are much larger than their hind flippers, and their hind flippers rotate forward enabling them to shuffle along on all fours when on land. Seals, on the other hand, with smaller and nonrotatable flippers can only hunch along on their bellies, scratching at the ground with their claws.

In the water, sea lions are almost continuously on the move**,** their bodies stretched out horizontally, undulating at the surface as they breathe. Seals, on the other hand, generally bob to the surface vertically**,** and drift with the tide while breathing. Sea lions are also noisier creatures than seals, barking or roaring while hauled out, whereas seals are usually silent, except for an occasional sneeze or bleating sound.

Pinnipeds spend the majority of their life at sea, feeding on fish and invertebrates or migrating to and from feeding areas. All, however, must return to land or ice to rest, breed, and give birth.

The places which are regularly used for breeding and pupping are known as rookeries; those used for resting are known as haulout areas. Both rookeries and haulouts are essential to the survival of these animals. Although one location may serve both purposes, such a site must be conveniently close to food resources, yet strategically remote from potential disturbance by land predators or human intervention and disturbance. A rookery may also be used as a haulout area, giving it quite a distinctive smell and lived in appearance. Haulouts, however, may be only temporarily used locations, and even buoys, jetties, or moored boats may provide a weary seal or sea lion a temporary rest site.

In Puget Sound, islands and islets are the usual rookery sites, and some are used by pinnipeds year after year. Puget Sound is still blessed with a number of such sites and with a rich and varied bounty of marine mammals. The species accounts that follow are intended to help you recognize the marine animals that occur in Puget Sound's inland waters, and the areas and conditions critical to their existence and well-being.

PACIFIC NORTHWEST SALMON

Definitions

Anadromous *adj.* Migrating up rivers from the sea to breed in fresh water. (Greek, *anadromos*, a running up; *ana*-, up +*dromos*, race.)

Pacific Salmon Listed As Threatened

The Federal Government on March 16, 1999 listed 9 types of Salmon as either Endangered or Threatened (endangered indicates a species that is likely to become extinct, threatened indicates a species that is likely to become endangered in the future). Listed under Threatened was Ozette Lake Sockeye, Hood Canal Summer-run Chum, Columbia River Chum, Lower Columbia River Chinook, Upper Willamette River Chinook and River Steelhead, Middle Columbia River Steelhead, Puget Sound Chinook. Listed as Endangered are the Upper Columbia River Spring Run Chinook.

Salmon Timeline

2 million years ago Pacific salmon arrive on the evolutionary scene 10,000 American Indians inhabit Pacific Northwest relying on Salmon as a staple in their diet and culture

1805 Lewis and Clark marvel at the great abundance of salmon in the Columbia River

1854-55 US Gov. signs treaties with tribes, preserving tribal rights to take fish in their "usual and accustomed grounds"
1877 The first of hundreds of salmon canneries built in Puget Sound, and commercial fisheries mushroom
1908 President Theodore Roosevelt says, "The salmon fisheries of the Columbia River are now but a fraction of what they
were 25 years ago"
1941 The Grand Coulee Dam closes more than 1,000 miles of upriver salmon habitat
1973 Congress passed the Endangered Species Act
1974 Judge George Boldt reaffirms tribal treaty fishing rights
1976 Eight regional fishing councils created around the nation to oversee fisheries between 3 miles and 200 miles off the US coasts
1985 United States and Canada sign Pacific Salmon Treaty
1991-92 Snake River sockeye and chinook listed under Endangered Species Act
1994 Salmon returns at all time low, leading to sweeping
1999 Salmon listed endangered and threatened (see above)
1999 The Pacific Salmon Treaty between US and Canada was renewed for the next ten years

Salmon have a tough life
If roughly 3,000 eggs were hatched and fertilized, they would hatch into alevin, and 300 of those would make it to the fry stage. Of those 60 would become smolts, of 60, only 6 would become mature adult salmon and 3 of those would make it up the stream to spawn and die. That is a 1% survival rate (which is very common). If these were hatchery fish they would have a 2-7% survival rate.

