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Introduction & Background Guide
Introduction

Welcome to the CoastWatch Curriculum, an inquiry-based educational experience for students in grades 4-12 who are eager to learn about the rocky intertidal environment and the marine ecosystem that is an important part of our extensive Alaskan coastline. CoastWatch is an environmental monitoring opportunity for you and your students that, in its most advanced form, will allow you to collaborate in local, regional and global efforts to collect information on change in our coastal ecosystems. Environmental monitoring requires repeated sampling of the same area over a period of time to provide evidence about how the environment changes over time. It provides the means to detect and measure the impact of specific changes on the ecosystem involved. The collaboration is not one-sided – students can provide scientists with scientific data they need over large geographic areas that would be very expensive for them to collect, and the students are given an opportunity to be engaged in “real science” and gain the understanding of the scientific process related to questions and problems that may be global in nature. The CoastWatch Curriculum builds from this foundation of coastal citizen monitoring, integrating hands-on activities, laboratory experiments, interactive games, student research, presentations, action plans, community outreach, writing, reflection, and collaborative art projects to better understand and celebrate our coastal and marine ecosystems.

Why monitor the intertidal zone?

The reasons for monitoring the intertidal zone are well-stated in a description of the LiMPETS program established for several Marine Sanctuaries on the West Coast of North America. Since the inception of the LiMPETS, the program has proved to be a critical monitoring tool in a time of rapid changes:

“We have established an intertidal monitoring program because we believe in the importance of tracking organisms over time. The rocky intertidal on the west coast of North America supports one of the richest and most diverse biotas in the world. This biota is subject to constant change, today largely from anthropogenic (human) causes... The very accessibility of the intertidal has lead to more and more people visiting it. And while reckless collecting might be decreasing now in response to better understanding, simply walking around on the rocks may be disturbing to some species, leading to unpredictable changes.

Moreover, by its very nature, the intertidal zone, both on rocky benches and sandy beaches, is exposed to many of the pollutants produced by human society. Contaminants released into the air fall on the surface of the sea and are carried into the intertidal, as are chemical contaminants such as oil spills. Waste materials dumped on the land are washed into the sea across the intertidal, some of it remaining there. Indeed, the animals and plants of the intertidal may be affected more severely by human activities than those in most other parts of the sea. Fortunately, because of their accessibility, they also may be the easiest to monitor, and so can serve as our marine canaries.

In addition, there are dramatic geological and climatic disruptions along these shores (earthquakes, severe storms, El Niño events, global warming) that could generate change in the biota. In response to a rise in both air and sea temperatures, we can expect the distribution of species along our coast to change ... Global warming may result in a northward shift in the
Moreover, global warming will likely cause a rise in sea level. The tightly organized zonation patterns of the intertidal, with species sorted into bands according to tidal height, may be particularly sensitive to global warming. A rise in sea level not only could shift the different zones higher on the shore, but the zonation pattern itself could change as the shoreline configuration and associated wave forces change. In addition, long-term, interannual cycles of sea level could influence zonation patterns.

This intertidal monitoring program will provide long-term data that can be used to follow changes, and it will also introduce people of all ages to the rich biota of the intertidal, hopefully building up a group of informed, concerned citizens who will watch over this fascinating habitat in the future.”

Organisms in Alaska’s intertidal zone live on the edge -- between the land and the sea, between human development and wilderness, between the Arctic and temperate climes. Changes happening along these edges may be reflected in the health, diversity, and abundance of intertidal organisms. Monitoring Alaska’s intertidal zone will provide critical data about an area affected tremendously by contemporary changes, including shifting patterns of vessel and foot traffic, pollution, and harvesting as well as sea temperatures, levels, and salinity.

**What is CoastWatch?**

CoastWatch students will be led through a series of activities introducing them to the process of using scientific protocols and collecting, entering and analyzing data. Pre-trip activities focus on identification and classification of marine invertebrates and seaweeds, the concept of scientific sampling, practice with data collection protocols, and beach stewardship. A sequence of beach field trip activities provides a continuum from discovery to data collection and on-site communication of results. Post-trip activities include data entry and analysis and environmental issue identification and an introduction to problem solving. The environmental issues begin with choices about how to behave on the beach field trip itself (“beach etiquette”) and proceeds to identification of issues relevant to the beach that they visit.

The CoastWatch Curriculum is focused on activities at the beach and extended learning opportunities designed to provide “real science” experience for your class and opportunities to examine environmental issues relevant to the lives of your students. These “real science” opportunities include:

- A Discovery Hike to the Beach to make observations and develop inquiries
- Conducting a CoastWalk and entering data into the CACS database
- Participating in GLOBE, an international school-based coastal monitoring program by collecting, entering, and analyzing data using the GLOBE protocols for environmental and physical conditions. Field trips to rocky beaches with high biodiversity are exciting, filled with teachable moments about the incredible changes of the tides, the colorful and seemingly bizarre shapes and forms of the marine invertebrates, the obvious communities of seaweeds and animals arranged in bands and zones related to their tolerance to wave
force and salt and exposure to air. Squishy encounters with mud and slime and the grasping of tentacles and tube feet never fail to engage the senses and pique curiosity in people of all ages, generating a starting point to an inquiry-based learning experience.

CoastWatch environmental monitoring activities will help increase your student's awareness of the importance of these organisms found on your beach field trip as it fits into the overall health of the coastal ecosystem. Students will engage in examining the biodiversity of intertidal organisms by measuring the number of different organisms found in an area. Over time the students will be able to relate both positive and negative changes in biodiversity on the beach to changes taking place in their communities. Our learning objectives address six basic biological concepts important to your student's understanding of what constitutes a healthy ecosystem.

**CoastWatch Learning Objectives:**

*Students will gain*

- an increased awareness of their local environment
- knowledge of specific ecological relationships and their importance
- awareness of the importance of biodiversity to the health of our coasts
- knowledge of the role of keystone species and their importance as indicator species
- awareness of environmental issues related to the role of humans in causing change in nearshore environments
- an understanding of the role of natural disasters or global climate change on nearshore habitats and the marine ecosystem
- an understanding that change occurs at different scales of time and space and the causes of such change can be natural phenomena, human activities or a combination of both
- an understanding about how scientists are collecting long-term data for the Gulf Watch Alaska monitoring program
As a class you will decide on which animal groups and/or species you would like to monitor. We have developed a species list that represents organisms that are important to monitor in the Gulf of Alaska. The species have been chosen for one or more of the following reasons:

- They are easy to find and/or identify
- They are important to the intertidal community because they are a:
  - Space occupier
  - Grazer
  - Predator
  - Filter feeder
- They are sensitive to disturbance and are therefore a good indicator species
- They are important to the human community
- They are representative of a trophic level (position within the food web, i.e. primary producer, primary consumer/herbivore, psecondary consumer - carnivore, etc.)
- Other special characteristics

By participating in this program students will gain skills in observing, measuring, collecting data, analyzing data and communicating results within the scientific community. They will also get a concrete understanding of the tidal zones and how different organisms adapt to survival in a constantly changing environment. They will develop the skills that will provide the tools for forming inquiries to begin exploring cause and effect in a coastal ecosystem by starting out with a local emphasis and branching out to explore global questions.

### Intertidal Species Being Monitored:

#### Primary Species

- Periwinkles (Littorina spp.)
- Katy Chiton (Katharina tunicata)
- Blue Mussels (Mytilus trossulus)
- Limpets (Lottia pelta & Tectura scutum)
- Sea urchins (Stronglyocentrotus spp.)
- All Seastars
- All Barnacles
- All Sea Anemones
- All Chitons

#### Seaweeds:

- Rockweed (Fucus spp.)
- Ribbon Kelp (Alaria spp.)
- Sea Lettuce (Ulva spp.)
- Sea Sac (Halosaccion glandiforme)
- Coralline Algae (order Corallinales)

#### Secondary Species:

- Hairy Triton (Fusitriton oregonensis)
- Moon snails (family Naticidae)
- Cockles (family Cardiidae)
- Sea Cucumbers (Cucumaria spp. & Chiridota spp.)
- Octopus (Enteroctopus dofleini)
- All Crabs
- All Nudibranchs
- All Clams
Our CoastWatch coastal monitoring program has three main components, with other additional options. Each component requires a different time commitment by your class. You will need to evaluate your time and decide which option best fits your curriculum needs and school schedule. The three options for involvement are as follows:

1: Beach Discovery
2: CoastWalk
3: Intertidal Sampling

A brief description of the options can be found below. As a teacher, you are not limited to choosing only one option – feel free to adapt these activities as you see fit. Including all of these units in your science curriculum will provide the best experience of place and metacognitive facilitation for your students to succeed. Whichever option you chose, you will find pre-field trip activities to prepare your class for field work, detailed descriptions of the field activities and protocols, data sheets, useful resources, curriculum standards alignment and follow-up activities.

**Beach Discovery**

Involvement at this level requires a minimal time commitment. The focus here is to get your students out to the beach and begin exploring the various communities found at the different tidal zones. Activities include beach discovery hikes, creation of species lists, doing timed counts as a focus to searching for various key organisms and getting your students familiar with the beach environment. Your main task at this point is to get them excited about being out and discovering this dynamic ecosystem. Expected time commitment would be one or two classroom sessions to familiarize your students with the beach environment and the intertidal organisms that can be found there, plus at least one field trip to the beach and then a follow-up classroom session to make an intertidal atlas or species list.

**CoastWalk**

CoastWalk is a unique community science and stewardship program sponsored by the Center for Alaskan Coastal Studies (CACS) with a three part mission to: build community awareness of the importance of our local marine habitats, gather data to detect long-term trends in biodiversity, and to observe the effects of human impacts on our shore. 2013 was the 29th year that CACS coordinated the annual effort on the Kachemak Bay shoreline. Participating in a CoastWalk survey takes the learning associated with a beach hike one step further by involving you and your students in a structured survey of a wide variety of marine and terrestrial animals, signs of human impact, beach debris and other things while walking a predetermined stretch of beach during the month of September and/or April and May.
Classes located both within and outside of the Kachemak Bay region are strongly encouraged to participate in a CoastWalk survey. If you are not located along Kachemak Bay, your class can play a leadership role in beginning a long-term coastal monitoring project in your area, which will provide critical baseline data and allow the area to be monitored for changes over time. CACS can assist in the creation of biodiversity checklists and data bases for regions other than Kachemak Bay, and will work to find local partners to assist as necessary.

All CoastWalk surveys include collection of data on environmental and physical conditions and are standardized with the worldwide GLOBE program. GLOBE (Global Learning and Observations to Benefit the Environment) is an environmental monitoring program sponsored by the National Science Foundation and NASA. Participating in a CoastWalk survey allows students to take part in a global, collaborative science project and compare their data to data throughout the world. Participation at this level allows you and your students to go beyond just looking at local questions about organisms and their habitats; you will branch out to explore global questions about climate change and share information with students and scientists worldwide.

The necessary time commitment would be similar to the Beach Discovery option (approximately 2-3 classes plus field study) except that you would need to spend an additional class period doing an activity to prepare your students to use the CoastWalk data forms. Completed data forms will then be sent to the CACS for entry in the CACS Coastwalk data base. Follow-up activities include determining issues that affect your stretch of beach and designing an inquiry to guide further beach explorations as well as analyzing findings and comparing them to other CoastWalk data.

**Intertidal sampling**

Intertidal sampling is the most intensive of the three options but also the most rewarding. You and your students will collect important data utilizing a variety of scientific protocols and spend more time learning about the intertidal organisms and their role in the beach ecosystem. This option involves using data collection protocols as a means to detect local change, including quadrat counts of various animal groups, timed counts which measure species abundance at a particular site, and/or vertical transects which assess species diversity along the intertidal zones. Following practice, the quadrat counts are very simple to perform. They involve looking for an area where a species is very abundant and doing a maximum density count and a random count in the same area. The timed counts are performed over a certain area of beach for 10 minutes and are similar to a species scavenger hunt. The vertical transects require the most detailed work, but provide an excellent picture of the distribution of animals along the tide zones and set up the best method for measuring change over time. All of these protocols are explained in detail in Unit 3 of this guide.
History of Coastal Monitoring in Alaska

History of Coastal Monitoring in Kachemak Bay

The Center for Alaskan Coastal Studies (CACS) has conducted educational programs in Kachemak Bay for more than 20 years. Our Field Station in Peterson Bay, accessible only by boat, has been the site of overnight Coastal Ecology Trips by more than 10,000 Alaskan students with their teachers and parent chaperones from Homer to Barrow. Field trips to rocky beaches, in an area where the tidal range is as much as 27 feet, are invariably the highlight of the excursion.

Our beach field trips are opportunities for experiential, inquiry-based learning. Teachers who participate in our Alaskan Coastal Ecology program use the beach field trip experiences as an essential part of quality learning related to important concepts included in the National and Alaska State Standards for science education. The concepts of biodiversity, adaptation, ecological interrelationships, and the forces that shape the earth are illustrated repeatedly in the context of both scientific inquiry and the “wow” factor. The field experience lends itself to inquiry-based, hands-on teaching methods identified in the standards for quality teaching practices. CACS sponsors teacher training workshops and provides traveling naturalist visits to align field trip, pre-trip preparation, and post-trip wrap-up activities with these standards and develop ways to extend and reinforce the learning in the classroom.

But beaches are more than sites for fun science education. They are among one of the most dynamic environments on earth and thus a good subject for the study of change, both in response to small and large-scale natural forces and the activities of people, who are drawn in increasing numbers to the shoreline for recreation and residential, commercial, and industrial activities. The nearshore zone, the combination of the intertidal zone and adjacent shallow subtidal zone, is a dynamic and interactive component of the marine ecosystem whose health and productivity are important to Alaskan communities and the world. Understanding the significance and consequences of changes in the nearshore zone can provide jumping off points for learning in geography, social studies, and environmental education. In addition, the learning can be developed in a culturally-relevant way in Alaska’s Native communities where observations may be long in the collective memory of elders and the culture.

COASTWALK Kachemak Bay Monitoring

To address the study and consequences of environmental changes in the nearshore CACS began, in 1984, to organize and support an annual Kachemak Bay CoastWalk. Citizen volunteers, including school classes and youth groups were encouraged to walk a stretch of the Bay coastline and we provided the means to conduct a survey of biological communities, physical conditions, and evidence of human use and impacts. Active stewardship through beach clean-up has also been a feature most years and has resulted in the removal and disposal of tons of trash and marine debris.
At the “local” scale of Kachemak Bay communities, the Kachemak Bay CoastWalk program was developed as a program to increase awareness about the condition of specific areas on the shoreline and the overall health of Bay environments. Surveys of plant and animal life and human activities and impacts serve as an “early warning” system for major changes (erosion, erosion control) and for unusual events (e.g., large jellyfish blooms, mussel die-offs). The long-term survey has provided the basis to track areas near communities receiving heavy use and devise access and education efforts to minimize or avoid damage to biological communities.

The concepts of the CoastWalk program that has been developed in Kachemak Bay over the past 29 years can be applied to other coastal areas throughout Alaska, and beyond. CACS is eager to utilize the lessons learned through facilitating this program in Kachemak Bay to help other communities, organizations, and classes adapt this program to their area on both small and large scales, from a single class monitoring field trip to a coordinated, community-wide effort.

Gulf Watch Alaska Ecosystem Monitoring

In 2002, CACS also became a partner in GEM, the Gulf of Alaska Environmental Monitoring and Research Program sponsored and supported by the Exxon Valdez Oil Spill Trustee Council. CACS began work on a community involvement plan for GEM to provide opportunities for schools and community-based organizations to participate in this ambitious ecosystem-scale program to detect and understand environmental change in the aftermath of the impacts that occurred from the Exxon Valdez Oil Spill. This program evolved into a larger Gulf Watch Alaska ecosystem monitoring program in 2012.

At the "ecosystem" scale, Gulf Watch Alaska is an ambitious science based program with a broader mission to sustain a healthy and diverse ecosystem and the human uses of marine resources in that ecosystem. The central scientific hypothesis is that natural forces and human activities working over local to global scales cause short-term and long-lasting changes in biological communities that support birds, fish, shellfish, and marine mammals. In the two decades following the Exxon Valdez oil spill (EVOS), and after extensive restoration, research and monitoring efforts, it has been recognized that full recovery from the spill will take decades and requires long-term monitoring of both the injured resources and factors other than residual oil that may continue to inhibit recovery or adversely impact resources that have recovered.

Monitoring information is valuable for assessing recovery of injured species, managing those resources and the services they provide, and informing the communities who depend on the resources. In addition, long-term, consistent, scientific data is critical to allow us to detect and understand ecosystem changes and shifts that directly or indirectly (e.g. through food web relationships) influence the species and services injured by the spill.
The goals of the program are to:

1. provide sound scientific information on biological resources and environmental conditions to management agencies, the scientific research community and the general public;

2. identify and help understand the impacts of multiple factors on recovery of resources injured by the 1989 oil spill; and

3. leverage partnerships with state and federal agencies, universities, non-profits and private entities to integrate and provide access to data from broader monitoring efforts in the region.

The Gulf of Alaska nearshore environment that extends from the highest reach of the tides to 20 meters in depth has been characterized as both the most productive habitats in the region and the most threatened. These habitats were most severely affected by the Exxon Valdez oil spill. They provide important feeding grounds for terrestrial and aquatic birds, mammals, invertebrates, and large fish. Humans depend on food from these rich meeting places of sea and river nutrients. In addition, they are the nursery areas for young marine organisms, unique habitats for specialized animals and major sources of seaweed production. The nearshore will be one of the four habitats in which GEM will focus monitoring efforts. The productivity in this zone is inextricably inked to supplies of nutrients and food from both the Alaska Coastal Current and offshore habitats and from watersheds. In turn, the nearshore provides nutrients and foods to the many animals that also depend on watershed habitats. The detection of changes in nearshore communities will thus be a lens into larger-scale ecosystem changes.

More information about the programs of the Exxon Valdez Oil Spill Trustee Council is available at http://www.evostc.state.ak.us and about Gulf Watch Alaska at http://www.gulfwatchalaska.org/

**GLOBE Monitoring**

In 2002, CACS became a partner in the GLOBE program. GLOBE is an international, hands-on, inquiry-based environmental science and education partnership. Sponsored by the National Science Foundation and NASA, the program brings together students, educators, scientists, schools, and communities to collaborate on environmental research directed at detecting and understanding climate change. At the heart of GLOBE are standardized data collection protocols, especially developed to be feasible for students to perform, and on-line data entry and analysis. GLOBE provides the opportunity for all students in K-12 classrooms to engage in authentic hands-on science research. Students essentially learn science by doing science.

Through the GLOBE program, individuals all over the world collect data on atmospheric and hydrologic conditions, which can then be compared to similar data from other areas of the world.

GLOBE Web site: http://www.globe.gov
Natural History of the Intertidal Zone

What Lives Where? And Why?

Imagine that you are a mussel. Where would you live in the intertidal zone? What do you think are the most important aspects of the environment that would affect your survival? Or imagine you are a sea star. How will you manage to find as many mussels and clams as you need to eat higher up on the beach without drying out before the tide comes back? Questions of this sort fascinate scientists, naturalists, and anyone who spends time roaming a rocky beach at low tide. The major and controlling factor in the life of this area is the range and timing of the tides. The action of the tides moves the water’s edge up and down the land in a predictable and regular fashion, creating living space for plants and animals and transporting nutrients and food items. Wave action can extend the intertidal zone even higher up on the land or sweep away whatever is not clinging or firmly attached. Plants and animals sort themselves out, either permanently by attaching to a rock or other hard substrate or temporarily by crawling or burrowing, somewhere along an invisible gradient of conditions from the lowest low tide to the highest high tide and splash of salty water.

Scientists have sought answers to these questions through studies on beaches and shores all around the world. The intertidal zone is a dynamic and harsh environment to which plants and animals must have adaptations that allow them to cope and survive. It is more crowded at the lower tidal levels where complex dramas are played out to find space and food while avoiding becoming food. The distribution of plants and animals in the intertidal zone appears to be a combination of responses to physical conditions and to biological interactions of competition and predation. Upper limits for plants and sessile (fixed) animals are generally set by their tolerance to physical factors while the lower limits are often set by biological interactions. For mobile animals, however, behavior often provides important adaptations that influence their distribution.

Four important physical gradients help explain plant and animal distribution in intertidal environments: 1) a vertical gradient from terrestrial (land) to marine (ocean) conditions, 2) a horizontal gradient of exposure to air and variable temperatures, 3) a gradient of particle size from bedrock to silt (mud) in substrates, and 4) gradients of salinity.

Tides

The movements of the tides create the conditions for life in the intertidal zone as they carry nutrients and food items along with larval forms of many animals that spend their adult life in the intertidal zone. Alaska’s coasts tend to have two tide cycles daily and a very large tidal range. The tide cycles are unequal each day with a higher cycle and a lower cycle; between the two cycles, there is a less extreme low tide (the high low) and a more extreme low tide (the low low) as well as a less extreme high tide (the low high) and a more extreme high tide (the high high). Furthermore, the extremity of
the tide varies day to day and month to month in a predictable way based on interactions with the sun, moon, coastline, and ocean bathymetry. Storm surges and pressure systems can have affect tidal height as well. Because of the high latitude, all of Alaska’s coastal areas have a large tidal range. In Kachemak Bay, for example, the maximum daily tidal range is 28.5 feet and the average 15.4 feet. Upper Cook Inlet has an even greater tidal range of up to 38 feet because the tides are constricted by the geography of the inlet north of Kachemak Bay. This constriction creates the fast-moving tidal bore that moves up Knik and Turnagain Arms, the second largest tidal bore in North America after the Bay of Fundy. Similar constriction of water happens in the upper reaches of Bristol Bay, creating tidal ranges of approximately 30 feet. On the other hand, the relatively wide Prince William Sound experiences tides about ⅓ as extreme.

To understand the way the tides affect conditions for life, it’s important to understand that tidal range is measured vertically, as if on a cliff. If a pole was placed in the intertidal zone in Kachemak Bay, the water would move up and down along the pole a total of 28.5 feet over the course of a day with extreme tides. On less extreme tidal days, it might only move up and down 10-15 feet. At low tide, this vertical movement of water can translate into many feet of steep shoreline or even miles of gently sloping beach being exposed. Another important concept for understanding how tides are measured is the concept of the zero-tide level, which is the average (mean) of the low tides over the course of a month. The tide level above or below zero in relation to the tidal range provides an indication of the amount of the total intertidal zone that is exposed at a particular place at a particular time. For example, a -2.0 tide at China Poot Bay (with an extreme low tide level at around -5.0) would expose only a portion of the low intertidal zone and communities compared to a -2.0 tide at a southern California beach where a -2.0 tide is the lowest tide of the year.

**Life in the Zone**

Vertical zonation is most distinct on the faces of large boulders or bedrock outcrops where all plants and animals are adapted to life on the same type of rock substrate. While band-forming plants and animals like mussels, barnacles, and fucus or rockweed (also called popweed) can predictably be found in the upper, middle, or lower portion of the intertidal zone, other plants and animals respond to variable local substrate conditions as well as to other factors. This is true of animals that hide under rocks when the tide goes out and animals that burrow in areas where sand and mud have accumulated. The addition of new habitat niches under and on smaller rocks and in sandy and muddy pockets increases habitat diversity and results in a larger species diversity (number of different types of species that can find suitable habitat) compared to that of a rock habitat. However, the plants and animals that may be found at each tide level is less predictable in an area of many habitat niches.

**Friends and Anemones**

In addition to physical factors, relationships between and among organisms also affect and often control survival at any specific site. The crowded conditions of the lower intertidal zone are thinned by competition, grazing, and predation. Behavior patterns of different animals also help explain where some are found or not found. Mobile animals, such as limpets and sea stars, rarely move so high up
in the intertidal zone that they are exposed to conditions that they cannot tolerate. Barnacle larvae have chemical sensing capabilities and settle in areas where the scar of a dead barnacle is present rather than on bare rock. Small sea stars, worms, limpets and snails move to the underside of rocks as the tide goes out where they are in a wetter micro-climate. Brittle stars clump together under rocks as do larger sea stars on the surface, which helps conserve water more than if the individuals were alone. Animals find shelter under seaweeds from drying and extreme temperatures.

### Intertidal Food Webs

#### Producers

Phytoplankton and algae are the producers in the intertidal zone. Phytoplankton are small, unicellular organisms capable of photosynthesis and buoyant enough to float in the upper layer of the water which receives enough light to support photosynthesis. Phytoplankton include microalgae, one-celled monerans, and bacteria. Diatoms and dinoflagellates are common phytoplankton in Kachemak Bay. Some diatoms are sessile, or attached, and appear as a slimy scum on intertidal rocks. Phytoplankton is either captured by zooplankton and other small animals in the water column, many of which are the larva of animals that settle and attach themselves to rocks in the intertidal zone such as barnacles and mussels, or filtered from the water by filter-feeders such as the clams, mussels, and barnacles.

Seaweeds, or macroalgae, are at first glance similar in form to flowering plants, but they attach and glue themselves to rocks and other hard surfaces (even the shells of molluscs) with holdfasts rather than rooting in mud or sand, have a stipe instead of a stem, and have blades instead of leaves. They reproduce by microscopic, floating spores rather than by seeds. The distribution of seaweeds in the intertidal zone is related to their ability to photosynthesize at varying light levels, and tolerance to desiccation (drying out), freezing, and grazing. Seaweeds are consumed by grazers such as limpets, some snails, chitons, and sea urchins.

Macroalgae are classified as green, red, and brown. (The color of the plant does not always match the classification because the grouping is based on many factors, not the color.) As a general rule, green algae are more often found in the upper intertidal zone, red algae in the middle zone, and brown kelp seaweeds in the lower zone and subtidally. Kelps that are annuals, in particular, are among the fastest-growing organisms in the world during May and June.

#### Filter feeding

A number of intertidal animals consume particles of organic material suspended in the water column and sediment, including phytoplankton, zooplankton, and detritus (dead material). Their feeding method is called filter feeding. The filter-feeding method of animals such as sponges, clams, and mussels involves passing water through their bodies using siphons, pores, cilia and other structures,
capturing particles in mucus and moving the food particles to their mouth or place where food is digested. But other methods are also used - worms ingest sediment and sort out the organic particles, sea cucumbers extend tentacles covered with mucus and contract them one at a time into their mouth to clean off the particles, and brittle stars move across the substrate and use their tube feet and mucus to pass particles to their mouth.

**Grazing**

Grazing occurs at both the micro- and macro-level. Several species of molluscs like periwinkles and limpets are microherbivores, using their radula (whip-like tongue with teeth) to scrape off films of diatoms and microalgae off rocks or other hard surfaces. Sea urchins and larger molluscs such as chitons can bite or rasp off chunks of seaweeds. Seaweeds have few defenses against grazers because they are fixed in place. Some grow in dense patches and tend to lose less mass to grazers. Others are encrusting species that adhere tightly to rocks; the calcification of the coralline algae limit the grazers that feed on them to just a few species of micro-herbivores. Some species have noxious substances that grazers avoid. Rockweed, for example, contains chemicals that make it indigestible by most species, so is rarely grazed. There is even an Acid Kelp (*Desmarestia spp.*) that produces and secretes sulfuric acid that can damage nearby seaweeds and erode cavities in the teeth of sea urchins hungry enough to feed on the seaweed.

**Predation**

Intertidal predators also come in all sizes, from the microscopic zooplankton and larva in the water column that capture phytoplankton to the Giant Pacific Octopus that can grow to be 100 feet long in deeper waters. Most are mobile so have a large advantage over the many animals which are sessile, but some remain in one place, like the sea anemone that relies on its stinging cells to attack prey that happen to come in contact with their tentacles. Slow-moving predators may have adaptations to open the shells of bivalves (the tube feet of sea stars) or to bore into their shells (radula of whelks and moon snails).