So what's the difference between wild salmon, hatchery salmon and farmed salmon?

- Wild salmon hatch and live in the wild, with little or no help from us.
- Hatchery fish are raised artificially in hatcheries, then released into rivers.
- Farmed salmon are cultivated the same way, but raised in floating net pens until they're ready to be harvested.

Salmon F.Y.I.
Salmon enter salt water when they are smolts. Smolts are young salmon whose bodies are adjusting to a salt water environment. This is an interesting problem for a fish. The fluids in its body are saltier than fresh water but not as saline as saltwater. When the fish are in fresh water it must prevent salt from leaving its cells. But, when it enters salt water it must prevent excess salt from entering its cells. Salmon are among the few fish able to change the direction their bodies pump salt to maintain a constant salt balance within their cells.

WATER QUALITY

Background Information

When studying water quality, there are several parameters to consider. All of the parameters are interrelated, and all of which affect those organisms who make the aquatic environment their habitat. The parameters in question are dissolved oxygen, pH, salinity, nitrogen, and erosion.

Dissolved Oxygen (D.O.)

Oxygen is essential to most life and most aquatic organisms depend on dissolved oxygen for survival. Oxygen diffuses into the water from the surrounding air. Aeration of water in fast moving streams, waterfalls and areas of waves also introduces oxygen into the water. Another important source of oxygen in the water is from photosynthesis. Marine plants, primarily phytoplankton, create oxygen as a product of photosynthesis. It is estimated that three fourths of the earth's oxygen supply is produced by phytoplankton in the oceans.

There are many factors that can affect the amount of oxygen in the marine environment. Measuring D.O. levels gives us clues to the presence or absence of oxygen. There are daily fluctuations in oxygen production. Sunlight must be present for photosynthesis to occur. At night, photosynthesis and thus oxygen production, stops, but plants and animals continue to use oxygen for respiration. As a result, dissolved oxygen levels in the marine environment will rise from morning through the afternoon and decrease through the night.

Water temperature affects dissolved oxygen levels as well. Gasses tend to dissolve more easily in cooler water, so dissolved oxygen levels tend to be higher in cooler water than warmer water. Natural seasonal/temperature changes can affect the amount of dissolved oxygen in the water. Human activities that cause an increase in water temperature also can affect the level of dissolved oxygen in the water. Some examples are thermal pollution from power plants, sewage or effluent discharges, removal of shading vegetation from land that borders water, urban runoff and dams.

Humans are the greatest cause of changing levels of D.O. in water, particularly as they add organic waste to the water. Sewage is a classic example of such waste as it is consumed primarily by aerobic bacteria. Aerobic bacteria are naturally occurring and they reproduce quickly in favorable conditions. Ideal conditions for the bacteria include large quantities of food (sewage) and oxygen. While they consume the sewage, they also consume oxygen for respiration. The more organic waste in the water, the more aerobic bacteria are present, the more oxygen consumed/removed from the water. In some situations, the presence of wastes will result in a hypoxic or low oxygen condition.

Humans discharge nutrients into the marine environment in the form of agricultural fertilizers, urban runoff and lawn chemicals ("nutrient loading"). These pollutants act as fertilizers in the water and speed plant growth. Plants grow, die and decay, again fueling the action of aerobic bacteria. Situations occur where an area is overfertilized, and bacteria consume decaying plants and oxygen faster than the surviving plants can produce it. Hypoxia can occur and will cause significant harm to or death of the organisms in the environment. An overabundance of aquatic plants due to “nutrient loading” can cause huge fluctuations in the oxygen level that result from photosynthesis.

Oxygen is poorly soluble in water and there is a small amount of it present in even healthy environments. The maximum amount of D.O. found in the natural environment is 14 or 15 mg/l. One might find more D.O. at the base of a waterfall, a cold mountain stream, or the rocky edge of the sea. **The ideal range of dissolved oxygen to support a healthy and diverse population of marine organisms is between 8 and 15 mg/l.** Four to five mg/l is the minimum level at which most organisms can survive.