Intertidal prey species have evolved a variety of passive responses to predators, including spines, thick shells, tough exoskeletons, noxious chemicals, and camouflage. A periwinkle that withdraws into its shell, closes its operculum, and seals the door with mucus can survive being swallowed and digested by a sea anemone for 20 hours! Prey have also developed behavioral responses such as the chemical detection of predatory sea stars by several bivalves, followed by rapid movement away. Prey can escape predation if they can develop refuges either spatially by adapting to a zone out of the reach of predators or temporally by shifting activity to a time when the predator is not active such as nighttime or timing larval settlement to a time when predation or competition is lower. Or they can grow so fast that they escape in size by becoming too large for a predator to successfully attack.
Scavenging and Decomposing
While a large amount of detritus is recycled by the suspension-feeders, other animals feed on larger chunks of dead matter. Several types of crabs and amphipods are the clean-up crew in the intertidal zone, but sea urchins, usually an herbivore, will also feed opportunistically on dead matter. Detritus passes through what can be thought of as a series of sieves in the intertidal zone. Crabs eat big chunks, beach hoppers eat minute particles or break up large pieces into small ones, sea cucumbers and brittle stars buried in the substratum sweep surfaces with tentacles, limpets and periwinkles sweep the rocks, other animals like brittle stars, sea cucumbers, and annelid worms eat dirt and sand to extract nourishment. The smallest particles are attacked by bacteria and recycled into nutrients that phytoplankton and seaweeds can use in photosynthesis.

Other Ecological Relationships
The intertidal zone is a wonderful opportunity to study ecological relationships beyond those of “who eats who”. Examples of competition and the varieties of symbiotic relationships - commensalism, parasitism, and mutualism - abound.

**Competition**: Occurs when a number of individuals of the same or different species utilize a resource that is in short supply. Competition occurs in the intertidal zone for space, for food, and for light. Some plants and animals compete by growing on top of other organisms. Competition is avoided by specializing and adapting to conditions that other species are not able to match. Species that dominate large areas such as barnacles, mussels, and rockweed are good competitors for space.

*Example Species:*
Limpets, Barnacles: Limpets compete successfully for space by removing newly-settled young barnacle spat by bulldozing them off of the rock. When the barnacles reach a large enough size, they are no longer susceptible to bulldozing.

Symbiotic Relationships
**Mutualism**: A relationship in which both members of the relationship benefit from the association.

*Example Species:*
Black Seaside Lichen, Orange Lichen: The lichens that grow in the splash zone are a combination of an alga and a fungus. The fungus provides structural support but cannot photosynthesize and the alga makes food for both partners by photosynthesis and benefits from the structural support of the fungus.
Burrowing Anemone, Algae: Some anemones have microscopic algae living in their tissues. These anemones have a greenish color as a result from the photosynthesis occurring. Photosynthesis results in some leaked mineral products that provide nutrients to the anemone and the algae are protected from grazers by their residence inside the anemone who is well-protected by stinging cells from predators.

**Commensalism:** a relationship where one member of the relationship benefits from the association and one is not affected positively or negatively.

*Example Species:*

Commensal Scaleworms, Gumboot Chiton, Sea Stars: The commensal scaleworms that live on sea stars and gumboot chitons are an example of this type of relationship. The scaleworms benefit by feeding on food particles around the mouth of the partner, but the sea stars and gumboot chiton are not really harmed by having the scaleworm living on them.

Hermit crabs, Snails: Hermit crabs benefit from the use of snail shells as their portable shelter, with no effect on the dead snail.

**Parasitism:** a relationship where one member of the relationship benefits from the association and one member is harmed.

*Example Species:*

Boring sponge, Hermit Crab: The boring sponge is able to secrete a substance that dissolves the calcareous shells of mollusks and barnacles, so it penetrates the shell and takes up residence. The parasite seriously weakens the shell. The wandering sponge encrusts on the shell of a hermit crab and hitches a ride with the crab wherever it moves. It eventually dissolves the shell, destroying the commensal relationship of the crab with its snail shell.

Epiphytic algae, Seagrass, Larger Algae species: Epiphytic algae such as seagrass laver grow on host species like eelgrass or large algae species. The epiphytic algae benefits from this by securing a ‘substrate’ to which it can attach. Even better, it is able to attach closer to the water surface, where it can acquire more light to photosynthesize. The host, whether it be another algae species or eelgrass, is harmed by this arrangement since the epiphytic algae blocks sunlight from reaching it and can increase drag on the host, leading to higher rates of destruction during times of high wave or current action.
Marine Debris in the Ocean & Intertidal

What is Marine Debris?

Marine debris is defined as human-made, solid materials that enters our waterways either directly (such as dumping) or indirectly (such as washing out to sea via river or stream). Marine debris includes both biodegradable items and non-biodegradable items. For thousands of years, marine debris was composed primarily of readily biodegradable items (wooden tools, hemp or linen ropes, cotton or hide clothing). Next, glasses, metals, and paper products were added to the mix. Manufactured glass and metals are not as biodegradable as ancient tools and fibers, but these products are quickly broken down by physical forces and have minimal impacts on the marine environment compared to plastic. Worldwide, about 80% of marine debris is now made up of plastic items. This plastic debris – and other types of marine debris – come from four main sources: land based/personal-use items, marine industries and recreation, container ship spills, and natural disasters.

Non-biodegradable items tend to cause the most problems as marine debris since they persist in the environment. Plastic is more of a problem than glass, not only because it is more prevalent. While glass does not biodegrade, it does break into increasingly smaller pieces and mineralize. Furthermore, it is fairly inert (usually doesn’t contain or absorb toxic chemicals), usually sinks, and becomes almost equivalent to a human-made rock in the ocean. On the other hand, plastic photodegrades into smaller pieces when exposed to UV light, but these pieces often contain or absorb toxins and can be easily mistaken by marine animals as food. Long or circular pieces of plastic can also entangle marine animals.

A Brief History of Plastic

Over 100 billion pounds of plastic were produced in 2013, and this figure has been increasing from year to year. The amount of plastic produced annually has grown approximately 40-fold between the 1950s and 2005. Looking at our lives today, it’s hard to think of how we could exist without plastic. But plastic is actually a relatively new addition to the world. It was first created by Alexander Parkes in 1856. He showed off this new product to the public, which we later came to know as cellulose, at the Great International Exhibition in London. The term “plastics” was coined by chemist Leo Hendrik Baekeland to describe his invention of the first fossil fuel based polymer, which he created in 1907. After the First World War when manufacturing techniques were refined and petroleum was readily available, plastics started their rise to popularity. However, they did not start to become common until after the Second World War, and there are still people alive who can remember a life without plastic in it. According to the American Chemistry Council, the plastic production process often begins by treating components of crude oil or natural gas in a “cracking process.” This process creates hydrocarbon monomers such as ethylene and propylene. The monomers are then chemically bonded together to form chains called polymers.

Simply put, polymers are chemicals made of many repeating units. They can be made by nature or
artificially in a lab, some examples include natural polymers such as spider silk, hair, and DNA, and synthetic polymers like silly putty and rubber. Characteristics such as flexibility, heat-resistance, and stable electrical properties can be imparted to plastic polymers by adding different chemicals or “plasticizers.” Polymers are often used in both industry and consumer products because they are durable, flexible, and strong.

**Transport of Marine Debris**

Global winds and currents transport marine debris and other pollution. Wind is the movement of air driven by differences in the density of air masses, which is determined by air temperature. Currents are the continuous and directional movement of water. Surface currents are driven primarily by wind and affect the upper 400 meters of the ocean. Deepwater currents, affecting waters below 400 meters, are driven by differences in the density of water masses, determined by both temperature and salinity (saltiness). Cold air is denser than warm air.

The same is true for water: cold water is denser than warm water. Also, water with a high salinity (saltier) is more dense than fresh water. Differences in the density of water can cause both downwelling and upwelling events. Currents caused by water density due to salinity and temperature are called thermohaline circulation: “thermo” for temperature and “haline” for salinity. This thermohaline circulation creates what is called the “global conveyor belt.” In areas of downwelling, warm surface currents (less dense) cool in transit to the poles. As they cool, they become more dense and sink down the water column. In areas of upwelling, winds parallel to coastal land pushes warm surface water offshore. Deep cool water upwells to replace warm surface water. This nutrient-rich cold water can create plankton blooms.

Global wind and current patterns can be generalized as warm equatorial water/air rising and moving north and cool polar air/water flowing along the surface toward the equator. The zones where warm and cold converge are the areas that create the main currents and winds on earth. The currents and winds interact with each other, which changes their direction from what you might predict.

The winds and currents are also deflected by the rotation of the Earth. This is called the Coriolis effect, and deflects winds and currents to the right in the northern hemisphere and to the left in the southern hemisphere. For more on the Coriolis effect, see

http://www.youtube.com/watch?v=i2mec3vgeaI - a short video about the Coriolis Effect from NOVA PBS

http://oceanservice.noaa.gov/education/kits/currents/05currents1.html - a webpage by NOAA devoted to understanding wind, ocean currents and the Coriolis effect

Because of wind, the Coriolis effect, and thermohaline circulation patterns, global ocean currents tend to follow a predictable pattern, and often move in a circular motion. For example, wind-driven currents off the coast of Southeast Asia and China drive warm water northward. As this water nears Japan, winds shift and begin pushing the water eastward. When the current meets the Western coast
of North America, some of the water pushes northward towards Alaska and some moves southward along the coast of California to the equator. Here, prevailing winds push the current back across the Pacific Ocean, where it begins to move northward again near Southeast Asia. Gyres often form in circular currents such as this, accumulating water, plankton, and debris in the center of the circle formed by the current. The North Pacific Gyre is located at the center of currents circling the North Pacific Ocean. “Garbage patches” of small bits of plastic and other marine debris are sometimes found within gyres as the debris concentrates over time. This poses serious threats to organisms living within the gyre ecosystem.

Monitoring Marine Debris

Beach cleanups with recorded items collected are a form of scientific data collection. While a simple beach cleanup does not take the traditional appearance of a scientific study with a laboratory coat and graduated cylinder, recording debris collection actually tells us a lot about what types of trash is entering the ocean and accumulating on shore. The Center for Alaskan Coastal Studies (CACS) has been conducting CoastWalk beach monitoring and cleanups since 1984. The data collected on wildlife, human activity, and marine debris collection along the Kachemak Bay shoreline through this program represents a long-term citizen monitoring project. The CoastWalk program has partnered with the Ocean Conservancy’s International Coastal Cleanup (ICC), a worldwide marine debris cleanup and monitoring effort. Therefore, data from Alaskan clean ups that is entered into the CACS database is available locally within Alaska and added to the global ICC database as well.

Marine debris accumulating along Alaskan shorelines originate from one of four sources. These sources include land based/personal-use items (such as waterbottles, shoes, food wrappers), marine industries (such as buoys, fishing lures, boat parts), container spill items (friendly floatees, nike shoes, items from known spills), and debris resulting from natural disasters (these items can range from gas containers and sports balls to docks and pieces of housing material). Trends in debris accumulating on beaches from each of these sources can be measured from the monitoring and cleanup efforts of Alaskan shoreline cleanups over the past 30 years. The recovery of land based/personal-use items in marine debris clean ups is increasing in the Alaska region. Categories of land based/personal-use items include: daily use items by individuals such as toothbrushes and food wrappers, household items such as soap dispensers, dishes, and appliances, and recreational use items like beverage bottles, food wrappers, and sandals.

On the other hand, there is evidence that debris from commercial fisheries and other marine industries may be stabilizing or even decreasing in some areas. Examples of debris from marine industries and recreation include: buoys, boat parts, nets, ropes, fishing line, strapping bands, gloves, and coolers.

Debris from container ship spills is difficult to track because shipping companies are not required to report spills in international waters. However, with ever-increasing amounts of products being shipped across the world’s seas, the risk of container ship spills is great and increasing. It is currently estimated that as many as 10,000 containers are lost every year. Other reports estimate the number is in the hundreds. Many freight vessels traveling across the North Pacific do so along the coast of
Southeast Alaska and the Aleutian Islands, crossing the Gulf of Alaska.

Recent container spills include: 1990 – Nike Shoes, 1994 – Hockey Gear, 1997 – Legos, and 2012 – Sport Memorabilia. Container ships also sometimes spill the raw plastic pellets, called nurdles or ‘mermaid tears,’ that are used in the manufacture of all sorts of products.

One well-known container spill helped oceanographers learn more about global currents. “Friendly Floatees” bath toys were being shipped across the Pacific Ocean to be sold by The First Years, Inc. In early winter, 1992 a container filled with the toys (as well as 11 containers filled with other products) were lost overboard in the middle of the Pacific Ocean. More than 28,000 floating bath toys spilled into the water. They were used by Curtis Ebbesmeyer, an oceanographer to model global ocean currents by keeping track of where the floatees made landfall.

Finally, tragic natural disasters like the 2011 Tohoku Earthquake and Tsunami in Japan and the 2013 Haiyan Typhoon in the Philippines have created influxes of marine debris worldwide and along Alaska coasts specifically. An astounding amount of land-based debris washed into the ocean along with debris dislodged from fishing, aquaculture, and marine recreation following the 2011 Tohoku earthquake and tsunami. Much of this debris drifted back to Japanese shores, but a large portion was swept by large-scale Pacific currents. Two researchers from the Washington Sea Grant, Miller and Brennan, predicted where the current-driven tsunami debris is likely to wash up. Relying on data from past debris studies and surface drifters, they concluded that “the coast of Alaska is the epicenter of drifter groundings in the northeast Pacific.” After the tsunami devastated Japan, the Gulf of Alaska Keeper and Center for Alaskan Coastal Studies have observed a significant increase in the amount of plastic foam pieces (including polystyrene/Styrofoam and polyurethane) on Montague Island and Gore Point, much of which is likely connected to the 2011 Tsunami.

On a more local scale, minor weather events cause damage to docks, boats, and shoreline development and scatter debris into the water every year, and more extreme events can cause upticks in the local occurrence of debris.

**Effects of Marine Debris**

A large amount of plastic marine debris is transported throughout the ocean by winds and currents. Much of this plastic accumulates in ocean gyres such as the North Pacific and North Atlantic. This plastic poses many threats to marine ecosystems when they entangle, smother, or are ingested by living organisms. As the plastic photodegrades into smaller and smaller pieces, the pieces are easily mistaken for plankton and often ingested by forage fish. These forage fish are in turn consumed by predators, some of which are then caught and eaten by people. Furthermore, plastics in the marine environment can block sunlight from penetrating into the water column, preventing phytoplankton from absorbing the sunlight needed to photosynthesize and obscuring the light small fish and zoo-plankton use to find food.
Three major effects of marine debris in the ocean ecosystem are entanglement, ingestion, and water pollution. Entanglement refers to what happens when animals get caught in pieces of debris such as fishing line, nets, rope, soda rings, and plastic bags. The mobility of these animals is threatened by entanglement, hindering their ability to acquire food, evade predators, and, in the case of marine mammals, sea turtles, and birds, reach the surface for oxygen. Entanglement can also cause physical injuries and sores as the animals struggle against the debris they are caught in and grow larger than they were when they were originally entangled.

Ingestion refers to what happens when animals consume marine debris. Photodegraded plastic often breaks into smaller and smaller pieces until it is about the size of plankton. These tiny plastic pieces (< 1 mm) are called microplastics. Microplastics are often ingested by small fish, baleen whales, filter feeders such as mussels, and other marine organisms. In some parts of the ocean, the small bits of photodegraded plastic outweigh plankton, the base of the ocean food chain. In 2001, the scientists from 5 gyres found that plastic nodules outweighed plankton 6:1 in the Pacific Gyre. In 2011, they tested again and found the nodules outweighed plankton 40:1. Larger pieces are sometimes targeted by predators such as albatross and sea turtles because they look like prey items, namely squid and sea jellies.

The ingestion of marine debris can cause both direct and indirect problems. The animals consuming the plastic can starve because their stomachs are filled with plastic rather than food. Dwindling populations of sea birds, sea turtles, and especially forage fish can disrupt entire food webs because low populations decrease availability of prey to predators up the food chain. When forage fish or benthic invertebrates consume microplastics, the plastic is stored in the digestive system or absorbed into the animal’s circulatory system, and accumulates there. When these forage fish with microplastics in their bodies are in turn eaten by larger fish, marine mammals, and birds, the microplastics make their way up the food chain. A large top predator can accumulate quite a lot of plastic in its system. This process is called bioaccumulation.

Bioaccumulation contributes greatly to the severity of the third major effect of marine debris: water pollution. As these pieces of plastic float throughout the ocean column they begin to provide unnatural habitat for tiny microbes. These microbes are attracted to plastics because the rough surface of the plastic provides an excellent surface for the microbes to cling to. As these plastics become home for microbes, they also begin to absorb Persistent Organic Pollutants (POPs) from surrounding seawater. These POPs are trace insecticides, pesticides, and industrial chemicals. When these plastics are ingested by animals, the microbes are digested and POPs subsequently absorbed into the animal’s fatty tissue. Then the animal’s predator eats its prey, digesting that fatty tissue and accumulating the POPs into the predator’s fatty tissue. Records of bioaccumulation of toxic POPs through eating plastics have been recorded in sea birds and top predator marine mammals such as Orcas. Plastics that contain POPs can also leach them into the surrounding water, so areas with large amounts of marine debris can have high level of toxic pollutants in the water column. These pollutants can be absorbed from the water into adult marine animals as well as their egg and larval stages.
Midway Atoll: A Case Study in Plastic Ingestion

Plastic ingestion by albatross on Midway Atoll serves as an illuminating, and concerning, case study of marine debris plastic ingestion by mammals. Sometimes it is difficult to identify where birds ingest plastics, as birds close to human settlements may feed on plastics from landfills, dumpsters, and restaurant parking lots. Because Midway Atoll is far from such human settlements, the plastics ingested by birds living on the Atoll are almost certainly from marine debris. Furthermore, albatross do not feed on land, but rather are surface ocean feeders, so the plastic they ingest is even more likely to be marine debris rather than litter on land.

Midway Atoll is located about 1200 miles Northwest of Honolulu, Hawaii. It has been designated as the Midway Atoll National Wildlife Refuge (MANWR), encompassed in the newly designated, and second largest marine protected area in the world, The Papahanaumokuakea Marine National Monument. Laysan, Black-footed, and Short-tailed Albatross all breed on the island. Unfortunately, Pacific gyres transport and concentrate marine debris near Midway Atoll and albatross feeding grounds.

Albatross are surface feeders, eating squid, fish, and flying fish eggs. As plastic marine debris has become more prevalent in oceans, albatross have ingested more of it, mistaking the plastics for food. Furthermore, flying fish lay their eggs on floating materials in the ocean. In the past, these materials were natural, such as wood and pumice. Now it is more common for flying fish to lay their eggs on bits of floating plastic, which are then ingested by any albatross that consumes the eggs.

When albatross feed, they cannot digest squid beaks and fish otoliths (ear bones). This tough matter accumulates in their stomachs until they regurgitate it out as a “bolus.” Plastic marine debris is now more and more commonly found in these boluses. Unfortunately, not all albatross can eliminate plastic they have ingested by regurgitating a bolus. Plastic often makes up more than half of the indigestible material in an albatross’s digestive track. If the bolus grows too large or the plastic is sharp, ingested debris may stay in the bird and cause a blockage in the digestive tract, perforate the gut, result in a loss of nutrition (due to displacement of food), or cause a false feeling of being “full”.

Sources of Oil Pollution

There are many sources of oil pollution in marine waters. Some of the petroleum actually comes from natural sources in the ocean where petroleum seeps from the ocean floor. Some sources state that these natural sources may account for up to half of the oil in the worldwide ocean. However, these seeps are so slow that the ecosystems around them are usually able to adapt. The other sources of oil pollution are connected to human use of oil. Some oil is spilled into marine waters during the extraction, making up about 5% of the oil input into marine waters due to human activities. The transportation and refining of oil is responsible for more than 20% of human-caused oil input to marine waters worldwide. Finally, releases related to the consumption of oil account for about 70% of the anthropogenic oil input worldwide. This category includes slow drips from cars, trucks, four-wheelers, and snow machines, improper disposal of used oil, outputs from two-stroke engines, and leaks from personal and commercial boats other than oil tankers. It is estimated that in North America, an average of 25 million gallons of oil and petroleum products enter marine waters every year. This is about twice as much oil was spilled during the Exxon Valdez Oil Spill.

Even though major oil spills might not be the leading source of oil in the marine environment, they can have devastating effects. Because the oil enters the marine environment rapidly and in a localized area, even relatively small spills can significantly impact marine organisms and the people that rely on them for food, livelihood, and recreation. In Alaska, the Exxon Valdez Oil Spill dramatically changed ecosystems and communities from Prince William Sound to the Alaska Peninsula. The Exxon Valdez Oil Spill occurred in Prince William Sound, Alaska on March 24, 1989. About 11 million gallons of crude oil were spilled into the Sound after the Exxon Valdez oil tanker ran aground on Bligh Reef. Storms carried the oil throughout Prince William Sound and almost 500 miles southwest to the Gulf of Alaska, Cook Inlet, and Kodiak Island. This is illustrated in the map at right:
In Alaska, transport of oil occurs by both pipeline and oil tanker. Understanding this technology can help to prevent spills in the future. The Trans Alaska Pipeline System includes the major pipeline in Alaska and some of its auxiliary pipelines. Constructing the Trans Alaska Pipeline System in the 1970s was an incredible endeavor. The pipeline spans 800 miles of rugged Alaskan terrain, much of it above ground due to permafrost. The pipeline crosses 30 major rivers and streams, 3 major fault lines, and 3 mountain ranges. It rises with the land to an altitude of 4,739 feet.

After the oil has travelled through the pipeline and arrives at the Valdez terminal, it is loaded on to oil tankers for transport to other domestic and international ports for refinement and sale. Measuring 986 feet, the Exxon Valdez was just a midsized tanker. At the time, the largest oil tanker in the world, the Seawise Giant was just over 1,500 feet. This tanker was retired and scrapped in 2010. Currently, there are four double-hulled supertankers that are 1,247 feet in length. These ships, the TI Africa, TI Asia, TI Europe and TI Oceania, were built in 2002 and 2003. Since the Exxon Valdez Oil Spill, issues of tanker safety have become very important. For example, some argue that if the Exxon Valdez had had a double-hull, the grounding on Bligh Reef would have punctured much fewer containers, thus greatly reducing the size of the oil spill in Prince William Sound. By 2015, all tankers in Prince William Sound are required to be equipped with double hulls and are escorted by two tug boats while in Prince William Sound.

**Oil and Water Do Not Mix**

In spite of precautionary measures to prevent them, oil spills from ships, offshore drilling operations, pipelines, and natural seepage continue. As past spills have so tragically demonstrated, a major oil spill can take a devastating toll on wildlife. Inshore fisheries, shorebirds, intertidal organisms, and shallow subtidal organisms are most often harmed because spills usually occur in the shallow coastal areas where these organisms are concentrated. The environmental impact of an oil spill depends on the size of the spill, the type of oil spilled, the prevailing wind and water conditions during the spill, and the variety and abundance of life (both wild and human) in the affected area.

The impacts of pollution are often difficult to see. A major oil spill, though, provides dramatic evidence of effects on wildlife. Examples of potential effects include damage to feathers and fur (leading to hypothermia), killing of embryos if oil seeps into eggs, suffocation of fish if gills are clogged, and death to marine and terrestrial animals if they ingest food or water contaminated by the oil.

When oil is spilled, it begins to change both physically and chemically. Some amount of the lighter, volatile compounds turn to gas and disperse in the air. The remainder of the toxic oil usually spreads out from the main slick as fingers of very thin, iridescent sheen on the surface of the water. This layer of sheen can be deadly to seabirds and other marine life that spend time on the surface.

As oil on the surface is agitated by wind and begins to weather, it changes. Within about two weeks it begins to form mousse: a thick, gel-like mixture of oil, air, and water. Media images of birds and other animals covered with mousse and heavy crude oil may leave the impression that this thick oil is the problem following an oil spill.
After spills take place, people often try to clean up, but it is a difficult, challenging, and expensive process. Sometimes the clean-up has unfortunate consequences. For example, the process of using detergents to clean bird feathers may actually damage the feather structure and arrangement, thus threatening the birds’ waterproofing. Birds may also be more susceptible to disease during this time of stress.

## Cleaning Up an Oil Spill

Oil spills can have devastating effects on wildlife and ecosystems as well as people. There is much debate about whether it is cost effective and humane to clean and rehabilitate individual animals after an oil spill. Other options include leaving animals to fend for themselves in their natural environment or euthanizing animals that are too injured to survive.

Many different clean-up techniques were used following the Exxon Valdez Oil Spill. Below a brief description of each technique is given. There are basically five ways to actively clean up oil spills: mechanical containment & recovery, application of dispersants, shoreline clean-up, active bioremediation, and in-situ burning of oil. Another response, not always recognized, is “no response.” After the Exxon Valdez Oil Spill, NOAA studied sites that were not actively cleaned up and documented considerable survival and recovery of marine life.

**Mechanical skimming** of oil is considered the response method least harmful to the environment, but it requires large quantities of equipment and personnel, as well as fair weather. It is a multistage process – first you need to contain the oil, then you need to recover the oil, next you need to temporarily store and transport the oil, remove the water from the oil, and finally dispose of the oil. In each stage the oil is handled, so special safety equipment and training is needed. The process is time-consuming and can bottleneck at any stage, breaking down the system. Equipment used can include skimmers, booms, suctioning devices, and buckets.

**Chemical dispersants** are used to break oil into small droplets in the upper part of the water column. They cause a chemical change to occur in the oil that allows it to disperse into the water column. This removes oil from the surface, potentially reducing impact on surface-feeding and -breathing animals. However, as the oil disperses through the water column and sea floor, it may increase the impacts on other species. Some of these species, such as small invertebrates and fish may consume or absorb bits of oil and then be consumed by larger predators, increasing the threat of bio-accumulation (toxins being concentrated as you go up the food chain). Some studies show that dispersants speed up natural dispersion, degradation, and evaporation. Other studies show that the dispersants themselves are highly toxic or that a mixture of dispersant and crude oil may be more harmful than crude oil alone. Dispersants may also be ineffective in cold waters. To be effective, dispersants must be applied soon after a spill, since weathered oils are hard to disperse. Mixing energy from wind and waves is also needed. Pre-approval is required from the government before dispersants can be applied on a spill.

**Shoreline clean-up** involves the physical removal of oil from beaches. This is the most labor and equipment intensive response method. Techniques must be chosen carefully. Removal of oiled
sediments and biotic materials can sometimes create environmental problems such as beach erosion. Pressurized hot water used to wash oil off of rocks can kill intertidal invertebrates. Running heavy equipment on shorelines can sometimes do more damage than the oil. A variety of shoreline clean-up methods are available. The one(s) used depends on the beach type, location, type of oil, and the equipment and manpower available. Citizen clean-up programs after the Exxon Valdez Oil Spill involved many different shoreline clean-up techniques, such as oiled seaweed pick-up on beaches. Seaweed is a natural oil collector so the more picked up meant less oil spread back out to bays and estuaries. Pom-poms made of oil-absorbent material were also used to pick up oil, and oil-absorbent pads were used to wipe off individual rocks. A rock washing program was developed by tying rocks in special bags where they would be washed by the tidal action of the ocean. Once back in the ocean, the oil can be picked up by mechanical skimming. Bioremediation, the use of fertilizer to increase populations of oil eating bacteria, was also tried.

**Bio-remediation** is the use of bacteria to eat the oil. There are many kinds of bacteria that occur naturally that consume oil to get their nutrients. This response method involves the release of large quantities of bacteria into the oiled area to eat the oil. While a useful tool, this has to be managed carefully and used in moderation to control oxygen depletion. If too many bacteria are added, they will use all the oxygen in the area, leaving none for the other organisms, often resulting in a dead zone, where nothing can live and there is a die-off of animals. This was a common method used in the Gulf of Mexico after the Deepwater Horizon spill.

**In-situ burning** is the technique of burning the spilled oil. It creates a temporary air pollution problem that may pose a risk to people and animals exposed to the smoke. Unwanted fires can also happen, and controversy exists about this method’s effectiveness and hazards. Burning works best on fresh oil within the first 24-48 hours. Specialized equipment and trained personnel are necessary.

Many people and agencies participate when an oil spill occurs in Alaska, including the Coast Guard, the local Regional Citizen’s Advisory Council (if there is one), the Alaska Department of Environmental Conservation, local fishermen, wildlife biologists, and many trained volunteers. While it is beneficial to have a large pool of people-power and variety of expertise, coordinating a response between multiple agencies and volunteers is extremely challenging. This activities illustrates some of the challenges that arise when trying to contain and cleanup oil in coastal areas.

**Priorities for Protection**

One of the most challenging aspects of oil spill response is that there are limited resources and people-power to contain and clean a spill. Rarely can all areas be protected -- instead members of the incident response team must make decisions that prioritize center areas over others. To help with this process, many areas have existing maps that highlight sites that are especially vulnerable or have extraordinary ecological, economic, or cultural importance. Geographic Response Strategies have been developed for much of Alaska to identify these areas, with input from local communities.

You can view or print out the Geographic Response Strategies maps for your area from [http://www.](http://www.)
Creation of Geographic Response Strategies for coastal Alaska is still underway. Most coastal zones of Alaska have at least some GRS sites identified, with the exception of the North Slope. Interior Alaska is also not included. If GRS maps have not yet been developed for your local area, NOAA’s Environmental Sensitivity Indexes (http://response.restoration.noaa.gov/esi) may be used instead. ESIs can also be accessed through ShoreZone (http://mapping.alaskafisheries.noaa.gov/szflex/), which will allow students to see photos of the coastal areas.

A Bit More About Oil

There are two theories about the origin of oil:

1. It formed when the planet was formed from elemental atoms under conditions of immense heat and pressure in the lower layers of earth’s crust. Problem: This theory has no proof, because the process could never be replicated in laboratory experiments!

2. It is the result from large deposits of organic matter (mostly plankton) millions of years ago, which was trapped without oxygen or bacteria and under great pressure and heat turned into oil.

The latter theory is generally well-accepted and is described in more detail here.

In addition to all the familiar animals in our oceans and lakes, there are billions of tiny one-celled animals and plants called plankton. In each miniscule body there are minute droplets of fats and oils (hydrocarbons). After dying, these bodies sink down to the bottom of the ocean. Over the centuries they pile up as layers of mud and ooze. During the rock-forming process these layers are squeezed, which forces the drops of oil to move with the water in the sediment. The water and oil move upward to the high points in the layers, where there is a cap rock that halts further passage. It is here that the oil and water separate and the oil nestsles in the tiny pores of the rock above the water. Gas usually accompanies the oil and can be found in the spaces in the rock above the oil. An oil field consists of sedimentary rock which is saturated with gas at the top, oil in the middle, and water below.

Crude petroleum is an exceedingly complex mixture consisting primarily of saturated hydrocarbons of the paraffin or methane series. The separation of components from such a mixture by the process of fractional distillation depends upon the fact that the compounds present in crude petroleum boil at different temperatures (have different boiling points, BP). Such a distillation is not efficient enough to permit the separation of individual pure compounds but yields “fractions” or mixtures of compounds having similar boiling temperatures. In an oil refinery, the crude oil is heated to different temperatures and the vapors are piped into a tall refinery tower where they cool and condense at different levels. Once they have been distilled into fractions, they are distilled further if necessary. Beyond fuel and lubricating oils, petroleum is also used in the production of plastics. More about this process is described in the section on polymers and plastics.
The viscosity of various petroleum products plays an important role in both the potential uses of that product and its behavior in the environment. Viscosity is defined as the property of resistance to flow in a fluid or semi-fluid; it is the “thickness” of a liquid, or the opposite of “runniness.” Molasses has a higher viscosity than water. In lubricating oils, the oil must be just the right viscosity – thin enough to fit between metal parts and yet thick enough to adhere to the parts.

NOTE: Because oil is a toxic substance, it is very important that activities involving motor or crude oil take place in a well-ventilated area and students wear gloves when handling the oil. If students are to smell the oil, only allow them to open the cap of the container briefly for a small whiff of the oil. Be sure to dispose of oil, oily water, and oiled gloves properly at the end of activities. Contact your local waste management program or harbor master for more details on how to dispose of oil.
Unit 1:

Marine Organisms & Ecosystems

Essential Questions:
How do biological processes influence human effects on marine ecosystems?
How can people study coasts and the ocean?

Enduring Understandings:
- Plants and animals can be sorted into groups and counted based on different characteristics.
- Coastal ecosystems provide a window to the ocean for study and understanding.
- Watersheds, rivers, wetlands, and the one big ocean of the world are an interconnected system.
- An ecosystem is a community of living things with its physical environment, functioning as a unit.
- Organisms in marine environments interact with one another and are interdependent in many ways.
- Harm to one species can affect the entire food web.
- Biological processes can magnify the impacts of human effects.

Lessons in this unit:
- Invent an Invert
- Fab Four Phyla
- Intertidal Zonation Demonstration
- Plankton Studies
- Plankton Races
- Marine Mammals
- Other Resources:
  - Rock Fish & Reefs: [http://www.handsontheland.org/cacs/](http://www.handsontheland.org/cacs/)
The Fab Four Phyla

Objective:
To become familiar with the four most abundant marine invertebrate phyla that can be observed on field trips and to understand the defining characteristics of each.

Concept:
By understanding the defining characteristics of each phylum, or animal division, to be monitored, students will be able to identify intertidal organisms and make assumptions about where to find these animals in the tidal zone. They will have the tools for formulating inquiries about the organism’s abundance at the site and assessing potential impacts to the species being monitored.

Materials:
- Science notebooks
- Pencils
- PBFS Field Atlas Pages for Fab 4 Phyla (1 animal for each student)
- Handout: Fab Four Information Sheet
- Costume materials and props (fabric, pipe cleaners/yarn/feathers for stinging tentacles, pinchers or tongs for claws, hard materials for shells, straws for siphons, etc.)

Procedures:
Make copies of the Fab Four Information Sheet for students. Access the PBFS Field Atlas and print out sheets so that you have 1 animal for each student, choosing animals that belong to the Fab Four Phyl (Cnidarian, Mollusk, Echinoderm, and Arthropod). The Field Atlas can be found here: http://www.akcoastalstudies.org/data/attachments/Intertidal_Field_Atlas.pdf

Introduction:
Begin by asking students what an invertebrate is and what the word means. Explain that most of the animals students will be seeing are intertidal organisms that live between the high and low tide zones.

Ask students to brainstorm animals without backbones that they have seen living on the beach.

Then introduce the fab four phyla as the most common groups of invertebrate animals that live between the tides.

Procedures & Activities:
Have students divide their journal page or piece of paper into fourths and label each box with a phylum from the fab four: Cnidarians, Molluscs, Echinoderms, and Arthropods. As a class, students should fill in the four boxes with their characteristics and small drawings of examples of animals within the phylum. (See next page for example.) Then reinforce knowledge with one or more of the following activities:

Intertidal Party Mixed-Pair Share
Pass out PBFS Atlas animal cards. Students read their card and become this organism. They will need to know: what they eat, what they do to defend themselves from predators, who their predators are, how they avoid drying out, and which of the fab four phyla they are in.

Then explain that the class is going to have an intertidal party and model what conversations at the party might look like.
The Fab Four Phyla Continued

When the educator says "MINGLE," everyone wanders around the classroom until the educator says "PAIR." At this point, the intertidal animals find the nearest organism and meet them. The taller animal will introduce themselves first by telling the other organism all about themselves and acting in character. Then the other animal will introduce themselves. Partners will figure out what they have in common and how they are different. Are they in the same phylum? Organisms should beware if they find themselves paired with a predator!

Ask for two or three students to share with the group what they learned about the intertidal invertebrate they met at the party. If time, mix, pair, and share again.

Fab Four Fashion Show
Take four volunteers and dress them in invertebrate costumes. Use classroom materials and encourage students to use acting to demonstrate their organism. For example, a student moving with clearly jointed legs and a hard "exoskeleton" of tote lids might be representing Arthropods. Students enter classroom one at a time. Other students must guess which of the fab four phyla the student is dressed as, and explain how they knew that based on the characteristics of the animal.

Tidepool Shuffle:
Work together as a class to create four unique dance moves, each representing one of the fab four. Designate one side of the classroom as "high tide" and one area as "low tide." When the educator shouts out the name of a phylum, the students all must do that dance move until the next direction is called. If the educator shouts out "high tide" or "low tide" students must move to the designated area of the classroom. You can begin elimination after a few practice rounds; students that do the wrong dance move or don’t go to the right tidal area are out. However, provide opportunities every once in a while for the students who are out to get back in by answering a question about one of the fab four phyla. Last student dancing wins.

Wrap-up:
Give students an opportunity to ask questions about the Fab Four and discuss some of the “exceptional” animals that are hard to place in a phylum, such as barnacles (Arthropods) and octopus (Molluscs).

Extensions & Lesson Connections:
Have students use field guides or the PBFS Field Atlas to research their organism and complete the "Search for Answers: Marine Invertebrate Research" worksheet or "Six-sided Cube Display." Templates can be found on the following pages.

Pair this lesson with "Invent an Invert" and assign each work group a phylum that their invented invert must belong to.

Evaluation:
Review student notebooks for complete and neat descriptions of the phyla, along with example drawings.
**Phylum Mollusca** *(soft)*
- Muscular foot used for locomotion
- Mantle that usually secretes an internal or external shell
- Soft-bodied
- varied feeding methods
  - filter feeders
  - grazers
  - predators
- grazers and predators have a radula: a file-like organ used for scraping, grasping, biting, drilling and tearing

Some members of this phylum include:
- **Bivalves**: clams, cockles & mussels
- **Polyplacophores**: Chitons
- **Gastropods**: snails (periwinkles, Hairy triton, moon snail), limpets & nudibranchs
- **Cephalopods**: octopus

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**Phylum Arthropoda** *("jointed foot")*
- Incredibly large diverse group
- Bilaterally symmetrical
- Animals with jointed legs
- Exoskeleton
- Generally grow by molting exoskeleton

**Class Crustacea** *("a crust")*
- Head bears 5 pairs of appendages
- 2 pairs of antennae
- Pair of compound eyes
- Respire through gills

Some members of this phylum include:
- barnacles
- shrimp
- crabs

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**Fab Four Information Sheet**
Phylum Echinodermata ("spine skin")
- 5-pointed (pentameral) radial symmetry
- Unique water vascular system which allows for movement of "tube feet"
- Calcareous skeletal structures which makes endoskeleton

Some members of this phylum include:
- sea stars
- sea urchins
- sea cucumbers

Phylum Cnidaria ("stinging thread")
- Animals with stinging cells (nematocysts) used for protection and predation
- Radial symmetry
- Single sac-like body space (coelenteron) used for gas exchange and digestion (mouth and digestive cavity)
- Primarily carnivorous
- Two body forms: polyp & medusa
- Hydrostatic skeletons

Some members of this phylum include:
- sea anemones
- sea jellies
- corals
Search for Answers

Marine Invertebrate Research

Name of your marine invertebrate: ________________________________

Scientific Name: ________________________________

Organism's Phyla: ________________________________

Describe your organism's habitat: ________________________________

Low tide survival adaptations: ________________________________

High tide survival adaptations: ________________________________

What does your organism eat? ________________________________

Does your organism have any predators? ________________________________

Is this organism abundant on your beach? ________________________________

How does your organism reproduce? ________________________________

How does your organism move? ________________________________

Does your organism have a larval stage? If so, what does it look like? ________________________________

Gee Whiz Fact 1: ________________________________

Gee Whiz Fact 2: ________________________________

How is your organism used by humans? ________________________________

Share your favorite intertidal recipe: ________________________________
Intertidal Zonation Demonstration

Objective:
Students will learn to identify the different tidal zones. They will understand how physical and biological stressors determine which zones organisms inhabit and their adaptations.

Concept:
The adaptations and habitat preferences of various organisms are shaped by physical and biological factors. The tidal cycle is a prominent physical factor in the intertidal zone.

Materials:
- Science notebooks
- Pencils
- Spray bottle or bowl of water
- Clean water
- Whiteboard
- Whiteboard markers

Introduction:
Begin by drawing a quick sketch of an intertidal profile on the board, from splash zone to subtidal and explain to students that different zones are exposed at different tides. You may also want to spend a bit of time explaining how tides work and/or reviewing a tide book.

Activities and Procedures:
Choose five students of the greatest height range possible within the group and line them up in front of the class from tallest to shortest. Describe what the intertidal zone is and what it means.

Start with the splash zone. Describe that the splash zone receives very little salt water and only at the highest tides. Give the tallest student a light misting with the spray bottle.

Ask the student if they can tell you what organisms they might expect to find in the splash zone. Write or draw those organisms on the board in the splash zone.

Move on to the high tide zone. Give that student two sprays and explain that the high tide zone is exposed to air for longer periods of time than it is covered in water.

Ask students to tell you what might be found here. Describe that animals here need adaptations for dealing with desiccation (e.g. hard shells). Review splash zone and high tide zone by giving more sprays to the students.

Move to mid tide zone. Describe how the mid tide zone is under water half of the time, exposed to air half the time. Give student some sprays.

Ask what might be found here and why (animals with somewhat softer bodies). Review all zones, and spray as you go.

Move to the low-tide zone and describe. Ask if animals in the high tide zone could also live in the low tide zone. Explain that they would be quickly consumed by the numerous predators that can only live in the low tide zone. Review all zones.

Now comes the sub-tidal zone, so move to the last student. Dramatically unscrew the cap of the bottle as if you are going to dump the whole thing on the student. Describe the sub-tidal zone and ask what lives here. Conclude by stating the sub-tidal zone is always ‘under water’ as you hold the un-lidded bottle over the final student’s head.
Intertidal Zonation Demonstration Continued

Wrap-up:

Review the animals you have drawn on the board, and other organisms you have seen during intertidal explorations. Discuss other challenging factors that intertidal organisms must deal with. Ask students to reflect in their science notebooks about what zone they would want to inhabit as an intertidal invertebrate and why. They should consider both physical (exposure to air, temperature, wave action, etc.) as well as biologic (predation, competition, availability of prey, symbiotic relationships, etc.) factors in the zone.

Extensions and Lesson Connections:

Pair this activity with the "Invent an Invertebrate" lesson to reinforce learning and give students an opportunity to apply their understanding of the challenges animals face in different intertidal zones.

Evaluation:

This is a fairly short and simple activity. Observe student engagement and participation during the demonstration, and review written reflection in science notebooks.
Invent an Invert

**Objective:**
Students will design and create an animal that has the special adaptations necessary to survive the demands posed by its intertidal habitat.

**Concept:**
Students will review intertidal invertebrate adaptations in a fun and creative way.

**Materials:**
- Science Notebooks
- Pencils
- Miscellaneous props, art supplies, or recycled materials
- Markers or colored pencils

**Preparation:**
Decide whether students will be creating the creature using the props provided to build a sculpture or model as an arts and crafts activity or if they will be dressing up a member of the group as the organism as a fashion show. Assemble the necessary materials for your choice of activity. Art supplies and recycled materials work very well for building sculptures. Pieces of fabric, rope, bungee cords, belts, utensils, tools, helmets, knee pads, hats, gloves, or whatever other odd things you can find work great for the fashion show.

**Introduction:**
Have the class brainstorm a list of the challenges an organism faces living in a coastal habitat.

You may want to distinguish between challenges faced in any coastal habitat and challenges unique to specific habitats. For example "avoiding being eaten" is general to all habitats, but "avoiding being washed away by waves" is more specific to rock and sand coast habitats.

This is a great time to brainstorm and review some of the real-life adaptations students have researched in class or observed in the intertidal zone.

**Procedures & Activities:**
Using the list of challenges you have compiled on the board, choose 3-8 challenges that each invented invertebrates will have to address through adaptations (avoiding predation, getting food, staying wet, large waves, etc.).

Break students into groups of 3-6 people.

Challenge students to work with the materials provided to design and construct a never-before-seen animal that is adapted to the conditions and challenges of a specific coastal habitat recently visited (sandy, rocky, salt marsh, or tidal mud-flat).

If you have chosen the fashion show option, explain to students that they should use the materials to dress up one of their team members as the unique invertebrate.

Instruct students to also provide a name for their invertebrate.

Once the invertebrate is invented, students should sketch their invertebrate in their science notebooks, labeling the specific adaptations and the challenge(s) they address. (Even if a team member will be playing the invertebrate, that student should return to human form to do this work.)
Instruct groups that they will be presenting their organism to the class. Each member of the group needs to participate in the presentation, whether it be as part of the demonstration or speaking.

The presentations must include the animal's name, preferred habitat, and adaptations to the intertidal zone.

Wrap-up:

Discuss why adaptations are important and how animals use adaptations. Ask each group to share how they decided what adaptations to give their new organism and the factors that were considered.

Extensions & Lesson Connections:

Pair this activity with the "Fab Four Phyla" lesson. Assign each group a phylum that their creature must belong to.

Evaluation:

Observe student participation and cooperation in group work and presentation of the invertebrate. Evaluate notebook sketches and presentation for understanding of the underlying concepts of challenges and adaptations.
Plankton Studies

Objective:
While examining ocean caught plankton under microscope, the students will be able to chart the seasonal development of larval invertebrates and monitor for potentially harmful phytoplankton.

Concept:
Students will gain understanding of the presence, diversity, and importance of marine plankton.

Materials:
- Net(s) for plankton tow
- Containers for samples
- Phyto- and Zoo-plankton ID guides
- Dissecting microscopes
- Compound microscopes
- Microscope slides
- Dissecting microscopes
- Slide covers
- Petri dishes
- Pipettes/eye-droppers
- Lens papers (for cleaning)
- Freshwater (for cleaning)
- Cloth rag or paper towels (for cleaning)

Preparation:
Prepare microscopes and materials for use. Arrange for a class trip to the coast to tow for plankton, or obtain a sample ahead of time.

Print out Phytoplankton and Zooplankton ID Guides from the Kachemak Bay Research Reserve: http://www.adfg.alaska.gov/index.cfm?adfg=kbrr_educationResources.home

Providing them with specific directions is crucial. Similar expectations should be set for the use of the plankton nets, which can be torn easily on rocks if not properly used.

Introduction:
Gather plankton net, sample containers, and students.

Ask students what they know about plankton, phytoplankton, and zooplankton.

Discuss their answers and possible misconceptions. Emphasize that plankton is a "lifestyle" of drifting and that not all plankton are microscopic. Being planktonic simply means unable to move horizontally against the currents and tides. Many planktonic organisms can move vertically throughout the water column, and even have some horizontal mobility, but they are still transported primarily by the tides and currents. Give examples like jellies and sunfish/mola mola. A great analogy to use is traveling on a plane or train: you can move around in the aisle, but you are going to end up wherever the plane is going. Similarly, plankton can move around in a section of water, but they are going to end up wherever that water is carried by the currents and tides.

Procedures & Activities:
Decide as a group where to conduct the plankton tow. You may wish to collect samples at various sites. If you do, carefully label the containers with location.

To collect a plankton sample, carefully lower the net into the water until it is just below the surface. It is important that the “cod-end” or small bottle at the end of the net fills with water rather
Plankton Studies Continued

than air. If it is floating, pick up the net until the cod-end fills with water.

Once the cod-end and net are submerged, move the net pole gently in a horizontal direction.

After a few moments, switch and go back the other direction. The goal with the movement is to keep the net just below the surface – too slow and the net sinks down where it can get caught on rocks, too fast and it will come above the water where you won’t find any plankton (but probably a good number of small insects).

Have students carefully take turns with the plankton net, making sure to keep it moving so the net does not sink.

If you are collecting samples at multiple locations, make sure the duration and speed of the collection is consistent between locations.

When the sample has been collected, bring the net out of the water. Fill the empty container with salt water and use it to rinse the insides of the net down into the cod-end.

Reach inside the net and carefully pull the cod-end up, emptying it into the empty container. Repeat this same process in different containers for any additional locations.

Return to the microscope lab. Demonstrate the proper use of both dissecting and compound microscopes and show students how to create a slide for viewing. Divide students into groups based on the number of microscopes available.

Assign each group to begin at either a dissecting or compound microscope and provide each group with a petri dish full of plankton sample. Groups at dissecting scopes are working to identify zooplankton, including invertebrate larvae, by using a pipette to transfer moving organisms from the sample to a clean petri dish or cavity slide.

Using the dissecting scope (and ID Guide), their goal is to identify as many zooplankton organisms from their sample as they can find.

They should sketch and record the names of these organisms in their science notebooks.

Meanwhile, students at compound scopes will examine a few drops of the plankton sample at higher magnification to identify phytoplankton.

Have students record their finds in their science notebooks with a sketch and scientific name of the organism.

Take breaks for the large group to discuss and view examples of invertebrate larvae or potentially harmful phytoplankton that are identified.

After approximately 10 minutes, have groups switch so that those identifying phytoplankton are now working on zooplankton and vice versa.

Wrap-up:

Discuss the organisms students identified.

Determine what type of phytoplankton and zooplankton seem to be most prevalent in the sample.

Ask students to discuss why people might be interested in monitoring plankton. Explain that some plankton, like crab larvae, might be monitored because of their importance to subsistence and commercial fisheries.
Other types of plankton can be harmful to human or ecosystem health.

Be sure to record any potentially harmful phytoplankton and explain why this is important. If you see any potentially harmful phytoplankton, contact the Kachemak Bay Research Reserve’s Harmful Algal Bloom Program at (907) 235-6377.

**Extensions & Lesson Connections:**

Compare larval invertebrates discovered as zooplankton with examples of adult organisms. Ask students to identify similarities and differences and discuss why zooplankton might look so different from their adult forms.

Pair this lesson with "Plankton Races" so students can better understand the unique forms and adaptations of plankton.

This lesson also works well as an introduction or follow-up to "Feed the Whales" to help students understand more about the food baleen whales are consuming.

**Evaluation:**

Review science notebooks for thorough, neat, and accurate plankton sketches. Observe student behavior during plankton tow and microscope lab, noting whether or not they follow directions.
Plankton Races

Objective:
Students will understand how the unique structure of plankton allows them to stay near the surface of the ocean, and create their own organisms in the quest for neutral buoyancy.

Concept:
Plankton are a crucial, but often overlooked, component of marine ecosystems. Furthermore, most intertidal invertebrates spend some of their life cycle in a planktonic phase. This activity is an excellent way for students to learn about the unique adaptations of plankton and use their problem-solving skills to create a well-adapted plankter model.

Materials:
- Pictures of Plankton Shapes (or real live plankton from a plankton tow)
- Bits of sponge (no larger than 1 in x 1 in)
- Bits of cork or foam (no larger than 1 in x 1 in)
- Toothpicks
- Metal washers and nuts
- Large tank of water
- Stop Watch

Preparation:
Set the toothpicks, sponge, foam, cork and pieces of metal on the table for students to use. Fill the tank about 2/3 of the way full with lukewarm water and place it on the table.

Introduction:
Begin by introducing the concept of plankton and that plankton is divided into two groups, phytoplankton and zooplankton.

Explain their importance in the ecosystem. As photosynthesizers, phytoplankton need to remain where there is light in the “photic” zone near the top of the water column.

Zooplankton consume phytoplankton or other zooplankton, so they too need to avoid sinking and stay near the water surface.

Have students brainstorm different adaptations types of plankton might have to slow their sinking. Share pictures of phytoplankton and zooplankton, or look at prepared microscope slides to introduce the variety of plankton morphology.

Procedures & Activities:
Explain that students will be creating their own plankton models. Once each group has created a plankter, the models will race in the aquarium. The one that reaches the bottom LAST will be the winner because plankton need to sink as slowly as possible so they can remain in the photic zone.

Break students into groups of 2-4. Provide toothpicks, sponges, cork and metal washers/nuts for students to build their plankton.

Give students 5 minutes to create the organisms. You can decide whether or not to let them test their models in the aquarium before the big race.

Ask student to sketch their models in their science notebooks and write the different components they included to achieve neutral buoyancy.
Plankton Races Continued

Have one student from each group explain the adaptations they gave their organism.

Then race the plankton. To do this you can either

1) use a stopwatch to time how long it takes each model to reach the bottom of the aquarium after being released at the surface or

2) release all models at the same time and proclaim the last model to reach the bottom as the winner.

You can repeat the race if there is time.

Wrap-up:

Have the winning team explain the adaptations that allowed their plankter to sink the slowest.

Compare the winning design with pictures of actual plankton and identify similarities. If there is time, provide groups with an additional 5 minutes to adjust their design and perform the race again.

Ask students to respond to the following questions in their science notebooks:
   - What worked well in the plankton design?
   - What could be better in the design?
   - Why is it important for plankton to be neutrally buoyant?

Extensions & Lesson Connections:

This activity works very well in conjunction with the “Plankton Studies” lesson.

Evaluation:

Assess student comprehension of neutral buoyancy and problem solving by the success of their plankton. Evaluate notebook sketches and responses for completeness, neatness, and comprehension.
Feed the Whales

Objective:
Students will compare sizes of marine mammals in Alaska waters. Students will learn to identify the different baleen whale feeding mechanisms. They will understand how these different feeding mechanisms are adaptations for feeding on specific food sources within the marine environment.

Concept:
Marine mammals are a specialized group. Many marine mammals are predatory, with large teeth and jaws to catch fast-swimming prey. However, baleen whales have adopted specific filter feeding behaviors to select small planktonic prey. While these whales select the smallest prey for consumption, they are among the largest animals in the world.

Materials:
- Science notebooks
- Pencils
- Stopwatch
- Tape Measure (50 meters)
- Tape (colorful or masking tape)
- Pepper / short blades of grass/ glitter (represents plankton)
- Round slices of carrot / sliced potatoes/ hard candy (represents fish & other marine mammals)
- Toothbrush/ fine tooth comb/large square paintbrush (represents baleen)
- Chopsticks/ toothed hair clip/ tongs (represents teeth)
- Large clear bin or bowl of water with sand on bottom (one per group)
- Handout: Marine Mammal Lengths
- Pictures of baleen and whale teeth

Preparation:
Fill a clear bin or large bowl with water for each group of students. Add “plankton” and “fish” to the water. Set out feeding options, one “baleen” and one “toothed jaw” for each group.

Introduction:
Begin by introducing marine mammals, identifying that although these mammals live in the marine environment they share some of the same characteristics of terrestrial mammals.

Marine mammals breath air through lungs, are warm blooded, have hair (at some point in their lives), give live birth to their young, and provide milk for their young through mammary glands.

Next provide the students with a marine mammal guide or the marine mammal handout provided.

Help the students to measure the length of three or four of the marine mammals on the ground (it is recommended to use a sea otter and a blue whale and two others).

Have the students place three to four piece of tape on one wall of the gym or end of the play ground. Place the tape about 3-4 feet apart. Have a student label each tape with the marine mammal name and length.

Help the students to measure each marine mammal with the measuring tape, and place a piece of tape at the end of the length.

Have students lay down, head to toe for each marine mammal, measuring the number of students in each animal.
Activities and Procedures:

Back in the classroom, provide the students with the handout entitled “Feed the Whale.” These are pictures of the two types of whales (Cetacea), baleen whales (Mysticeti), and toothed whales (Odonotoceti), and their food preferences.

Discuss the different feeding method of the two types of whales.

Split the class into groups of 3-5. Have the students observe the “food” available in their “ocean” in the bowl. Have them also observe the available feeding apparatus.

Ask the students to discuss and predict within their group which feeding apparatus will pick up which type of food, and which will pick up the most pieces of food in a 5 minute period of time. Have the students write their predictions in their science notebooks.

Next, have the students create a chart to keep track of the type and amount of food they collect with the two types of feeding apparatus.

Time the students as they collect food from their “ocean” bowls. Give the students 5 minutes to collect food with each apparatus.

Have the students record which type of food was most easily picked up by each apparatus. Have the students count and record the individual pieces of food picked up by each apparatus. Have the groups share their results with the rest of the class. Where the results similar in all the groups?

Finally, have the students in their groups match the apparatus and food type with the type of whale that uses that feeding apparatus and targets that type of food.

Baleen whale represented by the toothbrush/comb/paintbrush eat small plankton which get stuck in their hair-like baleen. Toothed whales select each prey item and hunt it, clamping or chomping it with its sharp teeth and strong jaws (hair clip/chopsticks/tongs).

Wrap-up:

Review the difference between the two types of whales, and their feeding apparatuses and behavior. Have the students reflect in their science notebooks about the difference in size between those whales with baleen and those whales with true teeth. Have them consider and hypothesize why baleen whales are generally larger than toothed whales and eat some of the smallest animals in the ocean (krill).

Extensions & Lesson Connections:

For an extension consider inviting an Elder in the community into the classroom to discuss the traditional use of marine mammals in your area. Here is a guide to inviting Elders to participate in your classroom: http://www.ankn.uaf.edu/publications/handbook/littlefield.html.

Evaluation:

Observe student engagement and participation during the both the class activity in measuring the length of marine mammals, and the group activity on whale feeding. Also review whale feeding charts and written reflection in science notebooks.
Unit 2: Introductions to Oceanography

Essential Questions:
How do physical processes influence human effects on marine ecosystems?

Enduring Understandings:

- Watersheds, rivers, wetlands, and the one big ocean of the world are an interconnected system.
- Climate patterns cause physical changes in the environment.
- Physical changes in the environment can challenge the conditions for life.
- Marine ecosystems are dynamic, with physical changes occurring on a daily, seasonal, and long-term basis.
- Weather systems and ocean systems have major influences on each other and the transport of solids and liquids in the ocean.