Another factor that affects D.O. levels is the amount of sediments in the water. Sediment increase in an aquatic environment will tend to darken the water, and thus absorb more of the suns light. This increases water temperature and decreases oxygen levels. Sediment runoff (“sedimentation”) occurs in freshwater streams (which lead to the Sound) from removal of riparian plants. Riparian plants are the vegetation which grows along the area where the land and water meet (riverbanks) and up to 100 feet inland on either side of the waterway – the riparian corridor.

Salinity
Ocean water contains salt due to erosion and breakdown of rocks, soil and living organisms on land. Salts make their way to the oceans. The evaporation of ocean water, concentration of salts and precipitation of fresh water are a rough equilibrium. Typically, seawater is about 3.5% salts. The amount of salt will vary in an estuarine environment, depending on the time of year, snowmelt conditions, rainfall, and proximity to the source of fresh water. Some organisms require 3.5 % salinity for their survival, others can tolerate a range. As Puget Sound is an estuary, the salinity levels vary dependent on the season and location.

Nitrogen
Nitrogen acts like a fertilizer in the marine environment. Some is necessary for phytoplankton to survive. Too much will overfertilize an area, causing excessive plant growth, decay and oxygen consumption. Often the result of too much nitrogen is hypoxia. Nitrogen can enter the system in the form of nitrates from commercial fertilizers, agricultural runoff (animal waste), automobile exhaust, or as a by-product of decaying organic material like sewage from municipal sewage plants or leaky septic systems. Nitrogen can be added to the system in the form of ammonia, resulting from the discharges of sewage and excrement from animals (geese and ducks). The presence of ammonia in the system indicates recent pollution. Ammonia will be converted by bacteria to form nitrites and eventually nitrates. Nitrates are present in later stages of nitrogen decomposition.

General info
It’s important to distinguish between point source and non-point source pollution. Runoff carries pollutants and finds its way into rivers, lakes and the ocean. These pollutants are called “non-point source” because they come from wide spread sources such as garden insecticides, car emissions caked on parking lots, lead from paints, etc. The origin of point source pollution is known, and comes primarily from industry, which has heavy environmental regulations to follow.

A large environmental problem is non-point source runoff, because the pollution comes from varied places. No monitoring or content regulations can be placed on this runoff. Runoff is also responsible for erosion, transportation and deposition of sediment taken from the lands topsoil, carrying with it agricultural fertilizers etc.

WEATHER AND CLIMATE

With weather, the development of an understanding of interrelationships will be the most obvious, since weather is a constant process of the atmosphere attempting to reach equilibrium. Human impact on the atmosphere can be discussed a bit (air pollution/greenhouse emissions/ozone layer depletion), and the sense of habitat to a lesser extent. The educator could choose to use the ship as a living metaphor for an organism that requires the winds for transportation. Or more intuitively, she could try to discuss the importance of having an atmosphere for the many species around Puget Sound that use the air, from the trees, to birds, to mammals in the water and out.

Five main concepts about the atmosphere/weather to present:

- There is pressure in the air
- The air is made up of things we can see and not see; just like looking at plankton in a water sample
- Moisture makes up mostly what we see: Clouds/Rain
- Heat and light's effect the atmosphere
- There is turbulence/equilibrium in the atmosphere

General principles:

The atmosphere is a constantly changing mix of molecules. The density of the molecules in the atmosphere diminishes with elevation one reaches the relative vacuum of outer space. This mix of molecules is constantly trying to attain equilibrium of temperature, pressure, and molecular composition (nitrogen, oxygen, argon, etc.). Alas, equilibrium can never be attained because a complex dynamic is at play. Interactions between solid and liquid forms of matter at the earth's surface, continual heating and cooling of the air due to solar cycles, and the daily rotation of the earth are the dominant factors, which prevent equilibrium. This is why the weather changes, and also why it is difficult to predict.