Lessons in this unit:

- Popcorn Spill
- Density Differences: Air
- Density Differences: Water
- Currents & Coriolis
- Predicting the Path of Marine Debris – Katie
- Pressure & Storms
- Geology & Plate Tectonics
- Tsunami Simulations
Density Differences: Air

Objectives:
Students will understand that air has different densities at different temperatures. They will recognize that these density differences drive global and local patterns of air movement as wind.

Concept:
Temperature-dependent gradients of density drive the movement of air, which in turn creates winds. As hot air or water rises, cool air moves in to fill the space left behind. Marine debris and ocean pollution is transported by both winds and currents.

Materials:
- Science notebooks
- Pencils
- Tape
- Small strips of paper
- 2 or more thermometers
- Computer/laptop and projector or SmartBoard

Preparation:
Identify a door or window to the outside that can be opened and move furniture for easy access to this spot. Set up computer and projector or SmartBoard to show the Majestic Plastic Bag mockumentary (http://www.youtube.com/watch?v=GLgh9h2ePYw).

Introduction:
Begin by showing the "Majestic Plastic Bag" mockumentary on YouTube: http://www.youtube.com/watch?v=GLgh9h2ePYw.

As a group, brainstorm different pathways plastics follow to the ocean.

Have students sketch a quick flow chart of a piece of plastic’s journey to the ocean.

Procedures & Activities:
Explain to students that marine debris is transported by both winds and currents, which are driven by temperature differences in water and air masses. This lesson focuses on air and wind patterns.

Explain to students that hot and cold air have different densities. Because molecules in cold air are less energetic and move more slowly, it is denser than warm air, where molecules are more energetic. The more dense cold air sinks as less dense hot air rises.

Conduct a temperature demonstration by asking for two volunteers.

Crack open a door or large window that leads outside.

Have one volunteer hold a thermometer at the top and another person hold one at the bottom.

Read and record the temperatures. (The top temperature should be higher than the lower temperature.)

Explain that as air warms, it rises. This creates a sort of vacuum below, which is filled by cool air.

Build simple ‘draftometers’ with students by having them tape a small strip of paper hanging vertically from a pencil.
Density Differences: Air Continued

Allow students a few minutes to measure drafts around the classroom and see for themselves how small air masses are flowing throughout the classroom based on differences in temperature and thus density.

If you have extra thermometers, have them measure the temperature in low-lying drafty areas and compare it to the temperature above these drafty areas.

Wrap-Up:

Ask students to revisit the flow chart they created at the beginning of the lesson. Have them identify the different physical factors that affected the transport of their plastic piece to the ocean. These physical factors will include the movement of air as winds, but students should also consider such factors as currents, tides and gravity.

Ask them also to identify three ways that they could interrupt this flow of plastic to the ocean (examples include proper disposal of plastic, recycling, reusable bags, cleaning up litter, filtering technology, etc.).

Extensions & Lesson Connections:

This activity is designed to be followed by the “Density Differences: Water” lesson. The “Currents & Coriolis” and “Predicting the Path of Marine Debris” lessons are also excellent lessons to pair it with for slightly older classes.

Evaluation:

The initial flow charts serve as a pre-assessment, while the revised flow charts should illustrate student understanding of how wind drives the movement of marine debris. Review the science journals for understanding of basic concepts of density-based movement air and how this concept can be applied to an understanding of wind.
Density Differences: Water

Objectives:
Students will observe that water has different densities, and that this density is affected by both the salinity and temperature of the water. They will understand that these density differences drive global and local patterns of water movement in currents.

Concept:
Temperature- and salinity-dependent gradients of density drive the movement of water. As warm, less salty water rises, cool, saltier water moves in to fill the space left behind. This creates currents in the ocean, which can transport marine debris, organisms, and people across the ocean.

Materials:
- Science notebooks
- Pencils
- Thermometers (1 per group)
- Clear plastic bins or large beakers (1 per group)
- Food coloring (blue, red, and green)
- Reusable cups or small beakers
- Paper or foam cup
- Thumbtack/pushpin
- Hot water (access to faucet or electric kettle)
- Room temperature water
- Ice cubes
- Salt
- Teaspoon
- Stirring stick (1 per group)
- Salinity meter (optional)
- Ground black pepper
- 2 eggs
- Handout: Salinity Layers Lab Instructions
- Handout: Warm & Cold Water Layers Lab Instructions

Preparation:
Prepare materials for the density layers experiments by making sure you have access to hot water and room temperature water. Store the ice cubes in a cold place. Arrange the other materials for groups to use (thermometers, cups or beakers, salt, food coloring, and clear bins/large beakers) on a lab table. Make copies of the handouts “Salinity Layers Lab Instructions” and “Warm and Cold Water Layers Lab Instructions” for each group.

Prepare the egg demonstration at the front of the class. Stir ¼ cup salt into 1 cup room temperature water. Let sit for a few minutes. Meanwhile, fill a different glass or beaker with freshwater.

Introduction:
Begin by introducing the beakers to the class. Do not tell them that one is saltwater and one is freshwater.

Have students hold the eggs to attest that they are approximately the same weight.

Carefully place on egg in the beaker of freshwater (it should sink because the freshwater is less dense than the egg) and carefully place an egg in the beaker of saltwater (it should float because the saltwater is more dense than the egg).

Observe as a class what happens to the eggs when placed in the different beakers of water.
Density Differences: Water **Continued**

Ask students to respond in their science notebooks to the following questions:

- Compare the way the two eggs behave in the water. Describe the differences.
- Why do you think the eggs float differently?
- Based on what happened with the eggs, which beaker contains denser water?
- Why do you think this water is more dense? What could affect the density of water?

**Procedures & Activities:**

Discuss the observations of the egg model with the class, but don’t reveal the characteristics of the water yet.

Explain that temperature and salinity affect the density, or weight per certain volume, of the water. Things that are less dense float, while things that are more dense sink.

Ask students to predict which is more dense: cold or hot water.

Break students into groups of 3-5. Pass out the "Salinity Layers Lab Instructions" to each group and explain where they can find the materials.

Instruct students to conduct the first experiment, which will focus on salinity. Which is denser salty water or freshwater? Have students write a hypothesis in their science notebooks about what will happen when salty water and fresh water are poured into the same tub.

If you have a salinity meter, instruct students to test the salinity of the salty water and fresh water. *(The tap water should have a salinity of about 0 parts per thousand, whereas the salty water should have a higher salinity. When the salty water is poured into the tub, it should sink below the fresh water.)*

Discuss the results of this experiment. When freshwater from rivers meets the saltwater of the ocean, what will happen to the freshwater? What if the freshwater is very cold because it is from a glacial river and the saltwater is warm?

Introduce the second experiment by asking students, which is more dense: warm water or cold water? If they have completed the “Density Differences: Air” lesson, students should be able to figure this out pretty quickly.

Ask students to make a hypothesis in their science notebooks about what will happen when cold water and hot water are put in the same tub with the room temperature water.

Pass the "Warm & Cold Water Layers Lab Instructions" out to each group and instruct them to conduct the experiment.

Ask students to write the results of the experiment in their science notebooks. *(If the experiment is done correctly, the cold, blue water will sink below the room temperature water. The hot, red water should form a layer on top of the room temperature water.)*

Discuss the results of this experiment. Ask students to think about what will happen when cold or salty water sinks in the ocean. What will fill in the empty space? *(Warmer or fresher water will fill in the space, and as the water moves, a current is formed.)*

Gather students around a table to demonstrate a current model to the whole class.
Density Differences: Water Continued

Set up a bin filled with 3 inches of room temperature water where everyone can see it.

Pour 3 inches of hot water into a paper or foam cup. Add 2 drops of red food coloring and stir well. Place a weight such as a marble or rock in the cup. Carefully poke a thumbtack into the cup near the bottom of the cup’s side. Keep the thumbtack in the cup and carefully place it into the water at one end of the bin.

Carefully place ice cubes at the other end of the bin.

When everyone in the class is ready to watch what happens, carefully remove the thumbtack from the cup to let the hot water slowly flow out. Add a few drops of blue food coloring around the ice cubes.

Observe what happens to the water cooling near the ice cubes and the warm water flowing out of the cup. (The cold blue water from the ice cubes should sink, while the hot red water should rise/stay on the surface and move towards the ice cubes to fill in the void left by the sinking cold water. When it reaches the ice cubes, the red hot water will cool and eventually sink.) You’ve formed a current!

Sprinkle a few pieces of black pepper onto the current to see how plankton or marine debris can transported in the ocean by currents.

Wrap-Up:

Ask students to respond to the following questions in their science notebooks:

- How does temperature affect the density of water?
- How does salinity affect the density of water?
- How do differences in temperature and salinity affect ocean currents?
- Choose one of the following things and describe a way it might be affected by ocean currents created by differences in the density of water:
  - Marine debris
  - Plankton
  - Fishing boat
  - Sea Otter
  - Kayaker
  - Sea bird

Extensions & Lesson Connections:

This activity is meant to follow the “Density Differences: Air” lesson and pairs well with the “Currents & Coriolis” and “Predicting the Path of Marine Debris” lessons.

Evaluation:

Review the observations, hypotheses, and experiment results in the science journals for understanding of the basic concepts of density-based movement of water how this concept can be applied to understanding of currents. Assess student responses to the prompts for comprehension and application of the material.
Salinity Layers Lab Instructions

1. Which is denser: salty water or freshwater? Write a hypothesis about what will happen when salty water and fresh water are poured into the same tub.

2. Fill your bin about ¼ full with room temperature tap water.
   
   *If you have a salinity meter, measure and record the salinity of the room temperature tap-water in your science notebook.*

3. Have one person from your group fill a cup or beaker with room temperature tap-water.

4. Stir 2 teaspoons of salt and 2 drops of green food coloring into the cup of tap-water.
   
   *If you have a salinity meter, measure and record the salinity of this water in your science notebook.*

5. Carefully pour this salt water along the edge of the bin into the bin.

6. Record the results of your experiment in your science notebook. Answer the following questions:
   
   - What happened when you added the saltwater?
   - Did the saltwater form a layer?
     - If so, is the layer below or above the freshwater?
   - Which is more dense, saltwater or freshwater?

7. After discussing the results with the rest of your class, empty the bins in the sink and rinse well.
## Warm and Cold Water Layers Lab Instructions

1. Which is denser: warm water or cold water? In your science notebook, write a hypothesis about what will happen when cold water and hot water are poured into the same tub with room temperature water.

2. Have one person in your group fill a bin or large beaker about a quarter of the way full with room temperature water to bring to your table.

3. Use a thermometer to measure and record in your science notebook the temperature of this water.

4. Have one person in your group fill a cup with room temperature water and add five ice cubes and 2 drops of blue food coloring.

5. Bring this cup to your table and record the temperature of the cold water in your science notebook.

6. Then, have one person carefully fill a cup with hot water (from a faucet or electric kettle) and add 2 drops of red food coloring.

7. Use the thermometer to measure and record the temperature of the hot water.

8. Have one person in your group slowly pour the cold water into the tub, pouring along the edge of the plastic tub so it flows more gently into the tub of water.

9. Next, have a different person slowly pour the hot water into the tub, pouring along the plastic edge.

10. Draw the results of the experiment in your science notebook and answer the following questions:

    - What happened to the hot water?
      Did it mix, sink, or form a layer on top?
    - What happened to the cold water?
      Did it mix, sink, or form a layer on top?
    - Which is more dense: hot water or cold water?

11. After discussing the results with the rest of your class, empty the bins in the sink and rinse well.
Currents & Coriolis

Objectives:
Students will understand that density differences drive global and local patterns of wind and water currents. They will recognize how Coriolis effect influences wind and current patterns, and how this can create ocean gyres.

Concept:
Temperature-dependent gradients of density drive the movement of water in currents. As warm water rises, cool water moves in to fill the space left behind. This movement is deflected by the rotation of the earth, called the Coriolis effect. Marine debris is transported by both winds and currents. Debris large and small tends to accumulate in ocean gyres, such as the North Pacific and North Atlantic.

Materials:
- Science notebooks
- Pencils
- Computer/laptop and projector or SmartBoard
- Globe or map of Earth
- Handout: Blank World Map
- Handout: Predominant Surface Currents in the Ocean
- Sphere or cylinder that can be drawn on
- Dry-erase markers

Preparation:
Load NOAA’s Ocean Explorer video on currents: http://oceanexplorer.noaa.gov/edu/learning/player/lesson08.html

Make copies of the world map and "Predominant Surface Currents in the Ocean" hand out for students.

Introduction:
Ask students to consider what direction wind usually comes from in your area. You may find it is easiest to think about winds during a particular season. For example, “What direction does most of the wind come from here in Homer during the summer?”

Designate the North-East-South-West areas of your classroom and also local landmarks (North is where the mountains are, South is where the Bay is) and ask students to move to the area of the classroom where they feel most winds come from locally.

Is there consensus? Based on their knowledge of how cold air moves to fill in areas where hot air rises, why might local wind patterns be like this? Does it make sense? Does it seem like cold air is coming straight toward warmer areas?

Explain that there is a notorious effect at work – the Coriolis effect.

Procedures & Activities:
Introduce a globe or map of the Earth. Ask the class to consider which areas of the earth are warm and cold and what would happen to the air and water in those areas.

Pass the maps with ocean/continent outlines out to students and ask them to mark areas of the globe that are warm and cold.

Then have students draw predicted movement of air and surface water based on their knowledge of how water and air move based on density differences.
Once all students have made their predictions, explain that the warm equatorial water/air rises and moves toward the poles and the cool polar air/water flows along the surface toward the equator.

The zones where warm and cold converge are the areas that create the main currents and winds on earth.

Show students a map of actual currents. Does it match what they predicted?

Explain that the Coriolis effect changes the movement of air and water from what you would expect.

Demonstrate the Coriolis effect by using a cylinder or sphere that can be drawn on with a dry erase marker.

Spin the object and have a student draw a line from the center to the top and then from the center to the bottom. *(The lines should be curved-pointing the same direction.)*

This shows how objects moving across the rotating earth are deflected by the rotation of the Earth. This is called the Coriolis effect, and deflects winds to the right of their path in the northern hemisphere and to the left of their path in the southern hemisphere.

The Coriolis effect becomes even more apparent when winds affect surface currents. The winds, which have already been deflected to the right by the Coriolis effect, start moving water in one direction, but this movement is deflected too!

Show NOAA’s Ocean Explorer video about Currents: http://oceanexplorer.noaa.gov/edu/learning/player/lesson08.html. This provides an excellent overview of what drives surface currents and the effects of Coriolis on surface currents. The last few minutes are about deepwater ocean circulation, so you may choose to skip them.

**Wrap-Up:**

Ask students to take the Coriolis effect into consideration and redraw their surface current map.

Provide them with a copy of the “Predominant Surface Currents in the Ocean” handout. And as them to describe how their redrawn map compare to oceanographers’ observations of predominant surface currents.

Explain that these general current and weather patterns are changed by phenomenon such as El Nino and La Nina.

When this happens, changes in sea surface temperatures along the equatorial Pacific shift currents, winds, and weather patterns.

Ask students to explain why changes in the surface temperature of the ocean would affect currents, winds, and weather.
Extensions & Lesson Connections:


Or use the El Nino activities that accompany the Ocean Explorer Currents video: [http://oceanexplorer.noaa.gov/edu/learning/player/lesson08/l8la1.htm](http://oceanexplorer.noaa.gov/edu/learning/player/lesson08/l8la1.htm).

As an extension, test students’ ability to apply the Coriolis effect to important decisions by using the basic flight plan simulator: [http://oceanexplorer.noaa.gov/edu/learning/player/lesson08/l8ex1.htm](http://oceanexplorer.noaa.gov/edu/learning/player/lesson08/l8ex1.htm). In this simple animation, students are pilots and must decide how to correct for the Coriolis effect to land successfully on an aircraft carrier.

This lesson can be followed by “Predicting the Paths of Marine Debris.”

Evaluation:

The initial map predictions serve as a pre-assessment, while the revised maps should illustrate student understanding of how the Coriolis effect deflects winds and currents.
Note: No one can predict exactly what the surface currents will do at any one time. Some surface currents shift seasonally, and others change even more frequently due to a variety of factors such as local winds and water temperatures. This image represents the best effort of oceanographers to show general trends in surface currents that have been observed over time.
Predicting the Path of Marine Debris

Objectives:
Students will understand that air and water have different densities at different temperatures and that these density differences drive global and local patterns of air and water movement in wind and currents. They will recognize how Coriolis effect influences wind and current patterns, and how this can create ocean gyres. They will create a flow-chart of plastic movement to the ocean, detailing how physical factors power this movement and how people can stop it.

Concept:
Temperature-dependent gradients of density drive the movement of air and water in winds and currents. As hot air or water rises, cool air or water moves in to fill the space left behind. This movement is deflected by the rotation of the earth, called the Coriolis effect. Marine debris is transported by both winds and currents. Debris large and small tends to accumulate in ocean gyres, such as the North Pacific and North Atlantic.

Materials:
- Science notebooks
- Pencils
- Computer/laptop and projector or SmartBoard
- Handout: Blank Map
- Handout: Predominant Surface Currents in the Ocean
- Handout: Science from Bath Toys

Preparation:

Research to find out if there is local drift card information available for your area.

Print 1 copy of the Science from Bath Toys story to read as the teacher.

Students can use their maps from the Currents and Coriolis lesson. If you haven’t done that lesson, make enough copies of the Blank Map and Predominant Surface Currents in the Ocean handouts for each student.

Introduction:
Begin by showing the “Majestic Plastic Bag” mockumentary on YouTube: http://www.youtube.com/watch?v=GLgh9h2ePYw).

At the conclusion of the video, ask students to write their reaction in their science journal.

As a group, brainstorm different pathways plastics follow to the ocean.

Have students sketch a quick flow chart of a piece of plastic’s journey to the ocean.

Procedures & Activities:
Explain to students that marine debris is transported by winds and currents, which are driven by temperature differences in water and air masses.

Discuss the transport of plastic and floating debris across the globe’s ocean. Explain that there is really only one ocean, and water moves around it in surface and deep ocean currents.
Predicting the Path of Marine Debris Continued

As currents are deflected to the right by the Coriolis effect (or to the left in the southern hemisphere), this creates a circular pattern. Water tends to ‘pile up’ within these circular currents, called gyres.

Currents concentrate marine debris in these gyres, creating what are sometimes referred to as ‘ocean garbage patches’. These garbage patches are dynamic, shifting with the winds and the currents. The map below demonstrates where some of these 'garbage patches' are located. Map from the NOAA Marine Debris Program.

Use the Global Science Investigator to demonstrate the path of drifter buoys into the North Pacific Gyre: [http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris](http://www.csc.noaa.gov/psc/dataviewer/#view=mdebris).

Pass out Blank Maps to students or have students use their Surface Current Map from the Currents & Coriolis Lesson. Work as a class to label the continents and ocean basins.

If you are using a blank map, provide a copy of the Predominant Surface Currents in the Ocean handout to students and have them transfer the currents onto their map.
Predicting the Path of Marine Debris Continued

Explain to students that one well-known container ship spill helped people to better understand currents and gyres.

“Friendly Floatees” bath toys were being shipped across the Pacific Ocean to be sold by The First Years, Inc. In early winter, 1992 a container filled with the toys (as well as 11 containers filled with other products) were lost overboard in the middle of the Pacific Ocean.

Tell students that, as you read the story, they should mark on the map the locations where the floatees made landfall, noting the year(s) they arrived there.

Read students the story of Science from Bath Toys.

Ask students to use their knowledge of currents and the information from the story to identify currents that might have transported the floatees. Can they figure out how the floatees ended up on those beaches? Are any of the floatee landfall locations surprising?

Finally, load the Ocean Surface Current Simulator (OSCURS): http://las.pfeg.noaa.gov/oscurs/.

Use OSCURS to predict the path of marine debris:

Drag the red balloon marker to choose the starting point. You may also input latitude & longitude information below the map. You can zoom in closer to Alaska.

Choose a time period for the simulator to run. Input this information below the map. The simulator can be used for time periods as far back as 1967, but it is best to use a duration of run less than a year. (May 1967-May 1968, for example, or June 2013-January 2014). Time spans longer than a year can be too much for the simulator to process.

On the left side of the map, click “Run Model” and see the predicted track for the debris.

Below “Run Model” you can change the color of the track so it is easier to view different runs. You can also change the “Optional Parameters.” The simplest parameter to adjust is the “wind current speed coefficient.” This refers to how much of the object sits above the water and is subject wind forces. The default setting is 1.0, but larger objects such as big bottles may have a coefficient as high as 2.0.

Have students choose a scenario and location in the Gulf of Alaska, Bering Sea, Arctic Ocean, or North Pacific. For example, where would the debris go if a shipping container of shoes spills overboard in the middle of the North Pacific in an October storm or if a plastic bag blows off a commercial fishing boat in Bristol Bay in June?

Ask them to predict, based on their knowledge of predominant currents, where a piece of marine debris might travel if it went overboard in that location. Have them write their predictions in their science notebooks.

Run OSCURS. Does the simulated location match with the students’ predictions?

Try changing the time and duration of the run. How is this track different than the first? What factors might be explain the difference?
Predicting the Path of Marine Debris Continued

Wrap-Up:

Finally, bring the concepts of wind and current to a local level. If you are located near the ocean, discuss whether your area experiences a day breeze on hot days. *(This is caused when the sun heats the land, causes warm air to rise from it. This space is then filled by cool air off the ocean. The reason the winds don’t come straight off the ocean? Coriolis effect!)*

Talk about the factors that drive heat and cold in your area and how they might affect local transport of debris.

Ask students to explain in their science notebooks a local weather or current pattern based on the information presented in this lesson.

Discuss some of the areas local bodies of water are likely to “receive” debris from, and where local debris may end up. Use local drift card models to confirm predictions if available.

Ask students to revisit the flow chart they created at the beginning of the lesson. Have them identify the different physical factors that affect the transport of their plastic piece to the ocean. These physical factors will include the movement of water due to density gradients, but students should also consider such factors as wind, tides, and gravity. Ask them also to identify three ways that they could interrupt this flow of plastic to the ocean (ie. proper disposal of plastic, recycling, reusable bags, cleaning up litter, filtering technology, etc.)

Extensions & Lesson Connections:

This activity works well as a follow up to the "Density Differences: Air," "Density Differences: Water," and "Currents & Coriolis" lessons.

The Marine Debris Science Kit from C-MORE (Center for Microbial Oceanography: Research and Education) is an excellent resource for an extended lesson using OSCURS. Lesson 2 of this kit allows students to use OSCURS to extrapolate the origin of specific marine debris pieces based on information about the date it was lost, where it was found, and the date it was found. The lesson information can be accessed here: [http://cmore.soest.hawaii.edu/education/teachers/science_kits/marine_debris_kit.htm](http://cmore.soest.hawaii.edu/education/teachers/science_kits/marine_debris_kit.htm) and the kit can be requested through: [http://cmore.soest.hawaii.edu/education/teachers/science_kits/requestform.htm](http://cmore.soest.hawaii.edu/education/teachers/science_kits/requestform.htm).

Evaluation:

The initial flow charts serve as a pre-assessment, while the revised flow charts should illustrate student understanding of how weather systems and ocean systems affect each other and the transport of solids and liquids in the ocean, as well as the connection of watersheds to the ocean. Review the science journals and maps to assess students’ understanding of predominant surface current patterns.
Science From Bath Toys

The story as pieced together by Curtis Ebbesmeyer, Oceanographer and beachcomber, adapted from the Alaska Seas and Rivers Curriculum, Alaska Sea Grant.

On January 10, 1992, a cargo ship was traveling from Asia to North America. It hit a storm in the North Pacific Ocean near where the 45th parallel intersects the International Date Line. (44.7°N, 178.1°E). Twelve containers were lost overboard.

One of the containers spilled 28,800 floating bathtub toys into the ocean. The yellow ducks, blue turtles, red beavers, and green frogs were packed in sets of four but the packaging dissolved at sea.

The first of the floatees showed up in Sitka, Alaska. Beachcombers around Sitka, Alaska started to find hundreds of the toys washed up on the beaches in August and September of 1992. From 1993-2004 beachcombers Dean Orbison and his 22-year-old son Tyler Orbison from Sitka found 111 toys. At a fair in Sitka, they showed a basket of the toys they found. It held 18% turtles, 35% ducks, 26% beavers, and 21% frogs. Many of the toys were faded, bitten by animals, and ruptured from being smashed against rocks by the surf.

Hundreds of toys were found near Shemya at the end of the Aleutian Islands, 3,500 miles from the spill, in 1995.

Karen Berger and Verne Krause found a turtle and a duck near Tacoma, Washington in 1996.

That same year, on the coast of British Colombia, Canada Guthrie Schweers found two turtles and a frog.

Also in 1996 a turtle was found on Kure Island, Hawaii, and in 1997 a beaver and a frog were found on Hawaii’s Lanai Island.

Beachcombers on the shores of Australia and Chile found beavers, and ducks in 2000.

In 2001, some of the floatees reached the location where the Titanic sank, in the Atlantic near Nova Scotia and Maine.

In July 2003, a duck was found in Maine.

In August of 2003, a frog was found as far as Scotland.
Popcorn Spill

Adapted from the Alaska Oil Spill Curriculum, Prince William Sound Regional Citizens Advisory Council

Originally adapted and used with permission from OBIS Oil Spill, Delta Education, Box M, Nashua, New Hampshire, 03061.

Objectives:
Students will estimate the environmental impact of a simulated oil spill, containership spill, or other pollution and will understand the impact of winds and currents on marine pollution.

Concept:
Winds and currents spread pollutants such as oil or debris very quickly, making it difficult to contain and clean up. Coastal organisms such as fish, shorebirds, and intertidal invertebrates are most often harmed by oil spills from ships, offshore drilling, pipelines, and natural seepage because these usually occur in the shallow coastal areas where these organisms are concentrated. Container ship spills and other sources of marine debris can have significant impacts on both open-ocean environments and coastal areas when the debris is washed ashore. Other sources of pollutants include spills, leaks, and improper disposal of chemicals onshore that are washed into the marine environment. The environmental impacts of pollution depend on the size of the spill, the type of pollution, the prevailing wind and water conditions during the spill, and the variety and abundance of life (both wild and human) in the affected area.

Materials:
- Science notebooks
- Pencils
- 20 liters of popped popcorn
- Handout: Impact Challenge Cards
- Pencils
- Guides for identifying saltwater/freshwater organisms
- 1 plastic bucket or can with a metal handle (about 20 liters in volume)
- 1 50 cm x 50 cm piece of plastic window screen, nylon mosquito netting, or several 50 cm x 50 cm sheets of small mesh cheese cloth
- 1 large rubber band, strip of inner tube, or elastic band that will fit snugly around the plastic bucket
- 3 100-cm lengths of wide duct tape or masking tape
- 25 meters of heavy twine or light rope marked off in 5-meter intervals
- 1 mini-hacksaw, jigsaw, or serrated knife
- Permanent marker

Preparation:
To make a popcorn slinger, cut out the bottom of the bucket with a hacksaw, jigsaw, or knife. With the bucket turned upside down, place the screen material over the open end of the bucket. Let the material drape over the side. With the duct tape or masking tape, tightly tape the edge of the screen material to the bucket. Firmly tie the 25-meter line to the metal handle on the bucket and tie a loop (large enough to go over a nearby rock or post) at the other end of the line.

Determine the location for your simulated spill. Although developed for the seashore, this activity may also be conducted at a lake, river, or stream. Reduce the amount of popcorn for smaller bodies of water.
Popcorn Spill Continued

The activity will be more exciting if you choose a site with strong dispersal features (such as water currents and wind) and an abundance of life. Breakwaters or docks are convenient places from which to toss popcorn into the water.

Decide if you would like to simulate an oil spill, container ship spill, or other source of pollution. If you conduct the activity at an inland site where oil spills rarely occur, tell students that the activity simulates a toxic chemical discharge from an industrial or agricultural source. The “Impact Challenge Cards” are designed for an oil spill, so you will need to adapt them if you choose another source of pollution.

Introduction:

Before you reach the site, discuss safety and assign a buddy system. Keep an eye on nonswimmers.

At the site, tell the students that they are environmental impact experts who have been rushed to the scene of an oil spill or other source of pollution to estimate its impact on the environment. Say that you will simulate the spill by tossing out a large bucket of popcorn to represent the pollution. Explain you are using popcorn because it will not harm the environment, and it floats like refined oil or plastic debris.

Explain to your group of “experts” that they are responsible for estimating the impact of the spill on (a) the landscape, (b) the plant life, (c) the animal life, and (d) human activities. Divide the group into four smaller groups (keep buddies together), and give each group an Impact Challenge Card. Tell the teams to assume that anything the popcorn touches will be covered with pollution.

Before you toss out the popcorn, ask the students to predict in which direction the spill will move and how long it will take to reach the shore. Ask someone to measure the time it takes for the spill to reach the shore or some other reference point.

Now you are ready to use your popcorn slinger. With the loop of the rope anchored to a rock or post, practice tossing the bucket a few times before putting in the popcorn. Take a strategic but secure position on a dock, breakwater, or large rock. The rope should be loosely coiled on a flat surface below your tossing arm so the rope will fly out freely when the bucket is tossed. Make sure you are not standing on the rope.

When you are ready, grab the rope about a meter from the metal handle and start swinging the popcorn slinger over your head. When the bucket has gathered momentum, let it fly out over the water. Try to pick a location where you can toss the bucket with the wind instead of against it.

After you have gotten the knack for tossing the bucket, place a small flat rock (about 200 grams) in the bucket and then put in about 20 liters of popcorn. With the teams ready to time and follow the spill, toss out the slinger.

After landing, the rock will help pull the bucket under the water and the buoyant popcorn will be forced out the top of the bucket. Let the bucket sink beneath the surface before hauling it in so the spill won’t be disturbed.

Count the marked intervals on the rope as you haul in the bucket to determine the spill’s starting distance from the shore.
Popcorn Spill Continued

Ask your environmental experts to begin their investigation, working with their groups to answer the questions on their Impact Challenge Cards in their science notebooks.

Join in and follow the movement of the spill with the rest of the group.

Near the end of the allotted time or after the spill has been thoroughly dispersed, gather the students together to have a Slick Talk to report their findings.

If you would like, you can give students a chance to (safely) attempt to remove the popcorn from the water using a variety of techniques.

Wrap-Up:

At the end of your Slick Talk, have students reflect on the following questions in their science notebooks. Then discuss their answers.

1. How quickly did the spill reach the shore?
2. What agents dispersed the spill?
3. How might different wind or water conditions affect the spill?
4. How could a spill be prevented from spreading?
5. Who should be responsible for cleaning up a spill?

Evaluation:

Review science notebooks for thorough and reasonable reporting of popcorn spill data in each expert group. Observe expert groups and presentation for successful participation and cooperation. Evaluate understanding based on student reflection in their science notebooks.

Extensions & Lesson Connections:

An excellent way to extend this lesson is to incorporate ROVs (remotely operated vehicles) and allow students to design and use ROVs for clean up efforts. The Prince William Sound Science Center has developed an excellent ROV & Oil Spill Response kit with funding from the Oil Spill Recovery Institute.

In this lesson, Students will work cooperatively to design and build an ROV (remotely operated vehicle) in response to a mock oil spill and demonstrate how to operate equipment similar to real-life oil response equipment.

Contact the Prince William Sound Science Center (http://www.pwssc.org, 907-424-5800) to request the ROV Teaching Kit. They provide many of the materials required to build the ROVs, as well as handouts, PowerPoint presentations, and directions for setting up a challenge course. The PWSSC lesson materials focus on an arctic environment, but can be adapted to other environments if you so choose.
## Impact Challenge Cards

<table>
<thead>
<tr>
<th>Impact Challenge Card #1</th>
<th>Impact Challenge Card #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape</td>
<td>Plant Life</td>
</tr>
<tr>
<td>Follow the spill and estimate its impact on the landscape. Get the 25-meter length of rope from the popcorn slinger and use it to estimate the area the spill covered.</td>
<td>Follow the spill and estimate its impact on plant life.</td>
</tr>
<tr>
<td>Water ______ sq. meters (length x width)</td>
<td>• How many different types of plants were affected?</td>
</tr>
<tr>
<td>Land ________ sq. meters (length x width)</td>
<td>• Which water plants and algae were hardest hit by the spill? Why?</td>
</tr>
<tr>
<td>• Where did most of the pollution end up? Why?</td>
<td>• How might this spill affect land plants?</td>
</tr>
<tr>
<td>• How might the underwater landscape be affected?</td>
<td>• How would animals that eat aquatic plants be affected?</td>
</tr>
<tr>
<td>• How did the spill change the general appearance of the landscape?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact Challenge Card #3</th>
<th>Impact Challenge Card #4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Life</td>
<td>Human Activities</td>
</tr>
<tr>
<td>Follow the spill and estimate its impact on animal life.</td>
<td>Follow the spill and estimate its impact on human activities.</td>
</tr>
<tr>
<td>• How many different types of animals were covered with by the spill?</td>
<td>• How might a spill affect recreation like fishing, swimming, kayaking, and beachcombing?</td>
</tr>
<tr>
<td>• What animals were hardest hit by the spill? Why?</td>
<td>• How might boats, docks, breakwaters, and other structures be affected?</td>
</tr>
<tr>
<td>• Which animals might be capable of escaping from a spill? Which animals might not be able to?</td>
<td>• How might drinking water or food be affected?</td>
</tr>
<tr>
<td>• How might a spill affect animals that live under rocks along the shore?</td>
<td>• How might the local industries be affected?</td>
</tr>
</tbody>
</table>
Pressure & Storms

Objectives:
Students will understand that density differences drive global and local patterns winds. They will recognize that barometric pressure is a measure of the density of air, and can be used to predict changes in weather. They will understand how the Coriolis effect influences wind patterns, and how this can create cyclones.

Concept:
Temperature-dependent gradients of density drive the movement of air. As warm air rises, cool air moves in to fill the space left behind. This wind is deflected by the rotation of the earth, called the Coriolis effect. Barometric pressure, which measures the density of air, is a way to predict weather patterns. In this activity, students will create their own tool to measure barometric pressure and use the data they collect to predict weather patterns. In tropical areas, warm water can fuel the movement of air. This movement, combined with the Coriolis effect, can create cyclones (typhoons and hurricanes).

Materials:
- Science notebooks
- Pencils
- Colored pencils
- Computer/laptop and projector or SmartBoard
- Desktop computers, laptop or tablets
- Handout: Pressure Chart February 7, 2014
- Handout: Wind Speed & Direction Forecast Chart February 7, 2014
- Handout: Make a Weather Barometer Lab
- Tin cans or glass jars
- Latex or rubber balloons
- Straws
- Rubber bands
- Tape
- Scissors
- Pieces of paper

Preparation:
Load the “Earth Wind Map” (http://earth.nullschool.net/).


Make enough copies of the “Pressure Chart: February 7, 2014” for every 2-4 students, or download a current pressure chart from NOAA (http://weather.noaa.gov/fax/aksfc.shtml#anal). If you choose to download a current pressure chart for your area, choose option 1a- Plot Chart Analysis Northern Hemisphere Pacific. This chart encompasses the entire North Pacific, but you may want copy only the area surrounding Alaska.

Make copies of the “Wind Speed and Direction Forecast Chart: February 7, 2014” for each group or download and print a current wind forecast chart from NOAA (http://graphical.weather.gov/sectors/aktrimmed.php). If you choose to download a current chart, click on the “Wind Speed & Direction” for as close to the current date and time as possible. Click on the printer icon in the upper right corner. Depending on your browser, it may be easier to go to the “Image List” link in the upper left hand corner and choosing the “WindSpd” link valid for the appropriate date.

Introduction:
Review what you have learned during the “Density Differences: Air” and “Currents & Coriolis” lessons.
Pressure & Storms Continued

Ask students to think about a recent wind storm. What direction did the wind come from? Based on student knowledge of how air moves along density gradients (from areas of high pressure to areas of low pressure) and is affected by Coriolis (deflected to the right in the Northern Hemisphere, and to the left in the Southern Hemisphere), ask students to write a hypothesis in their science notebooks about where the area of high pressure was and where the area of low pressure was in the recent storm.

Procedures & Activities:

Divide students into groups of 2-4. Pass out the “Pressure Chart: February 7, 2014” or the current pressure chart you have downloaded from NOAA.

Ask them to work with their group to first find and outline the state of Alaska on the chart. Next, they should shade areas of high pressure in blue and areas of low pressure in red.

Then, have students predict the wind patterns based on the areas of high and low pressure on the chart. Once they have discussed the possibilities with their group, they should come to a consensus and draw their predicted wind directions onto the chart.

Instruct students that if they predict strong winds, they should make their lines thick and if they predict weak winds, they should make their lines thin.

Have groups share their wind predictions with the class.

Then show groups the “Wind Speed and Direction Chart: February 7, 2014” or the current wind chart you have downloaded from NOAA.

Discuss any differences between their predictions and NOAA’s predictions. This is a great opportunity to reinforce knowledge about Coriolis effect, or introduce the concept if your students haven’t done much with Coriolis effect up to this point.

Show students the real time Earth Wind Map (http://earth.nullschool.net/). Examine patterns of local surface winds.

Look globally for wind storms rotating in a circular pattern – the spiral of winds should be fairly easy to spot. The winds are caused by pressure gradients, and the rotation is caused by the Coriolis effect.

Compare storms in the Northern Hemisphere to storms in the Southern Hemisphere. What direction are they rotating? (Storms in the Northern Hemisphere tend to rotate counter-clockwise, while storms in the Southern Hemisphere tend to rotate clockwise.)

To see how pressure gradients affect these winds, click on the word “Earth” in the lower left corner. In the options, scroll down to “Overlay” and choose “MSLP” for mean surface level pressure. Areas in purple indicate low pressure, while areas in grey indicate high pressure. Yellow-green areas have moderate barometric pressure.

Ask students what they notice about the pressure and winds. (Most storms you observed earlier are likely to be centered around areas of low pressure.) Why is this? (Air from high pressure areas is flowing to areas of low pressure, and these winds are deflected into a spiral by the Coriolis effect.).
Pressure & Storms Continued

Explain that the Coriolis effect has a strong impact on the formation of storms. In tropical climates, the Coriolis effect is a driving force in the creation of cyclones, also called hurricanes and typhoons.


Have students check the barometer every day and record their observations in their science notebooks.

Have students check the barometer every day and record their observations in their science notebooks.

After 5-10 days, ask them to analyze their data. What sort of weather patterns do they see when the barometric pressure drops? (Generally associated with an increase in clouds and precipitation, may be accompanied by wind.) What sort of weather patterns do they see when the barometric pressure rises? (Generally associated with a decrease in clouds and precipitation, may be accompanied by wind.) What if it is low and stays low? (Rain and clouds.) What if it is high and stays high? (Clear and sunny.)

Once they have analyzed their data, ask student groups to begin making weather predictions based on the changes they observe in the barometric pressure and charts of nearby pressure systems.

Show them how to access current Pressure Charts for the North Pacific: http://weather.noaa.gov/fax/aksfc.shtml#anal or print them out for students to use. Make sure they don’t look at any of NOAA’s predictions before making their own!

Have students write their predictions for the weather in the next 48 hours in their science notebooks.

Wrap-Up:

Ask students to use their weather predictions – based on their barometric pressure readings and the observed pressure charts from NOAA - to create a weather report for the classroom or school.
Pressure & Storms Continued

Have each group present their predictions, reasoning, and advice for how to prepare/what to wear on a different day.

Then, have students compare their predictions with NOAA predictions or real-time weather observations they make over the next 48 hours. Discuss other factors that influence the weather that they may not have taken into account.

Have students revisit their initial analysis of a wind storm. Based on what they have learned throughout their exploration of pressure, wind, and weather, ask students to rewrite their hypothesis about where the area of high pressure was likely located and where the area of low pressure was likely located during the storm.

Ask them to explain their hypothesis and identify any other information they would like to strengthen their hypothesis (examples of additional information include ocean and land temperatures, geographic features like mountains, etc.)

Extensions & Lesson Connections:

Ask students to create an easy-to-use guide to predicting weather based on what they learned. Place a student-made barometer in a prominent area of the school, along with the guide so that other students can predict the weather using the barometer.

This lesson works well as a follow up to the “Density Differences: Air” and “Currents & Coriolis” lessons. The collection of barometric pressure and weather observations pairs well with the “GLOBE Weather Monitoring” lesson.

Evaluation:

Assess student comprehension and application of material through their weather predictions. Your assessments should be based not on the actual weather, but on their application of the following general principles:

- **Decrease in pressure**: increase in clouds and precipitation, may be accompanied by wind

- **Increase in pressure**: decrease in clouds and precipitation, may be accompanied by wind

- **Steady low pressure**: rain and clouds

- **Steady high pressure**: clear and sunny

- Surface winds should normally flow from areas of high pressure to areas of low pressure, deflected about 45-90 degrees to the right. So, if there is a high pressure system to the north and a low pressure system to the south, you would expect winds from the Northeast or East.

- The greater the difference between high and low pressure, the greater the wind speed.

The initial hypothesis about pressure systems associated with a recent wind storm serves as a pre-assessment, while the revised hypothesis should illustrate student comprehension of the effect of pressure gradients and Coriolis effect on winds. Observe student participation and cooperation during group work, and assess student maps and entry of data in science notebooks for completeness, neatness, and accuracy.
Make Your Own Barometer Lab Instructions

1. Assemble your materials: 1 tin can or glass jar, 1 balloon, 1 straw, 1 rubber band, scissors, tape, paper.

2. One person in your group needs to blow up the balloon once and let the air out to stretch it.

3. Cut the balloon in half, so that you have a top half and a bottom half with the neck attached to it. Discard the half with the neck.

4. Work together to stretch the top half of the balloon firmly across the jar.

5. Seal the balloon in place with the rubber band, around the rim of the glass jar. To make an airtight seal, avoid gaps between the balloon and the glass.

6. Use the straw to create an “indicator needle.” Arrange the straw so that about ¼ of it is on the balloon and ¾ of it hangs off the balloon. Tape the straw onto the middle of the balloon lid so that about 1 inch of straw extends beyond the tape. Trim the straw if it’s too long, but leave at least half extending off the jar.

8. Put your finished jar next to a wall where it won’t be disturbed.

9. Tape a piece of paper to the wall behind the indicator needle of your barometer.

10. Write the names of the people in your group at the bottom of the piece of paper.

11. Mark the height of your indicator needle on the piece of paper. Make a note about the current weather conditions (clear, cloudy, rainy, windy, calm, etc.)

12. Check the barometer indicator needle every day. Mark the height of the indicator needle on the paper along with the current weather conditions.
Geology & Tectonic Plates

Objectives: Students will be introduced to the geology of coastal Alaska, with a focus on the plate tectonics that created and continue to affect the mountains and volcanoes along coastal Alaska. They will be able to identify the three broad categories of rocks (igneous, metamorphic, and sedimentary) and understand how these rocks are formed.

Concept: Dynamic geologic forces are at work in coastal Alaska. Radiolarian chert in Kachemak Bay is a marine sedimentary rock transported to our coastlines by plate tectonics. Students will use it as a case study to learn more about geology. The geology of coastal Alaska affects marine, intertidal, terrestrial, and human communities and influences currents and other oceanographic characteristics.

Materials:
- Science notebooks
- Pencils
- Oreos (1 for each student)
- Examples of radiolarian chert
- Photos of radiolarian chert
- Pictures of radiolarians
- Tectonic plate diagram
- Hand lenses
- Computer/laptop and projector or SmartBoard
- Desktop computers, laptop, or tablet for students (optional, for extension).

Preparation:
Set up computer and projector or SmartBoard to show the NOAA Ocean Explorer Plate Tectonics video: http://oceaneplorer.noaa.gov/edu/learning/player/lesson01.html.

Introduction: Begin with a quick discussion of what geology is (the study of rocks).

Then give students time to examine the samples and photos of radiolarian chert. Ask them to write at least 3 words in their science notebooks to describe the rocks based on the samples and photos.

Ask students to share their descriptive words, either with a partner or with the class.

Procedures & Activities:
Explain that this rock is called radiolarian chert and it is a type of sedimentary rock. It is formed when the silica, or glassy, skeletons of tiny plankton called radiolarians sink to the ocean floor.

As layers of these skeletons build up on the ocean floor, the pressure from the water above smushes them into siliceous ooze. Eventually this siliceous ooze hardens and forms a sedimentary rock.

Demonstrate the formation of siliceous ooze by having two or three students pretend to be radiolarians in the middle of the ocean, dancing around as happy plankton in the ocean.

After a while, conditions change in the ocean and the radiolarians pass away, drifting gently to the ocean floor as "marine snow." Have these dead radiolarians lie down on the floor.

Conditions become favorable and more radiolarians bloom, so choose 2-3 students to dance around in the middle.
When they die, they too float down, forming a layer on top of the previous radiolarians.

Continue like this for 2-3 more rounds.

Then, ask the students on the bottom how they feel. That squishing pressure is what changes all those microscopic radiolarian skeletons into ooze.

Explain that while some rocks like radiolarian chert are sedimentary, other rocks are formed in different ways. Do students know the other two types of rocks? Explain how metamorphic rocks (formed under heat and pressure) and igneous rocks (formed from melted magma).

Break students into 3 groups. Arrange the groups into 1 big circle, with students standing next to the rest of their group.

The first group represents sedimentary rocks. To do this, they layer their hands one on top of the other.

The second group is metamorphic rocks. They represent this by pushing their hands against each other to demonstrate the pressure metamorphic rocks are under.

The third group is igneous rocks, represented by throwing their hands in the air as a volcano erupting.

Place a volunteer, aid, or student between each group to "transform" the rocks.

As Sedimentary goes to Metamorphic: the volunteer sings David Bowie & Queen’s "Under pressure, um ba ba be de day da" as the students pass under their arms.

Metamorphic goes to Igneous: the volunteer screeches, "I'm melting" wicked-witch style.

Igneous goes to Sedimentary: the volunteer chants, "Break it down" as students pass.

Have the groups rotate through the rock cycle.

Then, switch directions. As students pass under the volunteers, they should say the same thing. This time though: as Sedimentary goes to Igneous: “I’m melting,” as Igneous goes to Metamorphic: “Under pressure,” and as Metamorphic goes to Sedimentary: “Break it down.”

Split students into groups of 3. Demonstrate the same sedimentary - igneous - metamorphic motions as above.

Explain that when you call out a type of rock, students have to find their group of 3 and complete the motion before you can call out "Rockity, Rock, Rock, Rock."

Play a few practice rounds, and then have a competition. Any groups that are too slow to find their group and complete the motion are out of the game. Play until you have a winner, and repeat, if there is time, to help reinforce the ideas.

Finally, explain how the coast of Alaska was formed via subduction. Show the tectonic plate diagram and explain that the heavier Pacific Plate subducts (sinks) under the North American plate near the Gulf of Alaska and Cook Inlet.

As the plate subducts, bits of rock on the ocean bottom are accreted (scraped) onto the North American plate.
This accretion process is what brought the radiolarian chert onto the land. It is also how the layers of rock got compressed, twisted, and contorted.

Reveal the OREOs as a scientific tool. Pass them out to the class, but remind them that eating scientific equipment is unacceptable!

Explain how the OREO is actually a model of the North American and Pacific plates (cookies) with a nice layer of siliceous ooze (crème) sandwiched in the middle.

Ask the student to separate the cookies/plates, trying to keep all the ooze on one plate. Which-ever plate has more ooze becomes the Pacific plate.

The student should then push the two cookies/plates together, pushing the heavier Pacific plate under the North American plate and scraping all that siliceous ooze onto the North American plate.

Have the students examine their mountains. Are they similar in any ways to the photos of radiolarian chert?

The movement of plates has many other effects besides the accretion of radiolarian chert. Show the class the NOAA Ocean Explorer Plate Tectonics video: http://oceanexplorer.noaa.gov/edu/learning/player/lesson01.html.

Wrap-Up:

Ask students to identify and describe in their science notebooks at least three ways that the movement of plates affects coastal Alaska (mountain formation, islands, volcanoes, earthquakes, tsunamis, etc.).

Have students revisit the three words they used to characterize radiolarian chert at the beginning of the lesson. Ask them to explain these rock characteristics based on their scientific understanding. (For example, the rock is “layered” because it is a sedimentary rock formed by layers of radiolarians getting pushed together or the rock is “hard” because it is composed of silica that was compressed under great pressure from the weight of the ocean.)

Extensions & Lesson Connections:

Discuss historic events connected to plate tectonics (1964 earthquake & tsunami in Alaska, 2011 Tohuko earthquake & tsunami in Japan, volcanic eruptions, etc.) and how those events affected local people and ecosystems. Explain to students what is done locally to prepare for and respond to these sorts of events. Show them Alaska Volcano Observatory (http://www.avolcanoes/) and National Tsunami Warning Center (http://wcatwc.arh.noaa.gov/) websites. Discuss ways that families, schools, and communities can prepare for such disasters. NOAA’s TsunamiReady program is a great resource: http://www.tsunamiready.noaa.gov/.
Geology & Tectonic Plates Continued

As an extension, have students use the “Plates of the Earth” exploration (http://oceanexplorer.noaa.gov/edu/learning/player/lesson01/l1ex1.htm) or “Drilling for Core Samples” activity (http://oceanexplorer.noaa.gov/edu/learning/player/lesson01/l1la1.htm) to reinforce and test their understanding.


Evaluation:

Review science notebooks for comprehension of geologic processes and plate tectonics. Their explanations of the scientific concepts responsible for the characteristics of radiolarian chert serves as a formative assessment of student understanding and application of geologic processes, and their list of ways plate tectonics affect Alaska serves as a formative assessment of student comprehension of plate tectonics. The “Plates of the Earth” exploration or “Drilling for Core Samples” activity can also be used as an assessment.
Tsunami Simulation

Objectives:
Students will create a demonstration of a tsunami. Students will understand the driving force behind tsunamis, and water movement creating multiple tsunami waves.

Concept:
Tsunamis are driven by sudden changes and shifts along the sea floor. These shifts can be landslides, volcanic activity, or an earthquake. A tsunami wave can grow to a few meter high by the time it breaks on the shoreline. Tsunamis are some of the most impactful natural disasters, and have devastated many coastal communities and cities.

Materials:
- Science notebooks
- Pencils
- Clear plastic bins (long and shallow)
- Food coloring (blue)
- Rocks and sand
- Water
- Flat piece of plastic, wood, or metal (about the size of a clipboard)
- Small balloons (waterballoon size)
- Brick or comparable sized rock
- Handout: What Causes a Tsunami?

Preparation:
Gather materials for students to create tsunami demonstrations in groups. Make copies of the handout “What Causes a Tsunami?” for each group. Set up projector or smartboard with audio to view introductory video. For additional background information on tsunamis, visit the NOAA Tsunami monitoring site: http://www.tsunami.noaa.gov

Introduction:
Introduce tsunami science to your class by watching this introductory 3 minute video.
http://www.history.com/videos/the-science-of-tsunamis

Discuss the three major causes of tsunamis, landslides, underwater earthquakes, and volcanic action. Discuss the movement of water after the disturbance on the seafloor, how this causes many short waves to eventually build into one large solid wall of water as the waves approach the shallow waters near the shore.

Procedures & Activities:
Explain to the students that they will be working in groups to build a demonstration of a tsunami including the triggering activity.

Break students into groups of 4-6. Have the groups decide (or assign to groups) which triggering activity they will demonstrate in their simulator. Have the students draw a plan for the tsunami simulator in their science notebooks. Have the group members work together to discuss and decide how they will simulate the triggering activity with the materials provided.

When the groups have drawn and discussed their plan for the tsunami simulator, instruct students to use the materials provided to build the demonstration. Have the students test out their simulators and determine if they are a good representation of the triggering activity they chose or were assigned. Have the students fix any part of the demonstration. If time allows, have them build trees and buildings on their shoreline.
Tsunami Simulation Continued

When all the groups are done building and testing their simulators, have each group present and demonstrate the simulators to the class. Be sure the students explain what the triggering activity is they are simulating, and how it displaces the water to cause the tsunami.

Note: The students should build up the shoreline, a gradual slope with the small rocks and sand. The tub should then be filled with water so that the water reaches about halfway up the shoreline, but still leaves a beach. Add a few drops of blue food coloring to each tub of water to better view the wave action. The flat wooden/plastic/metal piece, brick/large rock, and balloon should be used by the students to demonstrate the triggering mechanism. The flat wooden/plastic/metal pieces can be placed at the bottom of the clear bin under the water, a sharp tug up on the flat piece simulates the tension release from an earthquake. The brick or large rock simulates a landslide, and can be slid on the flat piece into the water. The balloon simulated an underwater volcanic eruption. The balloon can be blown up, held under the water, and then popped.

Wrap-Up:

Ask students to name, draw a diagram, and label the three major causes of tsunamis in their science notebooks. Have the students answer the following questions:

- How are tsunamis different from other waves?
- Are tsunamis preventable?
- What action should you take if you hear a tsunami warning?

Extensions & Lesson Connections:

For additional lessons on tsunamis, specific to Alaska, visit the Alaska Tsunami Education Program site: http://www.aktsunami.com

This lesson works well as a follow up to the "Geology & Plate Tectonics" lesson.

Evaluation:

Review the drawings of the models and causes in students’ science notebooks. Review the students’ participation during the simulator creation and presentations. Review the students’ responses to the questions in their science notebooks.
Unit 3: Exploring Marine Ecosystems

Essential Questions:
How are people connected to coasts and oceans?
How do people affect coasts and the ocean?
How can people protect coasts and the ocean?
What is the role of technology in protecting our coasts and the ocean?

Enduring Understandings:
- Art is a powerful way to communicate knowledge about and create an emotional connection to marine ecosystems and stewardship.
- Everyone is responsible for caring for the ocean.
- Connections between humans and the ocean are important.
- Plastics and other pollution knowingly or unknowingly introduced into the ocean by people can have negative effects on marine ecosystems.
- You can reduce the solid and liquid pollution you are introducing into the ocean.
- Making informed decisions as a consumer helps to protect the ocean.
- You can minimize the solid and liquid pollution you are introducing into the ocean.
- You can create new ways to care for the ocean and get others involved.
- Technology can have unintended consequences.
- Traditional knowledge, culture, stories, and long-term observations are important ways to learn more about marine ecosystems.
- Monitoring the same area over time can reveal local and global changes in marine ecosystems.
- Coastal ecosystems provide a window to the ocean for study and understanding.
- Plants and animals can be sorted into groups and counted based on different characteristics.

Lessons in this unit:
- GLOBE Weather Monitorings
- Counting Beads & Bobbles
- Sampling for the “e” Organism
- Practicing Protocols
- Be a Beach Steward
- Discovery Hike
- CoastWalk Monitoring
- Intertidal Sampling
Be a Beach Steward

Objective:
Students will learn how to behave during field trips to the beach in a way that is respectful and minimizes harm to the animals and habitats of the intertidal zone.

Concept:
By reviewing proper beach stewardship students will be properly prepared for both the field trip experience and the ways in which their presence and activities on the beach could impact the beach habitat they are trying to study.

Materials
• Beach stewardship grab bag
  • Cloth Bag
  • Kid’s Rubber Boot
  • Rock with shells or markings on top
  • Snail or clam shell
  • Toy shovel
  • Litter
  • Plastic crab or other intertidal animal
• Hand Out: Beach stewardship

Preparation:
Make enough copies of the Beach Stewardship hand out so each student can have one.

Place the beach stewardship grab bag items in a cloth bag or other container.

Introduction:
Ask students if they’ve ever hear the word steward before.

Just like a steward or stewardess on an airplane makes sure the passengers are safe and their needs are met, being a steward of something like a beach means taking care of it and making sure the organisms that make it home aren’t harmed can continue to live there.

Prepare students for their beach field trip by discussing possible impacts their presence at the beach might have and ways in which they can help to minimize the impact and prepare themselves for a successful trip.

Activities & Procedures:
Have students come up, one at a time, and pull an item out of the grab bag. Ask the student to try to think of a way that their item symbolizes a beach stewardship "rule" that should be followed or action they should take at the beach.

Wrap-up & Extensions:
Once all of the items have been pulled from the bag distribute the Beach Stewardship brochure and discuss any other items that are useful to your group.

Evaluation:
Observe student behavior during future intertidal exploration and monitoring trips to assess their understanding and application of beach stewardship concepts.
Be a Beach Steward Continued

Beach Stewardship Grab Bag
What the Items Stand For

Boot: Walk single file over areas of attached plants and animals. Walk, don’t run and watch where you step!

Rock covered with barnacles on one side: Return rocks to original position. Turn rocks over gently. Don't turn over really large rocks or you might crush the animals who live below!