Pressure is the density of molecules in a given volume of space.

For example, a box will be our unchanging volume of space. When it is empty, that is a vacuum. It contains no matter metaphorically. Now add one object, close the box, and have a participant shake it. Count the number of times you hear the object hit something. Now add two more objects, close the box, and count all the times you heard the objects hit something. Now add more objects and repeat. Each hit represents a "push" or a force acting upon other objects or the box. If the box were not strong enough, each "push" of force by an object would cause the box to expand. The objects are molecules and the box is earth's atmosphere. Our shaking represents the input of energy from the sun, which heats up the objects and moves them around. This demonstrates two principles of pressure. 1) For a given volume and mass (i.e. # of objects) more heat will create more pressure – which was heard when we left the box alone vs. when we shook it up. 2) For a given volume and temperature, an increase in mass will create a larger pressure – as was heard by the increase in noise when more objects were added to the box. Remember, each noise comes from an interaction between objects, and each interaction creates a push, or force. Pressure is a measure of this force.

Everyone take a deep breath
Materials: weather charts of pressure systems

Ask everyone to take a deep breath. What are they doing to the air? The purpose of this activity it to get the participants to think about wind. If they already know about changes in pressure this should be easy. Another way to go about it is with the balloons activity below, but this one is a mellow alternative. As an aside, ask the participants if their stomach goes in or out when they breathe in. Half the time when people try too hard their stomach goes in…so, where did the air go? Actually, the air goes to the lungs, which sometimes causes the chest to lift, and the stomach contract.

Back to breathing. Now ask everyone to again breathe in as much as they can. Then think about pressure. Is there higher or lower pressure in the lungs after breathing in? Another way to go about this might be to ask if it is harder to hold in the breath once you have breather in, or after breathing out. The answer is that the lungs have higher pressure after breathing in because of all the air that filled them up. There is a lot of good oxygen being pushed into the body. Then ask the participants to exhale as fast as possible. Now, are the lungs at lower or higher pressure? Now do it again, but this time have them put their hands over their mouths when they exhale and try to catch some of the air they exhale. This is really just a ploy to get them to feel the wind they create by depleting their lungs of air. The muscles in their bodies are working like a bellows to draw in and exhale air. Alternately filling to a high pressure, then exhaling to create an area of low pressure. Not close to a vacuum, just lower pressures of air relative to the ambient atmosphere.

Here is a new word. Equilibrium. From the word equal. If the pressure of air outside the lungs were the same as that inside, would the air want to move? No. But the body has muscles to lower the volume in the lungs, squeeze all the molecules in the lungs together, and create a higher pressure. Now, what did they feel at their hands? They felt the air leaving, from a place with a lot of air being pushed out, to place that didn't have a much force keeping the air from traveling there. There are many ways in which air in the atmosphere can become pressurized, but that is for another lesson. Nonetheless, air will always move from a place of high pressure to low pressure. This helps us predict wind. Wind, like sound, is a movement of molecules in the air. Unlike sound, wind is the very large-scale movement of air molecules. It is a large mass of air all moving in one direction, while sound acts like a wave that passes. Finally, bring out the weather chart and ask the participants which direction they think the wind will be moving. If it is a windy day, ask them where they think the low pressure and high pressure are.

TIDES AND CURRENTS

Goals: The following concepts may be addressed during a Tide and Current class on board *Adventuress*:

- Define and understand the cause and effects of tides and currents
- Understand local water movements in Puget Sound
- Learn how to look up tides and currents for any given time, date, location
- Understand the relation between tides and currents

What: *Tide* is defined as the vertical movement of water caused by the gravitational forces of the sun and moon. The tide of Puget Sound is semi-diurnal, meaning we experience high and low tides twice daily. There can typically be 10 feet between low and high tides in our area.