Snail shell: If you find an animal tightly attached, leave it attached! Don't collect shells and other "beach stuff" because they can be a home to other animals.

Toy/Plastic crab: Hold animals close to the ground...they may be slippery, slimy or quick. Use small tubs and buckets if possible to view animals. Cup hands and keep them moist with a little bit of water if you are holding animals.

Toy shovel: Fill in holes! Small animals left underneath a big pile of mud and sand can be killed and someone could fall in the hole and get hurt.

Hat: Dress warmly!

Litter: Don’t litter, in fact - encourage your group to pick up trash and debris they find!
Intertidal Discovery Hike

Objective:
To explore the beach and become familiar with the plants and animals in the marine intertidal habitat while collecting some basic observational data.

Concept:
Students need time to "discover" the beach. An initial Discovery Hike can provide a hands-on learning environment by familiarizing the students with common abundant organisms and an introduction to tide zones.

Materials:
- Handout: Biodiversity Checklist
- Clipboards
- Marine invertebrate guides or ID charts
- Stopwatch

Preparation:
Make copies of the Biodiversity Checklist.

All classes should participate in a beach discovery walk as an initial filed trip to observe local organisms, check out the various types of organisms to be found at the different tidal heights and to do an initial species biodiversity checklist. This will help classes who are participating in the Coastwalk and/or Intertidal Sampling projects pick their species to monitor and get the students excited about their field work.

Make sure you have done the pre-trip activities relevant to this field trip. Students should be dressed warmly and have an idea of what they will be looking for on their beach walk.

Activities & Procedures
Tell the students that they are going on a Discovery Hike which means they should walk with eyes wide open - exploring every nook and cranny on the beach, searching under rocks and beneath algae, and looking for plants and animals in every tide zone.

As a class you should decide on one of the following activities to do while you are at the beach as a way to structure your field experience. At the very least you should do the Biodiversity Checklist, which will provide data on the organisms that can be found at your beach and can provide the beginnings for further inquiry activities if you choose to do them. Timed counts can be a very exciting way to focus your search for animals and are highly recommended.

Biodiversity Checklist:
Use this list to check off all of the organisms you observe on the beach while on your Discovery Hike.

Divide your class into tide zones and have groups of students exploring tidal bands on the beach or you can have different groups walk a vertical band by beginning at the water's edge and working their way up to the highest level on the beach where an organism can be found.

Positively identify the organisms by checking with your identification guide and matching the scientific name if possible.

Once done, the class data can be combined to get a final comprehensive species diversity list.

Timed Counts:
Timed counts are a beach scavenger hunt! Groups will count one species (or animal group) of intertidal organism at a time for a 10 minute period.
Intertidal Discovery Hike Continued

Following at least 15 minutes of initial beach exploration, ask the class to choose the animal groups to count based on what they saw in their explorations.

Divide students into pairs.

Work as a class to assign each group an animal (or animal group) to count.

Each group should search for animals in a limited area where the category of animal is known to occur. For example, if you are searching for seastars, go to where you know seastars occur, then start your 10 minutes of counting.

If you have a large class, pairs of students can count the same animals but search in different areas of the beach. The numbers can then be combined for data analysis.

The goal is to count as many of the organisms as possible to give you an idea of the overall abundance of the organism on your beach.

Instruct students that they should only count those organisms they can see on the surface and should not turn over rocks or search under seaweed.

A student or the teacher should give the signal for starting and stopping the counts. Each group should count only one category of animal at time.

At the end of 10 minutes, gather students together to share observations.

Do another timed count with other animals, if you have time.

Wrap-up:

Hold a scientific convention to give students a chance to share their findings, talk about differences in observation techniques and scientific monitoring methodology, and learn from their peers.

Gather the group together and have a scientific convention. Ask each student group to report their findings to the rest of their scientist peers.

Act as a convention reporter, asking key questions of the scientists and audience: “How did you come about these findings?” and “How would you have gone about answering this question?”

In particular, it is key to prod students to ask and answer their own questions about the data they are collecting and the merits of their methodology.

Make a list of all of the students’ questions, group them in categories and discuss what makes a good “inquiry” or testable question.

Stress that scientists are just everyday people who have questions and attempt to answer them. Sometimes you can begin with one hypothesis but over time it can change with more observation or knowledge. Discuss the importance of sharing scientific knowledge within not only the scientific community, but the entire community at large as well.

Extensions & Lesson Connections:

This lesson works as a great introduction to student-designed inquiries or more involved monitoring projects.

Evaluation:

Assess data sheets for completeness and accuracy. Evaluate student participation and cooperation during group work, and observe student contributions during the scientific convention.
CoastWatch Survey

Objective:
Students will explore the beach and become familiar with intertidal organisms while collecting some basic observational data. They will build community awareness of the importance of our local marine habitats and gather data to detect long-term trends in biodiversity and the effects of human impact.

Concept:
CoastWalk is a unique community science and stewardship program that encourages students and community members to participate in general observations about their coastal environments. Stewardship programs promote a better understanding of the environment and a sense of responsibility for its future.

Materials:
- Handout: CoastWalk Data Sheets
- Handout: ICC Data Sheets
- Clipboards
- Map of your stretch of beach
- Pencils
- Binoculars
- Identification guides
- Thermometer
- GPS (optional)

Preparation:
Choose a site based on "Choosing and Mapping a Site" in the background information. Make copies of data sheets for students.

Introduction:
Review the data sheets with the class to familiarize yourself with what you might see on your field trip. Review the tide zones so that students are sure of where they are to be conducting their surveys.

Activities & Procedures:
Pass out CoastWalk and ICC Data Sheets and clipboards. Divide the class into two teams, with one team walking the high tide and the other team walking the low tide zone.

Instruct groups to walk a zig zag path along the high and low tide lines. You can also walk the low tide line out and the high tide line back if you need to.

Ask students to use tally marks in groups of five, then total when finished.

For large groups of organisms, students can count ten organisms. Using the amount of area taken up by those ten organisms, they can estimate the total count for the larger area.

Remind students that if they are not sure of the identity if an organism, they should check with you. If you don’t know it, don’t record it.

Walk your designated zone recording your data on the data sheets. Take pictures of organisms and unusual sites for documentation.

If you encounter a dead or stranded animal, make a note of its location and leave it alone.

Record atmospheric data (temperature, wind, etc.) at the midpoint of the survey.

Pay attention to and record evidence of human impact as well.
CoastWatch Survey Continued

Pick up trash along the way and take it to a local dumpster or recycling center.

Wrap-Up:

When you return to the classroom begin by asking students to describe the following in their science notebooks:

- The most interesting thing you saw
- Something that surprised you
- An observation that tells you the beach is healthy or unhealthy
- An organism you would like to learn more about
- A question you have about your observations
- One category (type of animal, atmospheric data, specific categories of human impact, etc) you think should continue to be monitored on the beach, and why you chose this category

Discuss their responses as a class.

Go over your data as a group. Discuss human impact issues that may have come up on your stretch of the beach.

Return your completed data sheets to the Center for Coastal Studies.

Submit atmospheric data to the GLOBE program (http://www.globe.gov).

Extensions & Lesson Connections:

Work with students to design an inquiry as a class or in teams of students. See the background information for guidelines.

Do the "Graphing Marine Debris" lesson to analyze your data and compare it to other areas of Alaska.

Keep some of your more interesting trash finds and hold an art contest back in the classroom. Challenge the students to come up with the most creative display of beach debris art. Use the marine debris you collected for the "Marine Debris Masks" lesson or "Gyre Dangles" and "Top of the Ocean Mat" stations of the "Effects of Marine Debris Station Rotations" lesson.

Evaluation:

Observe student participation and adherence to stewardship and safety guidelines during the CoastWatch Survey. Assess data sheets for completeness, neatness, and accuracy. Review science notebooks for insightful questions and understanding of what types of long-term monitoring are useful.
Counting Beads and Bobbles

Objective:
Students will experiment with a sampling technique and form inquiries about effective sampling techniques.

Concept:
It is important to have a uniform sampling tool and guidelines, protocols, for selecting how and where to sample so that data that is collected is an accurate representation of what was sampled and can be compared with data collected in other areas using the same protocol worldwide.

Materials:
- Bucket of beads and plastic shapes
- Slide holders or index cards with center cut out
- Large cafeteria trays
- Handout: Beads & Bobbles Data Sheet

Introduction:
Divide students into groups of 3-5 people.
Distribute cafeteria trays with various beads and bobbles on them to each group of students.
Tell them they will be counting the number of a certain type of bead found on their "beach" tray. Each beach tray represents a section of a beach and their goal is to find out how many of a certain kind of bead can be found on the beach. Each group needs to get an estimate of the total number of these beads found on their "beach" tray.
Give them 30 seconds and tell them to begin counting.

Activities & Procedures:
After 30 seconds discuss the results with the students.

Brainstorm ideas for a more efficient way to sample their "beach."
Introduce the idea of "random sampling" to get an estimate of population density. Discuss possibilities for making the sampling uniform.
Introduce the slide holder which will represent a quadrat - a common unit for sampling - as a means of getting a "population" estimate.
Pass out the data sheet. Instruct the students to randomly toss their quadrat onto their "beach" tray and count the number of beads in the quadrat.
Continue to follow the instructions on the Beads and Bobbles Data Sheet.

Wrap-up:
When everyone has finished share your results and discuss the follow-up questions as a class:
1. How close was your answer to your estimate?
2. What would make the instructions clearer?
3. Did we really answer the question of how many beads are in on our "beach"? If not, how could we?
4. How does this relate to how you might count the number of snails on a seashore?

Extensions & Lesson Connections:
This lesson is designed as a preface to the intertidal monitoring lessons included in Unit 3.

Evaluation:
Assess data sheets for completeness and accurate computation. Evaluate student participation and cooperation during group work.
Beads & Bobbles Data Sheet

1. Estimate how many beads you think are on the beach. __________

2. Toss a slide holder (your quadrat) onto your beach tray. __________

3. Count the number of beads in the quadrat. __________

4. Repeat steps 2 and 3. Record the number of beads. __________

5. Repeat steps 2 and 3. Record the number of beads. __________

6. Add the number of beads in the three quadrats (steps 3-4). __________

7. Divide the answer in step 6 by the number 3 to get the average number of beads in a quadrat.

\[
\frac{\text{step 6}}{3} = \text{__________} \text{__________}
\]

8. Measure the area of the beach tray. __________

9. Measure the area of the quadrat. __________

10. Divide the answer on step 8 by the answer in step 9 (area of beach tray/area of quadrat) to get the total number of quadrats in a beach tray.

\[
\frac{\text{step 8}}{\text{step 9}} = \text{__________} \text{__________}
\]

11. Multiply the answer in step 10 by the answer in step 7 (number of quadrats on a tray times the number of beads per quadrat) to get the average number of beads on a tray.

\[
x = \text{__________} \text{__________} \text{__________}
\]

12. Multiply the answer in step 11 by the number of trays on the "beach" to get the average number of beads on the beach.

\[
x = \text{__________} \text{__________} \text{__________}
\]
Sampling for the "e" Organism

Objective:
Students will experiment with a sampling technique and form inquiries about effective sampling techniques.

Concept:
It is important to have a uniform sampling tool and guidelines, protocols, for selecting how and where to sample so that data that is collected is an accurate representation of what was sampled and can be compared with data collected in other areas using the same protocol worldwide.

Materials:
- Newspapers
- Handout: Sampling the "e" Organism Data Sheet
- Slide frames
- Rulers
- Calculator (optional)

Preparation:
This activity is best done by older students (grade 7-12) or as a follow up to the Beads and Bobbles Activity. Make copies of the Sampling the "e" Organism Data Sheet for students.

Introduction:
Introduce the activity by telling your students that the class has the task of determining how many "e's" are used in a newspaper. Ask students for strategies that could be used to count the "e's." List all possibilities.

Explain that they will be counting the number of "e's" used in their section of paper to get an estimate of the total number of "e's" found in a newspaper.

Activities & Procedures:
Distribute a section of newspaper to each student.

Give students 3 minutes to count the "e's." After 3 minutes discuss the results with the students.

Brainstorm ideas for more a more efficient way to sample the newspaper. Introduce the idea of "random sampling" to get an estimate of population density.

Discuss ways to make the sampling uniform. Introduce the slide holder which will represent a quadrat (a common unit for sampling) as a means of getting a "population" estimate.

Pass out the Data Sheet. Instruct the students to randomly toss their quadrat onto a the newspaper and count the number of "e's" in the quadrat. Continue to follow the data sheet instructions.

Wrap-Up:
Discuss the meaning of "sampling" and what some objectives might be for sampling various things.

Have students share their results and discuss these follow-up questions as a class:
1. How close was your answer to your estimate?
2. What would make the instructions clearer?
3. Did we really answer the question of how many "e's" are in a newspaper? If not, how could we?
4. How does this relate to how you might count the number of snails on a seashore?

Extensions & Lesson Connections:
This lesson is designed as a preface to the intertidal monitoring lessons included in Unit 3.

Evaluation:
Assess data sheets for completeness and accurate computation. Evaluate student participation and cooperation during group work.
Sampling the "e" Organism Data Sheet

1. Estimate how many "e's" you think are in the newspaper  
   ________

2. Toss a slide holder (your quadrat) onto a single sheet of newspaper. 

3. Count the number of "e’s" in the quadrat.  
   ________

4. Repeat steps 2 and 3. Record the number of "e's."  
   ________

5. Repeat steps 2 and 3. Record the number of "e's."  
   ________

6. Add the number of "e's" in the three quadrats (steps 3-4)  
   ________

7. Divide the answer in step 6 by the number 3 to get the average number of "e's" in a quadrat.  
   ________ / 3 = ________

8. Measure the area of the newspaper page  
   ________

9. Measure the area of the quadrat  
   ________

10. Divide the answer on step 8 by the answer in step 9 (area of newspaper page/area of quadrat) to get the total number of quadrats in a newspaper page.  
    ________ / ________ = ________

11. Multiply the answer in step 10 by the answer in step 7 (number of quadrats on a page times the number of "e’s" per quadrat) to get the average number of "e’s" on a page.  
    ________ x ________ = ________

12. Multiply the answer in step 11 by the number of pages in the paper to get the average number of "e's" in the newspaper.  
    ________ x ________ = ________
Practicing Protocols

Objective:
Students will become familiar with the specific data entry forms for the monitoring activity you have chosen by practicing in the classroom.

Concept:
By becoming familiar with the data forms used on the beach to collect data in the field, students will be able to maximize their time in the field and will collect better quality data.

Materials:
- Copies of the relevant data sheets
- Large photos of the beach
- Quadrat
- Stopwatch

Preparation:
For this lesson, you’ll need to think about the monitoring activities you want your class to participate in. Make copies of the data sheets for the monitoring project(s).

Introduction:
Explain to your students that you will be monitoring certain species during your field trip to the intertidal zone.

This lesson is a chance to practice with the real data sheets that will be used during your field trip. Being familiar with the data sheets and the information that is to be collected, will improve their experience at the beach and make the data collected more useful.

Activities & Procedures:
Choose one of the following activities to do with your class based on which intertidal monitoring field activities you have chosen to do with your class.

Coastwalk Scavenger Hunt
Divide the class into pairs.

Provide each pair with the Coastwalk Data Sheet and a large photo of the beach.

Do a scavenger hunt to find as many items on your Coastwalk data sheet as possible.

When you have completed your organism scavenger hunt go outside (or to the lunch room) and look for signs of human impact in your schoolyard and collect data on trash found.

Come back together as a class and discuss your findings and answer any questions that came up while practicing the Coastwalk protocols.

Playground Protocols - Timed Counts
Divide your class into groups of 4.

Assign each group an "animal" to count. Your "animals" can be anything that is found in some quantity on your playground. For example, you can count trash, certain color rocks, or pre-planted items such as cones, balls, and popsicle sticks.

Give the groups their data sheets and use a whistle to signal the start time. You may want to modify the count time to be only 5 minutes if your area is small or there are not very many of the items you are counting.

Have students count their "animals" for the designated time and, when signaled, stop counting and regroup to go over their findings.

Lead a discussion about what assumptions can be made about playground use based on their findings.
Practicing Protocols Continued

Go over any problems or situations that may have come up such as picking up the item and moving it or keeping it, more than one person counting the same item, how to spread out and cover the most ground as a group, etc.

Switch items to count and do the activity again if time permits.

Photo Quadrat Practice

Using enlarged photos of a section of beach and your quadrat data sheets, have students work in groups of 4 to practice counting organisms in the quadrat and recording data.

Have students practice looking for the area where their organism seems most dense and counting and randomly tossing their quadrat and counting organisms.

Discuss the protocols for counting organisms that are only part-way in the quadrat.

Tally your findings and try to identify your organisms.

Practice on various photographs - or beach sections - if there is time.

Wrap-up:

Discuss the protocol(s) used as a class. If you will be using more than one protocol, compare and contrast the different ways of counting organisms.

Talk about ways the counts can be skewed. What do they need to do to ensure the most accurate count possible?

Be sure to provide time for students to ask questions about the protocols.

Extensions & Lesson Connections:

This lesson is intended to follow either "Sampling for the 'e' Organism" or "Counting Beads and Bobbles" and as an introduction to protocols for the intertidal monitoring projects.

The Alaska Seas & Rivers Curriculum has a great sampling lesson you can do as an extension that explores how researchers direct remote operated vehicles to collect data in undersea canyons (http://seagrant.uaf.edu/marine-ed/curriculum/grade-6/investigation-2.html?task=view).

Evaluation:

Assess data sheets for completeness and accurate computation. Evaluate student participation and cooperation during group work and contributions during class discussions.
Intertidal Sampling

Objective:
To explore the beach and become familiar with the plants and animals in the marine intertidal habitat while collecting some basic observational data. Specifically to answer the question: What is the density of common marine invertebrates on ocean coasts statewide?

Concept:
This data will create a baseline for densities of common invertebrates on coastal shores worldwide. The data will allow us to monitor the health of coastal ecosystems by providing us with data to track changes in densities of these common organisms over time and across multiple sites.

Materials:
- Density Quadrats (see instructions at end of lesson)
- Frequency Quadrat (at least 1)
- Timer or watch (for timed counts)
- Handouts: Relevant Data Sheets
- Clipboards
- Pencils or pens (with waterproof ink)
- Tide chart
- GPS and camera (optional)

Preparation:
Consult a tide chart or calendar to determine a day and time for your visit when there will be a low tide at the site. Prior to your trip, divide the class into pairs of students. Plan to arrive before low tide so that you have time to explore the lowest tide levels while they are out of the water.

Students will estimate the densities of certain broad categories of animals, common on many coastal shores worldwide. They will estimate the density, or frequency of common invertebrates in areas in the intertidal where they determine each invertebrate is common. There is a choice of sampling methods and species to count depending on which the class decides is best at their site.

The choices for sampling methods are to estimate:

1) density using quadrats 25x25 cm and estimating a maximum density (the average of 3 quadrats with the most you can find), and average density (the average of 3 quadrats tossed randomly in the same general area), or

2) frequency (presence or absence of species in a 50x50 cm quadrat divided into 25 equal sized squares, tossed 3 times), or

3) timed counts (number counted in 10 minutes of counting). The choices of species are snails, limpets or chitons, barnacles, a bivalve (mussels, oysters, clams or scallops), an echinoderm (seastars, sea urchins or sea cucumbers), or crab.

You may find you use all of these methods for different groups of animals, based on their characteristics, or you may want to limit your class to one or two of the sampling methods. Choose the sampling methods you will use and make copies of the relevant data sheets.

Introduction:
On the day of your first trip, discuss with your students the characteristics of your site, particularly the area where you are sampling:

What is the substrate mostly?
Rock, cobble/boulder, sandy, muddy
Intertidal Sampling Continued

What is the exposure to the open ocean?
*Open coast, protected bay, semi-protected.*

What general name would you give your site from the following (choose one, best)?
*Sandy bay, mudflat, rocky shore, cobble beach, sandy beach, estuary, sand with some rocks, rock with some sand*

Explore your site and choose the animals that you will count. It is strongly encouraged that you complete a Discovery Hike first to familiarize you and your students with the beach site and allow you to make a list of the most common animals at your site. On sandy shores, you can also count holes/casings/casts on the sand. Plan to count five categories of animals.

**Activities & Procedures:**

For each animal you are going to count, decide on what seems to be the best mode of sampling (maximum and average density, frequency sampling, or timed counts). As a class, first, spend 10 minutes trying out a sampling mode. If it doesn’t work well (takes too long to count, or animals are too rare for a quadrat count, or too numerous), switch to a different sampling mode.

Assign each pair of students a single category of animal to count either using a quadrat, or a timed count.

Once each team has a designated category and measurement technique (quadrats or timed counts) assigned, provide the necessary data sheets and send them to their particular area where the category is known to be common.

Have students collect their data on the corresponding Rocky Shore Monitoring data sheets. If you are doing timed counts as a group, a student or the teacher can be designated to give the signal for starting and stopping the counts.

**Sampling Methods:**

**Density Quadrats** (25x25 Quadrat): Find an area where the category of animal is very common.

Intentionally choose three sites where you find the most individuals in a quadrat and count the number in 3 different quadrats (maximum counts). Include any animal that is present in your quadrat, even if it is only part-way in the quadrat. Record these counts on your data sheet.

Then, in the same general area, toss the quadrat over your shoulder so that it lands at random but within the area where that animal occurs.

Count all of the individuals in that category that occur in the quadrat where it lands. Repeat this process three times. Record these counts on your data sheet.

**Frequency Quadrats** (50 cm x 50 cm quadrats, divided into 25 squares). Toss the quadrat 10 times at random in an area where that species is common.

Count presence or absence in each of the 25 squares of the quadrat. Record this data on your data sheet.

You will have a maximum of 25 for each quadrat. For example, you might find that the animal occurs in 10 of the 25 squares. This would be a frequency of 10/25 = .40 for that quadrat.
Intertidal Sampling Continued

If an individual is partway in the square, include it as “present” if it is more than halfway.

**Timed Counts.** If you are doing timed counts as a group, assign a student or teacher to give the signal for starting and stopping the counts.

Groups doing timed counts will need to search in a limited area where the category of animal is known to occur. For example, if you are searching for seastars, go to where you know that seastars occur, then start your 10 minutes of counting. Count only one category at time.

Record counts on the data sheet.

**Wrap-Up**

Photograph or videotape the site facing in all four compass directions (4 photos). This way you can keep track of major changes in the site over time. Also, note visual landmarks, make a sketch map, and take a GPS reading. Record the common name of the beach. This information will help you or another class to return to the same beach on future sampling times.

Ask students to describe the following in their science notebooks:

- The most interesting thing you saw
- Something that surprised you
- An organism you would like to learn more about
- A question you have about your data
- One category of animal you think should continue to be monitored on the beach, and why you chose this category

Discuss their responses as a class.

Pool the data from all groups and calculate the average for each method of sampling in each category of animal. Record the number of values (called “N”) that went into each average. For example, if 10 groups counted 3 quadrats each of chitons in density quadrats, that would be $10 \times 3 = 30$ values that went into that average. Explain that averages from categories with higher "N" values tend to be more accurate.

Submit the data to the Center for Alaskan Coastal Studies.

**Extensions & Lesson Connections:**

Work with students to design an inquiry as a class or in teams of students. See the background information for guidelines.

Ask students to present their data in a poster, powerpoint, or other visual format for sharing during a "Celebrate the Sea Party."

Repeat the survey over time and graph changes in animal abundance or distribution.

**Evaluation:**

Observe student participation and adherence to stewardship and safety guidelines during the Intertidal Sampling. Assess data sheets for completeness, neatness, and accuracy. Review science notebooks for insightful questions and understanding of what types of long-term monitoring are useful.
Background Information:

Random sampling can yield data with very low or no numbers, and can produce unreliable data when the habitat being sampled is highly heterogeneous, and where many species have clumped and/or very sparse distributions over the landscape. This is especially true for rocky shore habitats where tidal elevation can change dramatically over a short distance and where many microhabitats exist from tide pools to rock crevices. For this reason, we ask you to actively choose areas in the intertidal zone where the organism you are interested in is very common, for example, the barnacle “zone”. Within that zone, you then randomly throw quadrats and count the number of animals in each quadrat.

Instructions for making quadrats:

Density Quadrats: Using pvc tubing and elbow joints, cut tubing so that the inside dimensions of your square measure 25 cm x 25 cm. You will need one quadrat for each pair of sampling students.

Frequency Quadrats: Using pvc tubing and elbow joints, cut tubing so that the inside dimensions of your square measure 50 cm x 50 cm. Divide your quadrat into 25 equal sized squares marked with string. You will need one quadrat for each pair of sampling students.
GLOBE Weather Monitoring

Objectives:
Students will collect data about atmospheric weather conditions, including cloud type & cover, barometric pressure, temperature, and precipitation. This data will be submitted to GLOBE for international monitoring activities. Students will better understand how abiotic factors like weather influence living organisms.

Concept:
Students will contribute data to an international weather monitoring program. GLOBE is a unique citizen science program that encourages students and community members to participate in general observations about weather and environment. Students and scientists investigate the atmosphere through the collection of data using measurement protocols and using instruments that meet certain specifications in order to ensure that data are comparable. Learning activities aid in the understanding of important scientific concepts, the understanding of data and data collection methodologies.

Materials:
- Handout: GLOBE Weather Data Sheet
- Clipboards
- Pencils
- Thermometer
- Rain Gauge (optional)
- Board for measuring snow (optional)
- Cloud Type Poster
- Cloud & Contrail Cover Guide
- Beaufort Wind Scale

Preparation:
Set up a weather station near your school. Try to select a site that will not be strongly affected by surrounding buildings.

Ideally, your weather station will include a thermometer that includes a way to mark maximum and minimum temperatures, rain gauge, and snowboard, as well as more advanced equipment like a sling psychrometer (relative humidity) or barometer (pressure). If you cannot include all of this equipment, simple measurements like temperature, cloud cover, and cloud type are useful too.

To estimate wind speed, you can find an easy-to-read, land-based Beaufort Wind Scale chart at the Mount Washington Observatory Weather Discovery Center: http://www.mountwashington.org/education/center/arcade/wind/beaufort.html or a NOAA chart with descriptions of both land and sea can be found at http://www.spc.noaa.gov/faq/tornado/beaufort.html

This lesson includes a data sheet with many categories, but you may create your own specific to the parameters you choose to measure. Some GLOBE data should be collected as close to “local noon” as possible. However, it is better to collect data at a different time than not at all, so do not let this dissuade you.

Introduction:

Explain to students that they are going to participate in a global weather monitoring program. The data they collect will be combined with data from all over the world to help scientists understand conditions in the atmosphere and learn more about weather (day to day conditions) and climate (conditions over time).

Procedures & Activities:

Head outside with the data sheets to the weather station to read the instruments. You will need to demonstrate how to read each instrument on the
first day of the project. On following days, skip this demonstration.

Break students into teams, depending on the size of the class and the amount of data you are collecting. For example, if your class is small and you are collecting a lot of data, one team could be the “water team” and read and record information from the hydrometer, rain gauge, and precipitation pH tests. If your class is large and you are only collecting data for a few parameters, you could have a larger team read and record data for only one parameter, or you could have each team record all parameters you are measuring and compare results between groups, deciding on the most accurate data for each parameter.

**Possible Parameters to Measure:**

**Cloud Type:**
Look at all the clouds in the sky, look in all directions, including directly overhead. Be careful not to look directly at the sun. Identify the types of clouds that you see using a cloud type poster or GLOBE Cloud Observation Chart: [http://www.globe.gov/documents/348614/351665/atmo_ds_cloudsobs.pdf](http://www.globe.gov/documents/348614/351665/atmo_ds_cloudsobs.pdf).

Check the box on your Data Sheet for each and every cloud type you see. There are three types of contrails. Record the number of each type you see. This online story book can be a good resource for cloud identification, as well: [http://www.globe.gov/documents/348830/350460/ElementaryGLOBE_Clouds_en.pdf](http://www.globe.gov/documents/348830/350460/ElementaryGLOBE_Clouds_en.pdf)

**Cloud Cover & Contrails:**
Look at the sky in every direction. Estimate how much of the sky is covered by clouds that are not contrails.

Using the Cloud & Contrail Cover Guide, record which cloud classification best matches what you see. Record which contrail classification best matches how much of the sky is covered by contrails.

**Temperature:**
Open the instrument shelter being careful not to touch or breathe on the thermometer.

If you are using a mercury thermometer, position yourself so that your eye is level with the mercury in the thermometer. Read the current temperature.

If you have a max/min thermometer, read the bottom of the indicators for maximum and minimum temperatures. Record on the data sheet. Use the magnet to gently move the maximum and minimum indicators down until they just touch the mercury.

If you are using a digital thermometer, use the buttons to toggle through current, maximum, and minimum temperature. Record on the data sheet. Reset by holding the button down for one second.

Close the instrument shelter.

**Rain Gauge:**
Read the level of the water in your rain gauge; be sure your eyes are level with the water in the measuring tube. Read the level at the bottom of the meniscus.

Record the rainfall amount to the nearest one-tenth of a millimeter.

Pour the water into the sampling jar and cover it for the pH measurement, if you will be testing that.
GLOBE Weather Monitoring Continued

Record the number of days rain has accumulated in the gauge. (The number of days since the rain gauge was last checked and emptied.) Dry the rain gauge and remount it on its post.

Snow:
Insert the measuring stick vertically into the snow until it rests on the ground. Be careful not to mistake an ice layer or crusted snow for the ground.

Read and record the depth of the snowpack.

Repeat the measurement in at least two more places where the snow is least affected by drifting. Report all three of these numbers as the total snowfall.

After a new snow has fallen on earlier snow, gently insert the measuring stick vertically into the snow until it touches the snowboard. Read and record the depth of new snow. If there is new snow, take at least two more measurements at different spots on the snowboard. Report these numbers as the depth of new snow.

Record the number of days since the last reading of snow on the snowboard.

Wind Speed and Direction:
GLOBE does not actually collect data on wind speed and direction, but it is an important component of understanding and predicting weather and the movement of currents, marine debris, and pollution.

To measure wind direction, use a wind direction instrument such as a wind sail or slowly rotate your body until you feel the most wind. Winds are identified by the direction from which they are coming. So if your wind sail is pointed south, the wind is a north wind because it is coming from the north, blowing to the south. Use the Beaufort Wind Scale to calculate speed.

Other measurements:
Other parameters include precipitation pH, aerosols, barometric pressure, relative humidity, surface temperature, soil temperature, ozone, and water vapor. Check the GLOBE Atmospheric Conditions webpage for more information on how to measure these parameters: http://www.globe.gov/web/atmosphere-climate/overview.

Wrap-up:
Use the daily weather data to remind students what they might need to wear for recess or field trips. Discuss how the weather might affect various organisms in the surrounding ecosystems.

Extensions & Lesson Connections:
Weather observations can be used along with readings from the homemade barometers to make and test daily weather predictions as outlined in the “Pressure & Storms” Lesson.

Have students graph weather conditions throughout the monitoring project. Visit the GLOBE data portal (http://vis.globe.gov/GLOBE/) to compare your weather to other areas of the world.

Use the data you have collected to make predictions in other activities, such as “Popcorn Spill” or “Plastics in Motion.”

Evaluation:
Observe student participation and cooperation in data collection. Review data sheets for accuracy, completeness, and neatness.
## Cloud & Contrail Cover Guide

<table>
<thead>
<tr>
<th>Cloud Cover Classifications</th>
<th>Contrail Cover Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Clouds</strong></td>
<td><strong>None</strong></td>
</tr>
<tr>
<td>The sky is cloudless; there are no clouds visible</td>
<td>There are no contrails visible.</td>
</tr>
<tr>
<td><strong>Clear</strong></td>
<td><strong>0-10%</strong></td>
</tr>
<tr>
<td>Clouds are present but cover less than one-tenth (or 10%) of the sky.</td>
<td>Contrails are present but cover less than one-tenth (or 10%) of the sky.</td>
</tr>
<tr>
<td><strong>Isolated Clouds</strong></td>
<td><strong>10-25%</strong></td>
</tr>
<tr>
<td>Clouds cover between one-tenth (10%) and one-fourth (25%) of the sky.</td>
<td>Contrails cover between one-tenth (10%) and one-fourth (25%) of the sky.</td>
</tr>
<tr>
<td><strong>Scattered Clouds</strong></td>
<td><strong>25-50%</strong></td>
</tr>
<tr>
<td>Clouds cover between one-fourth (25%) and one-half (50%) of the sky.</td>
<td>Contrails cover between one-fourth (25%) and one-half (50%) of the sky.</td>
</tr>
<tr>
<td><strong>Broken Clouds</strong></td>
<td><strong>&gt; 50%</strong></td>
</tr>
<tr>
<td>Clouds cover between one-half (50%) and ninetenths (90%) of the sky.</td>
<td>Contrails cover more than one-half (50%) of the sky.</td>
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<tr>
<td><strong>Obscured</strong></td>
<td><strong>Obscured</strong></td>
</tr>
<tr>
<td>Clouds cannot be observed because more than one-fourth (25%) of the sky cannot be seen clearly.</td>
<td>Contrails cannot be observed because more than one-fourth (25%) of the sky cannot be seen clearly.</td>
</tr>
</tbody>
</table>

Record what is blocking your view of the sky:
- Fog
- Smoke
- Haze
- Volcanic Ash
- Dust
- Sand
- Spray
- Heavy Rain
- Heavy Snow
- Blowing Snow
Cleaner Harbor Tour

From the Alaska Oil Spill Curriculum, Prince William Sound Regional Citizens Advisory Council.

Objectives:
Students will identify and analyze non-point sources of pollution in a local area. They will learn about efforts to minimize pollution and create their an action plan to prevent and clean-up pollution.

Concept:
Preventing and cleaning-up small amounts of pollution can make a difference for animals, people, and ecosystems. In coastal areas, oil from tiny spills, leaks, and bilge water from recreational, subsistence, and commercial vessels can be a major problem. Oil is just one type of pollutant that can have adverse short and long-term effects on animals, people, and ecosystems.

Materials:
- Science notebooks
- Pencils
- Clipboards (1 per group)
- Handout: Pollution Data Sheet

Preparation:
This activity works best as a field trip to a local harbor or port, especially if you are able to meet with the Harbormaster or other official or volunteer who works to keep the harbor clean.

Introduction:
Explain to students that you are going to be investigating the local harbor (or school parking lot), looking for evidence of oil pollution and other types of pollution.

Tell them that although major oil spills have devastating impacts on ecosystems, as much as 10 times more oil makes its way into the oceans each year from improper disposal of motor oil and oil leaks.

Set expectations for safe and respectful behavior, being mindful that it is a working harbor (or busy parking lot).

Activities & Procedures:
When you arrive at the harbor, divide students into groups of 4-6 and provide each group with a clipboard, data sheet, and pencil.

Instruct the students to examine the area and look for evidence of pollution. Any pollution they find, whether it be oil, litter, etc. should be recorded and described on their data sheet. If they can’t identify the pollution, direct them to sketch it.

If you have no harbor or port to visit, a quick trip to the school parking lot will probably yield evidence of motor oil. Try to time your visit when there won’t be much traffic.
After 15-20 minutes, have the groups analyze their data and write the 5 most common types of pollution in the science notebooks.

Then have each group present the type of pollution they noted most frequently. Discuss any differences in the data sets.

Before you leave the harbor, look for proper oil disposal sites and posters about clean boating.

If possible, meet with the Harbormaster or other harbor employee/volunteer at the harbor or invite them back to your classroom. Ask them to explain a little bit about efforts to keep the harbor clean. Provide a chance for students to ask questions. If you have visited the parking lot, ask a custodian or janitor to speak with the class, or ask someone from your community’s waste management facility.

Wrap-Up:

Discuss possible impacts of pollution in the harbor. How does it affect the students? Ask students how the pollution gets there. Who is responsible for it? Have students raise their hands if they know someone who has had an accidental fuel spill, oily bilge, or oil leak before. Brainstorm ways to minimize pollution in the harbor or parking lot, and have students write at least five ideas in their science notebook.

Work as a class to implement one idea for action, such as providing oil absorbent pads to boaters, or have each student create a poster or radio public service announcement about preventing pollution.

Extension & Lesson Connections:

Have students present or implement their action plan at the "Friends of the Sea Party" described in Unit 6.

This lesson also pairs well with the "Popcorn Spill" lesson.

Evaluation:

Evaluate students on successful completion of the pollution datasheet, cooperation within their group, and adherence to directions and safety precautions. Check science notebooks for accurate analysis of data and understanding of ways to minimize oil pollution.
Pollution Data Sheet

<table>
<thead>
<tr>
<th>Type (litter, oil, fishing gear, other)</th>
<th>Description</th>
<th>Location</th>
<th>Size or Amount</th>
<th>Sketch</th>
<th>Notes</th>
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</table>

Where did you find the most pollution?

How could this pollution be prevented?
Unit 4: History of Human Uses of Marine Ecosystems

Essential Questions:
How do people affect coasts and the ocean?
How can people protect coasts and the ocean?
What is the role of technology in protecting our coasts and the ocean?
How can people study coasts and the ocean?

Enduring Understandings:
- Pollution knowingly or unknowingly introduced into the ocean by people can have negative effects on marine ecosystems.
- You can minimize the solid and liquid pollution you are introducing into the ocean.
- Everyone is responsible for caring for the ocean.
- Making informed decisions as a consumer helps to protect the ocean.
- You can create new ways to care for the ocean and get others involved.
- Technology can have unintended consequences.
- Traditional knowledge, culture, stories, and long-term observations are important ways to learn more about marine ecosystems.
- Monitoring the same area over time can reveal local and global changes in marine ecosystems.
- Overusing plants, animals, and other ocean resources can disrupt marine ecosystems.

Lessons in this unit:
- Human-Coastal Connections
- Fishing Over Time
- Community Interviews: Changing Technology
- Graphing Marine Debris Trends
- Ocean Full of Debris Game
- Marine Debris Source Sorting Relay
- Bentwood Hats
- Plastic Polymer Lab
- Plastics in Society
Human-Coastal Connections


**Objectives:**
Students will understand how humans are connected to the ocean and other living things. They will appreciate their own connections to the ocean.

**Concept:**
Marine resources are an important part of Alaska’s history, culture, and economy. In this simple activity, students have a chance to reflect on their own connections to the ocean.

**Materials:**
- Science notebooks
- Pencils

**Preparation:**
Draw a concept web graphic organizer on the board. An example is included on the next page.

**Introduction:**
Share with the class a story about your own personal connection to the ocean – maybe fishing, kayaking, or other marine pursuits and industries.

**Activities & Procedures:**
Ask students to replicate the concept web graphic organizer in their science notebooks and fill it in with their personal and community connections to the ocean. They should put their own names at the center of the web, and also include connections between other parts of the web. (i.e., they are connected to their uncle, the fisherman; and to their aunt, the marine biologist, and those two are connected to each other. Or, they eat salmon, they have an uncle and the uncle fishes for salmon, they love to watch eagles and eagles eat salmon.) Help students focus on finding significant connections, rather than simply listing as many as they can.

**Wrap-up:**
Have students respond to one of the following prompts in their science notebooks:

1. How and why the ocean is important to me, OR
2. How would my life change if I had no connections to the ocean?

Lead a class discussion based on their responses to the prompts.

**Extensions & Lesson Connections:**
Have each student write a thank you note to the ocean for all it provides to him or her and the community.

This lesson works well in conjunction with the “Fishing for the Future” and “The Legend and Science of the Bidarki” lessons.

**Evaluation:**
Assess student understanding of ocean connections through their completed graphic organizers and response to the wrap-up prompt.
Example Concept Web Graphic Organizer
Fishing Over Time

**Objectives:**
Students will understand how technological advances can change individual success in fisheries. They will become familiar with the concept of sustainability and discuss ways that technology can alter sustainability outcomes.

**Concept:**
Fishing is an important part of Alaska’s history, culture, and economy. However, marine resources such as fish are often at risk of being overexploited. As technology improves, fish stocks become more susceptible to overfishing. Sustainable fishing practices must be adopted to ensure that fishing continues to be a cherished part of Alaska’s culture and economy in the future, and to maintain and restore the health of ocean ecosystems. Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive.

**Materials:**
- Science notebooks
- Pencils
- Smoked salmon or other fish to sample
- Handout: Fishing History Fact Sheet
- Handout: History of Fishing in Alaska
- Digital Resource: 50 Years of Fishing In Alaska
- Book: Commercial Fishing In Alaska, Alaska Geographic Series

**Preparation:**
Optional: Contact an elder or retired fisherman in your community and invite them to visit the class. Roby Littlefield’s guidelines to “Elders in the Classroom” is an excellent resource as you work to involve Elders and community members in your classroom activities: [http://www.ankn.uaf.edu/publications/handbook/littlefield.html](http://www.ankn.uaf.edu/publications/handbook/littlefield.html).

Borrow a copy of *Commercial Fishing in Alaska*, from the Alaska Geographic Series. This may be available from your local library, and is included in the CACS teaching kit that accompanies this curriculum.

Make copies of the “History of Fishing in Alaska” info sheet so that each group has access to information on their focus fishery.

Load “50 Years of Fishing in Alaska” on a computer that students can access, or provide a couple of print copies for classroom use.

**Introduction:**
Ask students to tell the class about different ways that they have caught fish, and list the types of technology that they have used for fishing (fishing pole, dip net, gill net, etc.).

**Activities & Procedures:**
Choose one of the methods and discuss how it has changed over time. See the Fishing History fact sheet and History of Fishing in Alaska handout for guidance, if you are not familiar yourself.

Use the “50 Years of Fishing in Alaska” report or Alaska Geographic’s book, Commercial Fishing In Alaska, to show a few photos and/or illustrations of how fishing technology has changed over time.

Split students into groups of 3-5 and have them choose one of the following fisheries:
- Salmon
- Halibut
- Crab
- Herring
- Cod
- Scallops
Fishing Over Time Continued

Using the Fishing History fact sheet, Commercial Fishing in Alaska, and other resources, students should research how their fishery has changed over time, answering at least 5 of the following questions in their science notebooks:

- Was this type of fish/invertebrate traditionally harvested by Alaska Natives? If so, how and where?
- When was this fish/invertebrate first caught commercially?
- What type of commercially fishing gear was first used on this fish/invertebrate?
- How was this type of fish/invertebrate sold originally (salted, canned, etc.)?
- What is one major technology change in gear or boats that changed this fishery?
- What is one major technology change in processing or finding fish that changed this fishery?
- When did this fishery reach its peak in either amount of fish/invertebrate caught or value of the harvest?
- What’s the current status of this fishery? How many fish/invertebrates are caught annually? Is the fishery healthy & sustainable or declining?
- Is this fish/invertebrate still utilized as an important subsistence resource?

Then have each group choose two types of gear or technology used in this fishery, past or present, and compare them.

They should answer all of the following questions in their comparison:

- Which technology is older?
- How many fish could be caught at one time?
- How far did you have to go in a day to find fish?
- How many people does it take to use this technology?
- How might fishing with this technology affect other species of plants and animals?

Finally, have groups create a basic timeline of the history of their fishery to present to the class.

After the presentations, compare the different fisheries. Which ones have been affected the most by technological changes? What effects have these changes had on the fish, ecosystems, and local communities?

If possible, invite an elder or someone in your community with many years of experience fishing to join the discussion and to share stories of fishing and how they have seen it change.

Ask what might happen to fish populations as the technology changes.

Introduce and discuss the idea of sustainability:

“Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive.”
Wrap-Up:

Offer the smoked salmon or other fish dish you have brought to share. As you enjoy the fish, discuss how some changes in fisheries promote sustainability while others can threaten it.

Ask students to reflect in their science notebooks, answering the following questions:

- Which fishery do you think is the most sustainable? Why?

Extensions and Lesson Connections:

This lesson works very well in conjunction with the "Fishing for the Future" and "Community Interviews" lessons.

Evaluation:

Review student presentations and responses in science notebooks to assess comprehension and application of the information they have gathered through research. Evaluate student participation and cooperation during group work.
Community Interviews - Changing Technology

Objectives:
Students will understand how technological innovations have changed the economy, ecosystems, and culture of communities in Alaska. They will conduct interviews with local Elders and community leaders to find out how technologies have affected the community.

Concept:
From fisheries to oil development, snacking on pickled kelp to kayaking on the bay, tourist ships to container ships, Alaska’s coastal and marine ecosystems are inextricably linked with the wellbeing of our communities. The use of these resources has changed over time as attitudes have shifted and technology has advanced. Understanding the effects of technology on coastal and marine resources and working to promote the sustainability of these resources is important so that these resources can continue to be a cherished part of Alaska’s culture and economy in the future, and to maintain and restore the health of ocean ecosystems. Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive.

Materials:
- Science notebooks
- Pencils
- Small tokens of appreciation (jam, cookies, etc.)
- Audio or video recorder (optional)

Preparation:
Contact an elder or member of your community and invite them to visit the class. Roby Littlefield’s “Elders in the Classroom” is a great guide as you work to bring Elders and community members into your classroom: http://www.ankn.uaf.edu/publications/handbook/littlefield.html.

Introduction:
If possible, invite an Elder or someone who has lived in your community for many years to speak about how technology has affected the community. Possible topics include, but are not limited to: fishing technology, transportation technology, communication technology, refrigeration/freezing technology, and oil exploration/extraction technology.

If you cannot arrange for a guest speaker, ask students to think about and list some types of technology they use regularly.

Discuss how these technologies have changed over time, and have in-turn affected the people and communities that use it. Has the technology had any unintended negative consequences? Think about how the technology is made and disposed of, and potential impacts on relationships, health, and the environment.

Activities & Procedures:
Explain to students that they are going to conduct interviews with local Elders and other community members about how technologies have created change in the communities.

First, have students think about the people they know that have lived in the area for a long time and have a lot of knowledge about the local community and ecosystems. Help them with suggestions of Elders, grandparents, community leaders, retired teachers, etc.
Each student should list 3 people they would be interested in interviewing, in case some of the people aren’t willing or able to do an interview.

Have each student write a personal note to the first person they want to interview, explaining that they would like to conduct an interview to learn more about their experience living in the community as technology has changed.

If at all possible, students should approach their potential interviewees in person to set up the interview. If they can’t arrange in person, they should drop the note off at the person’s home or send it via the mail or e-mail as appropriate for the individual. Help students decide the best method.

If a first potential interviewee is unavailable, the student should choose someone else from their list.

Once interviews are scheduled, work with students to develop an initial list of questions for the interview. Some possibilities include:

- What has changed the most in this community since you have lived here? Are any technologies connected to that change?
- Describe a technology that has had positive effects on this community.
- Describe a technology that has had negative effects on this community.
- What types of technology have changed the local economy?
- What types of technology have changed the local ecosystems?
- What types of technology have changed the local traditions?
- What types of technology have changed the way we gather, store, and prepare food?
- Do you think technology is a good thing or a bad thing for our community? Why?

Ask students to develop their own questions around the topic, too.

Before students do their interview, provide an example and time to practice in class.

Ask how they feel about interviewing someone. Discuss if they have ever conducted an interview before or seen someone conduct an interview. What are the skills people need to conduct a good interview? (Might include: patience, listening, friendliness, not interrupting, curiosity, etc.)

Model the way an interview might be conducted. Ask a volunteer to come up to the front of the class. Have your volunteer play the role of an interviewee from the community while you model effective interview skills.

Ask the rest of the class to take notes on what you do and say to make the speakers feel comfortable and anything you do or say that they undermines this or makes the interviewee uncomfortable.

Be sure to introduce yourself and get to know the interviewees a bit before you get into the actual questions. Be sure to smile and thank them for their time.

Then ask some of the questions you developed for this topic.
After each major question, be sure to summarize what they said to make sure you understood it correctly, and ask “Did I miss anything important?”

With one of the questions, summarize the answer incompletely. When you ask, “Did I miss anything important?” your interviewee should add the missing information. Be sure to thank them.

At the end of the interview, once again thank the interviewee for their time and let them know how to contact you if they think of anything else or want to change an answer.

Conclude the interview. Then ask the interviewee:

- What did I do to make you feel comfortable?
- Is there anything I did to make you feel uncomfortable?
- What have you learned about interviewing from this experience?

Have other students reflect on the above questions and share their observations with the class.

Divide students into groups of 3. In their group, students should designate an interviewer, interviewee, and observer for the first round.

Have the first interviewer in each group conduct a 5-minute interview. The observers need to take notes on all the positive things the interviewers do to make the interview go well.

After the first round of interviews, have students provide feedback within their groups.

The observers should share their notes with the interviewers and the interviewee should add what the interviewer did to make it a comfortable experience.

Then, have the interviewers ask their groups for suggestions on things they could improve upon.

Have each group conduct 2 more interviews, rotating through the roles so that everyone has a chance to try each one.

At the end, ask students what they’ve learned about interviewing and record their answers on the board.

Finally, have students conduct their interviews outside of class. They should record the answers in their science notebooks or another notebook.

After they finish the interview, they should submit a transcript of the questions and answers.

You may also choose to use audio or video recorders for some of the interviews. If this is the case, guide students on the use of the devices and allow them time to practice in class.

**Wrap-Up:**

Once everyone has conducted their interview, discuss as a class the most interesting things they learned from the interviews: What types of technology were described as having positive or negative effects on the community? What were they surprised to learn? Were any of their own perspectives and opinions about technology changed through the interviews?

Have students write thank you notes to the people they interviewed, including one thing they learned from the interview.
Community Interviews Continued

Work as a class to create small gifts for the interviewees. A great way to do this is to make something from local foods, such as jam, berry muffins, or smoked salmon. If this isn’t feasible, students can used pressed flowers, mushroom prints, or pebbles to make bookmarks or cards.

Extensions & Lesson Connections:

To extend this activity, speak with a local museum or historical society to find out if they would be willing to archive or exhibit the interviews done by your students. Work with the museum/historical society to ensure you have proper permission from the interviewees to use their interviews in this way. Visit the museum/historical society as a class to learn more about the work they do and why they feel these interviews are important to record.

Evaluation:

Assess student understanding of the interview process and changing role of technology by reviewing their interview questions, contributions during discussion, and thank you notes. Evaluate their interview transcripts for completeness and accuracy. Note whether students participate meaningfully in group discussions, and observe their use of cooperation and respectful feedback during interview practice.
Bentwood Hats

Objective:
Students will learn about Alutiiq hunting traditions and techniques by creating and decorating bentwood hunting hats of their own.

Concept:
Students will gain a better appreciation of traditional ways of harvesting marine mammals in southcentral Alaska.

Materials:
- Large sheets of construction paper
- Bentwood Hat Tracing Pattern
- Scissors
- Pens/pencils
- Markers, colored pencils, or paint
- Feathers
- Beads
- Yarn
- Stapler
- Glue
- Hole punch

Preparation:
Copy or trace the bentwood hat tracing pattern onto a large sheet of paper so that it will match the size of your students’ heads. Cut the pattern out.

Introduction:
Ask students to think about the gear they wear when they go out hunting, fishing, berrypicking, or hiking.

Explain to students that hunting visors were traditionally used by Alutiiq sea hunters. The headgear served in a functional way, protecting against sea spray and sun glare and channeling sound to the hunter’s ears.

The visors also held great symbolism and ritual. The headdress was considered a mask that held the hunter’s human shape hidden from their prey, the sea mammals.

The bentwood hats were painted and decorated with amulets of bone, ivory, baleen, feathers, and Russian trade beads.

These hats were highly individualized and reflected the owner’s personality and achievements. More celebrated hunters wore more elaborate visors. Original bentwood hats were brightly colored and carved from wood.

Encourage students to make their hats unique to themselves and their personality.

Procedures & Activities:
Provide each student with a large, clean sheet of paper.

Have each student trace the bentwood hat pattern onto their paper and use scissors to cut out the pattern.

Using markers, paint, or colored pencils, students should decorate one side of their hat to reflect their achievements and personality.

Ask students to think about and incorporate some of their own connections to the ocean in their decorations.

Continue to personalize the hat by adding feathers to the top or beads around the side with yarn and glue.

After allowing sufficient drying time (if needed), bend the hat around the student’s head, connecting the long, slender ends. Staple or tie the ends.
Bentwood Hats Continued

Using the single-hole punch and yarn, create a neck strap to keep the hat from blowing off the student's head.

Wrap-up:

Come together as a group and ask for volunteers to explain what is depicted on their hats, or have everyone take turns presenting their hats.

Extensions & Lesson Connections:

Try this "Spout!" activity to test the hats’ ability to channel sound to their ears by counting the sounds they hear while wearing the hat and not wearing the hat. Have one student sit blindfolded while wearing his or her hat. Arrange the other students at various points in a semi-circle away from them. Have the blindfolded “hunter” point at the source every time they hear the sound of a porpoise spouting. Silently point to the students arranged in the semi-circle. When they are pointed at, they must make the sound of a porpoise spouting by blowing air out their mouth. (Demonstrate how to make the sound and don’t allow students to do it very quietly.) The hunter’s goal is to point directly at the “porpoise” that is making the spouting sound. Keep track of how many porpoises the hunter finds this way. After the hunter misses 3 spouts (either by not hearing a spout or point at the wrong spot), their turn is over. Give a few more students the chance to be the hunter. Discuss what would make it difficult to find a porpoise, whale, sea otter, or seal while hunting on the ocean, and what tricks hunters might have used beyond the bentwood hats.

This lesson works well in conjunction with "Human-Coastal Connections," "Fishing over Time," "Community Interviews" and "The Legend and science of the Bidarki." It could also complement the "Marine Debris Masks" lesson. In fact, you could create bentwood hats of marine debris.

Evaluation:

Observe student effort and craftsmanship during the creation of the bentwood hats.
Plastics in Society

Objectives:
Students will understand important characteristics about plastics and how these properties affect the fate of plastic as marine debris. They will connect their personal use of plastics with the problems of marine debris, and design ways to minimize the improper disposal of plastics.

Concept:
Plastics are a unique and relatively recent technology created by linking monomers together. A variety of polymers and chemical additives are used to make a range of plastics with diverse characteristics. Different types of plastics have different properties that affect the likelihood that the plastic will end up as marine debris and also how the plastic may affect the marine environment. Individuals have great power as plastic users to change their own consumption and disposal habits and influence others to minimize plastic waste.

Materials:
- Science notebooks
- Pencils
- Handout: Estimated Life Span of Plastic Products
- Handout: Plastic Number Chart
- Handout: CoastWalk Plastic Data
- Variety of plastic products
- Laptop/computer and projector or SmartBoard
- Rubric: Plastic Pollution Action Plan

Introduction:
Ask students to look around the room and take note of all the plastic. Think about all the things we use every day that are made of plastic.

Play a game of plastic Scattergories to brainstorm these items with the students.

To do this, think of a category of plastics, or a place they are used. Topics could include “Plastics used in clothing” or “drinks served in plastic,” etc.

Split the students into groups and have each group brainstorm items in that category in a given amount of time- 30 seconds to three minutes.

At the end of every round, have groups share their lists. Each group gets points for each unique response they come up with.

Discuss how prevalent plastic is in society and explain that over 100 billion pounds of plastic was produced in 2013.

Show students the Estimated Life Span of Plastic Products to illustrate that once plastic is produced, it sticks around for a long time.

Procedures & Activities:
Examine different plastic products and look for the number on the bottom.

Divide students into groups of 2-4 people.

Provide students with the Plastic Number Chart and a variety of plastic items. The plastic recycling number on each product indicates the type of polymer and other chemicals in the plastic.

Ask students to sort their plastics by recycling number and then identify what polymers are used in what products.

Have them record this information in their science notebook.
Plastics in Society Continued

Then come together as a class to list the different products found for each category of plastic. Discuss how some types are more easily recycled while others are more difficult to recycle.

Also explain that some numbers of plastics contain or can accumulate toxins. Ask students to think about what this might mean for marine debris issues.

Have students work in their groups to hypothesize what types of plastics are most likely to become marine debris, writing their hypothesis in their science notebooks with an explanation of their reasoning. Have students consider how common each type of plastic is, where products of that type might be used, and how people dispose of them. For example, PETE (type #1) may be common in marine debris because many PETE products like soda bottles are used at the beach and on the water.

Present students with data from CoastWalk and have them determine if their hypothesis is supported or not supported by this data.

Wrap-Up:

Finally, brainstorm solutions to our plastic problem. Ask students to identify where we can cut down on plastic waste most easily (single use items).

Have each student identify one disposable plastic item they can cut back on or eliminate from their personal use.

Then, have students work in groups of 2-4 to develop an action plan to cut back on plastic pollution in their school or community.

Provide examples of successful efforts, such as plastic bag bans, plastic recycling, and reusable water bottles.

Give students the Plastic Pollution Action Plan Rubric so they are clear on the expectations.