Current is the horizontal movement of water caused by the tides vertical movement. Current is referred to as a flood or ebb current. The current floods and ebbs; twice daily in Puget Sound (in general). Typically, near the time of high and low tide, the current goes "slack" for a short time. Charts and tables are published each year to predict tides and currents in Puget Sound..

Around Puget Sound, the current can be as strong as 7 knots (1 knot = 1 nautical mile/hour). It is greatly influenced by the shape of the land both above and below the water. It is measured in terms of the direction in which it is traveling (unlike the wind, which is measured by the direction from which it is coming).

So What: Understanding the tide and current involves a thorough understanding of the influence of the sun and the moon on the earth. Knowing the earth's position in relation to these celestial bodies and their gravitational force, will help develop a keener sense of the subject. Calculating tide and current creates the chance to turn theory into practice!
Tides and currents are especially important in Puget Sound because it is an amazingly dynamic estuary. As a whole, Puget Sound acts as a large estuarine basin. Within the basin are 16 major freshwater rivers adding to the dynamic water movement of the area.

VOCABULARY

SCIENTIFIC TERMS

Adaptation: The changing of structure, form or habits of a plant or an animal to improve its chances of survival in a particular place.

Algae: A group of aquatic non-flowering plants which include certain seaweed and microscopic phytoplankton.

Aquatic: Growing or living in or on water.

Benthic Organisms: Plants and animals living in or on the bottom in an aquatic environment.

Brackish Water: Mixture of fresh and salt water.

Consumers: Organisms that get their energy by eating other organisms. Herbivores, carnivores, omnivores and detritovores are all consumers.

Detritus: Dead or decaying plant, animal, and organic material. An important food source and part of the food web.

Ebb Tide: Falling or lowering tide.

Erosion: The wearing away of land surfaces by wind or water. Erosion occurs naturally but it can be intensified by human land use practices.

Estuary: An area where a river meets a sea. Water in an estuary is a mixture of fresh and salt.

Flood Tide: Rising tide.

Food Chain: The order in which energy as food is transferred from one group of organisms to another.

Food Web: Interconnected series of food chains.

Habitat: The specific area or environment where a particular type of plant or animal lives.

Interrelationship: Connections and relationships between different organisms in an environment.

Intertidal: Area between the highest and lowest tide lines on shore.

Marsh: Low wet, grassland without trees, periodically covered by water.

Non-Point Source Pollution: Pollutants entering waterways from a general area such as runoff from farmland or suburban communities.

Nutrients: Chemicals (primarily Nitrogen and Phosphorus) necessary for organisms to live.

Organism: A living individual, plant, animal or otherwise.

pH: A measurement of the acidity or alkalinity of a solution; estuarine water is naturally slightly basic.

Photic Zone: The depth of water in which light can penetrate. The top 100 meters of the surface of the ocean.

Photosynthesis: The process by which plants convert sunlight into living tissue using carbon dioxide and nutrients. Oxygen is produced as a by-product.

Phytoplankton: Plant form of plankton. Forms the base of almost all aquatic food chains.

Plankton: Drifting or weakly swimming plants or animals living in water, often microscopic, but sometime seen with the naked eye. Forms the base of the food chain in water environments.

Point Source Pollution: Pollution from an identifiable source, such as an outfall pipe from a sewage treatment plant.

Producer: Organisms that use the energy of sunlight and some simple chemicals to produce food energy that they and all other organisms need to survive.

Salinity: The measurement of the amount of salt in water, usually measured in parts per thousand. Thirty-six ppt is average for seawater.

Sediment: Particles that settle and accumulate at the bottom of a waterway.

Tides: Periodic movement (raising and lowering) of a body of water caused by the interactions of the gravitational forces of the sun, moon, and earth..

Turbidity: The measure of water cloudiness; it may be affected by the amounts of sediment or plankton in the water.

Watershed: An area of land that is drained by a river or other body of water.

Zooplankton: The animal form of plankton.

NAUTICAL TERMs

Aft: A direction toward the rear part of the vessel.

Anchor: An object used to grip the sea bottom to hold a boat in a desired place. Usually connected to the ship by chain, rope or wire.

Bearing: The direction in which an object is observed (either in reference to the compass or the heading of the boat).

Ballast: Weight in the hull or keel of the boat to make it more stable.

Belay: (v) To fasten down a line. More generally, as a spoken order, to halt or cease a particular action.

Below: Beneath or under the deck. One goes “below” when going down into the cabin.

Bilge: The lower internal part of a boat’s hull, adjacent to the keel. On Adventuress, it is the space below the sole boards and the outer planking.

Binnacle: A support or pedestal in which the compass is secured.

Block and Tackle: An arrangement of pulleys and rope, which increases hoisting or hauling power for heavy work, such as pulling in a sail in a strong breeze.

Boom: Long piece of wood which runs along the bottom edge of a sail and attaches to a mast.

Bow: The front or forward end of the boat or ship.

Bowsprit: A spar or log fixed to the deck at the bow and pointing forward to carry a sail ahead of the boat.

Bulkhead: A wall; a divider between compartments

Buoy: A floating, anchored navigational aid.

Compass: A device used to indicate geographical direction.

Course: The intended direction of steering.

Draft: The depth of a boat below the waterline.

Foresail: A sail attached to the forward mast on a schooner. Pronounced “fors’l.”

Forward: Describing things in the front section of the ship.

Furl: To fold or roll up a sail and secure it to a boom or bowsprit.

Gaff: A long stick called a spar supporting the upper side of a sail.

Galley: The ship’s kitchen.

Halyard: A line used to raise and lower the sail. Attatched to the top of the sail, it runs down the mast and is made fast either to the mast or a rail on deck.

Head: The ship's bathroom. Also, the foremost part of the vessel, where toilets were once located.

Helm: The wheel or tiller by which a ship is steered.

Hull: The body of a boat, typically not including superstructure or houses.

Jib: Farthest forward fixed sail on a boat used to balance sail forces and to aid tacking.

Jibe: To change direction in such a way that the back of the vessel crosses the eye of the wind.

Keel: Found on the underside of a boat. Prevents the boat from moving sideways in the water.

Mainsail or "Mains'l": The primary sail on a boat. It is responsible for a good portion of the boat's speed.

Mast: A spar or tall log set upright to support sails and rigging.

Port: The left side of a vessel.

Rigging: The lines of a vessel arranged to hold the mast in a vertical or near vertical position and to control the sails.

Sheet: A line (rope) used for adjusting (trimming) sails.

Spar: Any mast, boom or gaff on board a boat.

Starboard: The right side of a vessel.

Stern: The back end of a vessel.

Tack: A way of turning the vessel. The bow of the vessel crosses the path of the wind and the sails are blown from one side of the vessel to the other.

END NOTES

We try to do our best to keep up to date on resources and information related to current events and our curriculum. If you see a link that is outdates or no longer works, or if you have additional information that you would like to bring to our attention please let our Education Coordinator know.

As an Educator/Deckhand it is important to stay current on your understanding of our curriculum, current events as well as teaching techniques. Onboard the ship we try to provide opportunities to collaborate with other crew members, as well as specific times to reflect and review teaching styles and curriculum. Since we cannot always carve out that time we ask that keep up with that as much as you can on your own time.

Here is an example of some self- assessment questions we utilize on the ship that are useful to review with yourself and/or other crew members.

Shipboard Learning Community (SLC) Assessment

Steering questions to help you self-reflect on your teaching experience and help provide meaningful considerations for daily shipboard debriefs.

- Did you achieve your outcomes?
- How were the students engaged and what could you have done differently to change the level of engagement?
- Was the lesson appropriate for the population?
- Were you prepared and if not, how could you be better prepared in the future?
- Did you work to teach to multiple learning styles or did you find difficulty in teaching to multiple styles?
- Are there learning opportunities for yourself you would like to further develop to make your teaching more successful?

-Sometimes a teacher, always a student-