Have students begin by identifying at least 3 sources of plastic waste in their school or community, and then give them 15-30 minutes to work as a group to create a draft action plan to minimize plastic waste from one of those sources.

Once all groups have developed an action plan, have groups present their ideas. Discuss the action plans as a class and decide on one to pursue.

Work as a class to revise the chosen action plan and implement it. Depending on the level of the class and the plan you choose, this may be a simple endeavor or may require further time both in and out of class.

Extensions & Lesson Connections:

Have students present or implement their action plan at the "Friends of the Sea Party" described in Unit 6.

Evaluation:

Observe student participation during group work. The successful sorting of plastic types can be used as a measure of cooperation and student understanding. Review student science notebook entries, including plastic type hypothesis. Evaluate these entries for completeness, effort, and understanding of the concepts. Use the Plastic Pollution Action Plan rubric to evaluate draft action plans and presentations.
Plastic Polymer Lab

Objectives:
Students will understand important characteristics about plastics and how these properties affect the fate of plastic as marine debris. They will connect their personal use of plastics with the problems of marine debris.

Concept:
Plastics are a unique and relatively recent technology created by linking monomers together. A variety of polymers and chemical additives are used to make a range of plastics with diverse characteristics. Different types of plastics have different properties that affect the likelihood that the plastic will end up as marine debris and also how the plastic may affect the marine environment. Individuals have great power as plastic users to change their own consumption and disposal habits and influence others to minimize plastic waste.

Materials:
- Science notebooks
- Pencils
- Handout: Estimated Life Span of Plastic Products
- Handout: Polymer Lab
- Elmer’s Glue (1 cup for every 2-4 students)
- Borax (1 teaspoon for every 2-4 students)
- Food coloring (optional)
- Mixing bowls (1 for every 2-4 students)
- Mixing cups (1 for every 2-4 students)
- Spoons (1 for every 2-4 students)
- Ziploc bags
- Gum drops (optional)
- Toothpicks (optional)
- Laptop/computer and projector or SmartBoard

Preparation:
Set up computer and projector or SmartBoard to show the “How It’s Made – Plastic Bags” video by the Discovery Channel on YouTube (https://www.youtube.com/watch?v=8CfL5xl2N1Q). This video on YouTube sometime begins with advertisements, so play through these during your preparation.

Prepare a sample polymer by mixing 1 cup white Elmer’s glue with 1 cup warm water, and a drop or two of food coloring, if you’d like. Combine 1 teaspoon of borax powder with ½ cup warm water. Mix well and then pour into glue mixture, stirring well with a spoon. Once the molecules start to link up, forming a polymer, use your hands to knead it.

Arrange these ingredients, mixing bowls, and measuring spoons and cups on a back table for students to use themselves during the lesson.

Introduction:
Show “How It’s Made – Plastic Bags” – a YouTube video by the Discovery Channel.

Ask students to write down questions and comments in their science notebooks during the video.

Discuss their questions and comments, as well as overall reactions to the video, afterwards.

Procedures & Activities:
Explain that the plastic production process often begins by treating components of crude oil or natural gas in a “cracking process.”
Plastic Polymer Lab Continued

This process creates hydrocarbon monomers such as ethylene and propylene. The monomers are then chemically bonded together to form chains called polymers. In the video, the polyethylene is a polymer made of ethylene monomers.

Simply put, polymers are chemicals made of many repeating units. Explain that polymers are a very important part of our lives. Natural polymers include rubber, silk, plant cellulose & starches, DNA, and proteins such as keratin (wool, hair, feathers) and gelatin (like in jello). There are hundreds of synthetic polymers including glue and plastics such as:
  o Bags and food wraps
  o Polystyrene foam cups, plates, and takeout containers
  o Bottles (soda, juice, milk, water, etc.)
  o Nylon rope and fishing line
  o Clothing (synthetic fleece, spandex, nylon, etc.)
  o Neoprene wet suits
  o PVC plastic pipes
  o Teflon pots and pans
  o Credit and ID cards
  o Absorbent part of disposable diapers

Brainstorm with the class why polymers are useful (they are strong and can be flexible), and have students write at least three important uses for polymers in their science notebooks.

Next, reveal your sample polymer and explain to students that they will make their own polymer using borax and glue.

In fact, the glue is actually already a simple polymer, but the borax crosslinks the polymers in the glue to create a more complex polymer … a type of plastic!

Divide students into groups of 2-4 people.

After making a polymer, explain more about how plastic polymers interact with the natural world. Because of their hardy molecular structures, plastics take a long time to break down. They are not biodegradable. If you bury plastic in the ground and come back in any number of years, it will be intact. Biological organisms, like bacteria and worms cannot decompose it.

However, plastics are photodegradable. When exposed to sunlight for prolonged periods of time, the chains that form plastic polymers begin to change. Sometimes the bonds between the polymers break or oxidize. Where the bonds are changed, the polymer can break. Other times the opposite happens and additional cross-linking occurs between the polymers. Because this can make the plastic less flexible, it can also actually lead to more breakage. As more photodegradation takes place, plastics break into smaller and smaller pieces.

Ask students to think of times they have seen photodegraded plastic -- maybe they’ve left a plastic bag in the sun too long or seen the cracked dashboard of an old car.

Pass out “Estimated Life Span of Plastic Products” to students. Although we have estimates as to how long this process takes based on current rates of degradation, no one is really sure because plastics haven’t been part of the world long enough to know.

Because it takes so long to breakdown, plastic isn’t like other kinds of trash. When it ends up in our landfills and in our oceans, it doesn’t just go away.

Have students write in their science notebooks three ways it is beneficial that plastics don’t biodegrade and three ways it is harmful that
Plastic Polymer Lab Continued

plastics don’t biodegrade.

Wrap-Up:

Ask students to make a list of all the polymers they use in their lives and prioritize them from most to least important.

Identify which of these polymers come from petroleum products (hint: pretty much all plastic products!).

Discuss ways to reduce, reuse, and recycle these things. Could any of the plastic polymer products they use be replaced with something that is more sustainable?

Challenge students to identify at least one plastic polymer product that they will cut out of their “diet” for the next week.

Extensions & Lesson Connections:

Extend this lesson by teaching students more about the chemistry of a polymer. Explain to students that white Elmer’s glue is already primarily composed of the polymers polyvinyl acetate and polyvinyl alcohol. In this experiment they used borax (sodium borate) to cross-link these chain polymers to create a different polymer. The chain polymer is made up mostly of monomers of polyvinyl acetate (C4H6O2) linked together. Provide each group with gum drops in three colors and toothpicks, as well as a diagram of the molecular structure of a chain of polyvinyl acetate. Ask them to create a molecular model using the gumdrops and toothpicks. Each color of gumdrop can be a different element (Carbon, Hydrogen, and Oxygen) and the toothpicks represent the bonds between them. Below is a diagram of the molecular structure of polyvinyl acetate. Since it is a polymer, after all, the smaller monomers repeat over and over again. The diagram below has two molecules of the monomer C4H6O2 linked together:

Once each group has created their basic polyvinyl acetate model with gumdrops, explain that the borax (sodium borate) crosslinks these polymers at the acetate groups (C2H3O2) that “hang off” the polymer. This results in the long chains of polyvinyl acetate being linked together, which reduces the viscosity of the compound, making it more solid and “bouncy.”

This lab pairs well with the "Plastics in Society" lesson.

Evaluation:

Observe student participation during group work. The successful creation of polymer slime can be used as a measure of cooperation, student understanding, and ability to follow multi-step directions and measure ingredients. Review student science notebook entries, including uses of polymers, and the pros and cons of plastic not biodegrading. Evaluate these entries for completeness, effort, and understanding of the concepts.
Polymer Lab

1. You will need 1 mixing bowl and 1 mixing cup and a spoon.

2. Go back to the table to measure 1 cup of glue and 1 cup warm water into your mixing bowl.

3. Mix \( \frac{1}{2} \) cup warm water and 1 teaspoon of borax into your mixing cup.

4. Return to your desks.

5. Mix the borax mixture into the glue mixture and stir well.

6. When you notice your slime starting to take shape as monomers link into polymers, remove the slime from the leftover water and knead with your hands.

7. Play with and observe your completed polymer for a couple minutes

8. Split the polymer among each member of your group and store in Ziploc baggies.

9. Clean up your lab station.
Marine Debris Source Sorting Relay

Objectives:
Students will be able to recognize four major sources of marine debris and connect their own consumer and community choices to the four sources of marine debris.

Concept:
Marine debris has existed for thousands of years, since people have been creating and disposing of tools and clothing. Until the invention of synthetic plastics, most marine debris was biodegradable. Plastics are a unique and relatively recent technology, and have vastly magnified the problems caused by marine debris. There are four main sources of marine debris: land-based/personal use, marine industries & recreation, container ship spills, and natural disasters. Individuals have great power to change their own consumption and disposal habits; influence others to minimize plastic waste; and prepare for, rebuild, and clean up after large- and small-scale natural disasters.

Materials:
- Science notebooks
- Pencils
- Whiteboard, Flipchart, or SmartBoard with appropriate tool to write on it
- Large Bins (2-4)
- A variety of marine debris
- Notecards
- Markers

Preparation:
Fill bins with different types of clean marine debris collected from beaches or borrowed from the Center for Alaskan Coastal Studies (www.ak-coastalstudies.org). Make sure each bin contains at least 10 items, and that those items represent all of the 4 major source categories for marine debris.

Write one of the four source categories (land-based/personal use; marine industries & recreation; container ship spills; natural disasters) on notecards so that you have 4 complete sets. If you are planning to use student-defined categories, do not write on the cards until the categories have been defined.

Introduction:
Ask students to think back to a time they were on the coast or ocean. What kinds of litter and marine debris did they see?

Divide students into groups of 2-4. Give groups 2 minutes to make a list in their science notebooks of debris they have seen personally.

After the time is up, have groups share their debris items.

Write them on the board and discuss the items as you do. Where did they see these debris items? Was there a lot of them, or just one? Where might they have come from?

Activities and Procedures:
Have students return to their groups and work to divide the common types of debris they have seen into 3-5 broad source categories.

The categories used later in this lesson are Land-Based/Personal Use, Marine Industries & Recreation, Container Ship Spills, and Natural Disasters. However, do not tell students these categories before they create their own.
The goal is to get them thinking about the broader sources of marine debris and how they would categorize items.

Have groups share their categories.

Discuss what types of debris might be missing from these categories. Students are likely to be familiar with land-based/personal use type debris and debris from marine industries and recreation, although they might use other category labels. However, many students will not be familiar with debris from container spills and natural disasters.

If debris items from these categories have not been considered, introduce the concepts to the class by asking about items like basketballs that fell off a shipping container or foam from buildings and docks.

Then, explain that marine debris comes from many sources and these sources can be organized into many different categories. Explain that categories that are sometimes used are: Land-Based/Personal Use, Marine Industries & Recreation, Container Ship Spills, and Natural Disasters.

Divide students into 2-4 teams for a relay race.

Arrange bins filled with clean marine debris at the front of the classroom – one bin for each team.

Place notecards with labels for marine debris source categories (land-based/personal use; marine industry & recreation; container-ship spills; natural disasters OR student-defined categories) about ten steps away from each relay team.

Make sure each team has their own set of labels.

Explain that the first member of each team should run or speedwalk to a piece of marine debris, place it with the correct (or most plausible) vector label, and return to tag their next teammate.

The game continues until all of the marine debris has been sorted.

Instruct students that if they are unsure of where a piece of debris belongs, they can consult their teammates.

Begin the race! When the first team finishes, stop the race and sort through the piles as a class.

The group with the most marine debris correctly placed in the categories wins.

Wrap-up:

Discuss any debris that was difficult to place within a category. Look at debris items to see if any could be from natural disasters, either local or across the ocean. Spend some time discussing how natural disasters can be linked to debris. Since the 2011 Tohoku Earthquake and Tsunami in Japan, marine debris clean ups along the Gulf of Alaska, Prince William Sound, and Southeast Alaska have collected significantly higher amounts of polystyrene and polyurethane foam that are likely linked to aquaculture buoys that were ripped away during the tsunami and insulation from homes that were destroyed. Take a moment to recognize the immediate tragedy of the disaster, and the long-term effects this marine debris might have. Explain that smaller scale weather events can create marine debris too. Briefly discuss ways that people living in...
coastal areas can prepare for extreme weather to protect themselves and their property, and prevent debris from entering the ocean.

**Extensions & Lesson Connections:**

This lesson pairs well with Designing Debris Solutions and Graphing Marine Debris Trends.

If you would like, extend the relay race into round two. Replace the source labels with likely effects on marine and coastal organisms (entanglement, ingestion, smothering, toxins, etc.) and mix the marine debris back up for a second relay. This links well to the Effects of Marine Debris on Ecosystems, Marine Debris Masks, Gyre Dangles, and Top of the Ocean lessons.

**Evaluation:**

The successful sorting of debris can be used as a measure of cooperation and student understanding.
Ocean Full of Debris Game

Objectives:
Students will recognize that container ship spills contribute to the problem of marine debris. They will connect their own consumer and community choices to this source of marine debris.

Concept:
There are four main sources of marine debris: land-based/personal use, marine industries & recreation, container ship spills, and natural disasters. Container ship spills are an often overlooked source of marine debris, but it is estimated that every year as many as 10,000 containers filled with products are spilled from shipping vessels. These container ship spills can result in novel and interesting things becoming marine debris, but the spilled products can pose a major threat to marine ecosystems. While individuals have no control over the rough weather that can cause these spills, individuals do have great power to change their own consumption habits and influence others to minimize the demand for plastic products that are shipped from overseas.

Materials:
- Science notebooks
- Pencils
- Whiteboard, Flipchart, or SmartBoard with appropriate tool to write on it
- Bowl, cloth bag, hat, or other container
- Small slips of paper

Preparation:
Write the following objects on small slips of paper and fold the slips in half. Place in a bowl, bag, or otherwise opaque container.

Tiny pieces of plastic/nurdles
Hockey Gloves
Hockey Shinguards
Nike Shoes
Bags of Doritos Chips
Legos
Fly swatters
Aluminum Briefcases
Bananas
Foam basketballs
Rubber Duckies
Plastic Turtles
Plastic Frogs
Plastic Beavers
Car Tires
Blue Water Bottles
Flip-flops

Introduction:
Ask students to think back to a time they were on the coast or ocean. What kinds of litter and marine debris did they see?

Divide students into groups of 2-4. Give groups 2 minutes to make a list in their science notebooks of debris they have seen personally.

After the time is up, have groups share their debris items.

Write them on the board and discuss the items as you do. Where did they see these debris items? Was there a lot of them, or just one? Where might they have come from? What were the strangest items the students saw?

Procedures & Activities:
Explain that sometimes odd products spill off of container ships and end up as marine debris.
Ocean Full of Debris Game Continued

Container ship spills are an important component of marine debris. Anything that is shipped across the ocean may end up spilling in rough weather or if the ship is loaded in an unbalanced way.

Explain that debris from container ship spills is difficult to track because shipping companies are not required to report spills in international waters.

However, with ever-increasing amounts of products being shipped across the world’s seas, the risk of container ship spills is great and increasing. Approximately 90% of worldwide cargo travels by sea, and at any moment in time an average of 6.7 million containers are in transit on the world’s ocean. In 2010, more than 8 billion tons of goods were transported by sea. It is currently estimated that up to 10,000 containers are lost every year, sinking to the bottom of the ocean or spilling their contents to float in the currents.

Many strange items have made their way into ocean ecosystems and washed ashore after spilling from shipping containers.

Explain to students that you are going to play a game called “Ocean full of debris” to learn about some of the strange things that have spilled into the ocean from container ships.

Break students into two teams.

Have each team choose a name and write the names on the board.

Show the students a bowl, cloth bag, or hat and explain that it represents the ocean, and within it are the names of different items that have washed into the ocean due to container spills.

Have a representative from each team “rock, paper, scissors” to see which team will go first.

Explain that in the first round, a student from the first team will step forward to the front of the class and draw a slip of paper with the name of an object from the bowl.

The student has 30 seconds to describe the object without using any words listed on the piece of paper (so if the piece of paper says baseball bat, they can’t say “base,” “ball” or “bat”).

His or her team tries to guess the object correctly. If they do, the team gets a point and the student draws a new slip of paper from the bowl.

When the 30 seconds are up, play stops. The student must return the slip of paper to the bowl if it has not been correctly guessed, but if it has been correctly guessed, the slip of paper is removed until the next round.

The second team sends a representative up. Like the first player, he or she has 30 seconds to get his or her team to guess as many objects as possible by describing them.

Play continues, alternating back and forth until all of the slips of paper have been guessed.

Then, the paper slips are placed back in the bowl and the second round commences, in which the student must get his or her team to guess the object by acting it out without speaking or making any sounds.

At the end of that round, return all the slips to the bowl.

In the third round, players may only say one word for each slip they draw.
Ocean Full of Debris Game Continued

This word cannot be a word on the slip of paper. This round is difficult, but if students have been paying attention in earlier rounds, very much possible.

At the end of the third round, tally the points. The team with the most points wins.

Wrap-Up:

Discuss the “Ocean full of debris” objects used in the game with the students. Ask students if they were surprised by any of the objects.

Revisit the first round, in which students described the objects. Have them think about how they described the objects. How many times did students use phrases such as, “This is something you use to _____” or “I wear this to _____”? Reiterate that objects spilled into the ocean from container ships are often objects we use in our every day life.

Read the slips of paper one by one and ask students to raise their hands if that is similar to a product they have used or bought for themselves or someone else.

Discuss what it means to ship products hundreds and thousands of miles across the sea. Have students think about products that are made locally and discuss a few items as a class. Ask students to reflect in their science notebook, writing about the following questions:

- What products have I used in my own life that are similar to the products spilled from container ships?

- What is a product I use that could be grown, made, or repurposed locally?

Extensions & Lesson Connections:

Follow this lesson with a marine debris beach clean up, or use data sheets from a previous clean up to analyze how many objects, if any, on local beaches could be sourced to container ship spills. You can contact the Center for Alaskan Coastal Studies for information on recent debris sightings in Alaska thought to be linked to container ships.

This lesson pairs well with the "Plastics in Society" and "Marine Debris Source Relay" lessons.

Evaluation:

Review student science notebook entries, including the list of debris they have seen and their reflection on container ship spills and locally-made products. Assess these entries for completeness, effort, and understanding of the concepts.
Graphing Marine Debris

Objectives:
Students will understand how marine debris has changed over time and how the invention and increasing use of plastic products has magnified and changed issues surrounding marine debris. They will be able to explain recent trends in marine debris and connect their own consumer and community choices to the four sources of marine debris.

Concept:
Marine debris has existed for thousands of years, since people have been creating and disposing of tools and clothing. Until the invention of synthetic plastics, most marine debris was biodegradable. Plastics are a unique and relatively recent technology, and have vastly magnified the problems caused by marine debris. There are four main sources of marine debris: land-based/personal use, marine industries & recreation, container ship spills, and natural disasters. Individuals have great power to change their own consumption and disposal habits; influence others to minimize plastic waste; and prepare for, rebuild, and clean up after large- and small-scale natural disasters.

Materials:
- Science notebooks
- Pencils
- Whiteboard, Flipchart, or SmartBoard with appropriate tool to write on it
- Markers
- Notecards
- Masking tape
- Handout: CoastWalk 2012 Data
- Handout: ICC Data

Preparation:
Create a line with masking tape on the floor to form the x-axis of your human-size graph.

At the beginning of this line, place a perpendicular line of tape on the floor to form the y-axis.

Make small dash marks along the y-axis to represent every 5 students (or an appropriate scale for your group size.)

Introduction:
Ask students to think back to a time they were on the coast or ocean. What kinds of litter and marine debris did they see?

Divide students into groups of 2-4. Give groups 2 minutes to make a list in their science notebooks of debris they have seen personally.

After the time is up, have groups share their debris items.

Write them on the board and discuss the items as you do. Where did they see these debris items? Was there a lot of them, or just one? Where might they have come from?

Procedures & Activities:
Split the debris items into the four source categories (land-based/personal use; marine industries & recreation; container ship spills; and natural disasters) or into other categories defined by the students.

Reveal the x- and y-axis on the floor.

For each category, place a notecard label below the x-axis. Go through the categories one by one and instruct students to come forward if they have seen an item of marine debris from this category on the coast or ocean.
Graphing Marine Debris Continued

Line the students up perpendicular to the x-axis and mark how far along the y-axis the line reaches on the floor with a piece of masking tape.

Have students return to their seats, and then move on to the other categories, following the same procedures.

When all categories have been completed, have students gather round to look at the graph they have created.

Instruct students to recreate the bar graph in their science notebooks, with # of students who have seen the item on the y-axis and category of marine debris on the x-axis.

Explain that marine debris clean ups take place throughout Alaska and the world, and that data from these clean ups is recorded, so that it is possible to identify the most common debris items found in Alaska and worldwide.

Have students write the following in their science notebooks:

- A hypothesis (educated guess) about the 3 most common marine debris items collected during international clean ups
- Reasoning to support that hypothesis
- A hypothesis about the 3 most common items collected during Alaskan clean ups
- Reasoning to support that hypothesis

Remind students that they are transitioning from broad categories of items to more specific categories like “ropes and nets” or “plastic beverage bottles.”

Then students should share their hypotheses and reasoning with a partner and agree on their top 3 for international clean ups and their top 3 for Alaskan clean ups.

Write student hypotheses on the board.

Wrap-Up:

Then pass out data from ICC and Alaskan clean ups that identify most common debris items. Discuss the data. Were any hypotheses supported? Was the data surprising? Ask students to reflect in their science notebooks on the following questions:

- Why might these be the most common items?
- Were do they come from?
- What can I do to decrease the amount of these common debris types?

Extensions & Lesson Connections:

You may extend the graphing activity to deal with data from your class’s marine debris clean ups. See the "Data Entry and Analysis" Lesson for more information on accessing and analyzing the data.

This activity pairs nicely with "Marine Debris Source Sorting" and "Designing Debris Solutions."

Evaluation:

Review student science notebook entries, including: list of debris they have seen, hypotheses and reasoning for common debris types, graph of debris types, and reflection on why these types are most common and what could be done to minimize the amount of this debris. Evaluate these entries for completeness, effort, and understanding of the concepts.
Unit 5: Human Effects on Marine Ecosystems

Essential Questions:
How do people affect coasts and the ocean?
How can people protect coasts and the ocean?
How do physical processes influence human effects on marine ecosystems?
How do biological processes influence human effects on marine ecosystems?
What is the role of technology in protecting our coasts and the ocean?

Enduring Understandings:
• Pollution knowingly or unknowingly introduced into the ocean by people can have negative effects on marine ecosystems.
• You can minimize the solid and liquid pollution you are introducing into the ocean.
• Making informed decisions as a consumer helps to protect the ocean.
• You can create new ways to care for the ocean and get others involved.
• Weather systems and ocean systems have major influences on each other and the transport of solids and liquids in the ocean.
• Organisms in marine environments interact with one another and are interdependent in many ways.
• Harm to one species can affect the entire food web.
• Biological processes can magnify the impacts of human effects.
• Technology can have unintended consequences.
• Overusing plants, animals, and other ocean resources can disrupt marine ecosystems.

Lessons in this unit:
- Bioaccumulation Game
- Marine Debris Effects Station Rotations - Katie
- Sheen-Oil-Mousse
- Oil Spill in a Pan
- Oil Experiments
- Critter Clean Up
- GRS Priorities for Protection
- Community Meeting
- Fishing for the Future
- Melting Glaciers & Silty Salmon
- Ocean Acidification
Albatross Alert

Objective:
To learn about the special adaptations albatrosses have that distinguish them from other types of sea birds and to learn more about the unique habitat requirements of the Short-tailed albatross.

Concept:
Albatross have unique adaptations for surviving for long time periods at sea. The Short-tailed Albatross has unique requirements for nesting which have contributed to their population decline and classification as endangered.

Materials:
- Science Notebooks
- Pencils
- Freezer paper for wings
- String
- Measuring Tape
- Pictures of various seabirds or Seabird ID Guides
- Markers, colored pencils or fabric crayons
- Handout: Albatross Alert Worksheet
- Handout: Albatross Story

Preparation:
Make a copy of the Albatross Alert! Worksheet and Albatross Story for each student.

Introduction:
Show pictures from the book Seabirds: a Zoo-book series or from any other resource you might have on seabirds. Present a slide show on various types of seabirds and discuss general characteristics of each and special adaptations they each may have for survival in their unique habitats.

Activities & Procedures:
Have students pair up to work on the Wing Span activity.

Give each pair a bird name. Instruct them to research the wing span of their bird and the shape of the wing.

Have them make a lifesize replica of their wings using butcher paper.

Once everyone has completed the task, have each pair present their bird and its wing span.

Display the wings on a large wall with the smallest wings at the bottom and the largest wings (the albatross) at the top.

Wrap-Up:
Discuss the pros and cons of wing’s shape and wing span and how this determines a bird’s habitat. Try to encourage students to make comparisons between seabirds and between other types of waterfowl that they may be familiar with.

Wrap up your albatross explorations by discussing the various findings of the groups and sharing drawings.

Extensions & Lesson Connections:
Make a mural or a seabird wall hanging with the drawings from Station 4. Follow the manufacturer’s directions for using fabric crayons and transfer pictures onto a large piece of fabric or onto individual fabric blocks which can then be sewn together for a fantastic classroom display!
Albatross Alert Continued

Work on observation skills by making "field sketches" of the various albatrosses found in Alaska, drawing from field guides or other photos of seabirds. Ask students to make notes about their distinguishing features such as similarities and differences in beak shape, head shape and markings.

Evaluation:

Observe student participation and cooperation in group work and presentation of the wingspan. Evaluate sketches and presentation for understanding of the underlying concepts of seabird adaptations.
Albatross Story

Once there was a volcano – a single volcano that rose above in the Pacific Ocean as a small island off the coast of Japan. It was a special island because it was the perfect nesting spot for a special seabird – the Short-tailed Albatross. This special sea bird spends almost all of its year at sea, using its long beautiful wings to soar effortlessly for hours and miles over the ocean – circling for food. The only time the albatross comes to land is to nest and the only place it wants to nest was this one special island – which just happens to be an active volcano!

Hundreds of years ago this went on without much ado – the Short-tailed Albatross soaring and fishing for squid and other fish that might come close to the surface of the ocean in the summer, and nesting and raising a single chick each year in the fall and through the winter. But, unfortunately for the Short-tailed Albatross and other albatross as well, their beautiful long feathers were just the thing to make beautiful hats for fashionable women in the late 1800s and early 1900s. Their feathers were used for pen plumes and feather beds as well. Because they are such a large bird, weighing almost 15 pounds, they were killed for their meat too. Almost 5 million Short-tailed Albatross were killed until almost no birds were left and they were close to extinction.

To make matters even worse, the volcano erupted in the 1930s, causing extensive damage to their nesting site. Typhoons would also flood the volcano’s crater, washing volcanic ash over the eggs and chicks as the storm water cascaded down to the sea. For a while it looked like the species was extinct. But against all odds, ten albatross were discovered on Torishima Island in 1951. The Japanese government declared the bird a national monument! But that was not enough to help these birds recover.

Then along came a young man named Hiroshi Hasegawa, who decided to make it his life mission to save these birds from extinction. He studied the birds and began a Short-tailed Albatross conservation study. One thing he learned was that the bird’s eggs, which were laid on the steep slope of the volcano, would often roll into the sea. So he planted native grasses on the slope to help keep the eggs from tumbling into the ocean. He had great success in just one year – egg survival went from 30 percent to 60 percent!

But…in 1987 a giant landslide happened on the upper slope of the colony. Mud flows buried the chicks and washed away eggs. This time the Japanese government stepped in and helped Hasegawa and he terraced the slopes and built barriers to slow down erosion. This helped some, but the problem of the volcano still was looming in the background. Hasegawa decided to try to help the birds set up a new colony on the OTHER side of the island – where the slope was not so steep and there was more vegetation. He painted decoys and set them up in various courting poses – he even broadcasted mating calls over a loud speaker to fool the birds into thinking this was an active breeding site. His trickery worked and mating pairs arrived and set up nests.
Hasewaga has worked for nearly 30 years to help bring the population back and his effort is paying off. In 1996 more than 100 new chicks were counted at two nesting sites. The Short-tailed Albatross is not out of danger though, it still remains on the Endangered Species list because its population numbers are not strong enough, it still is threatened by the possibility of a volcanic eruption at any time, and increased amounts of plastic pollution floating in the ocean pose a real threat to their safety. But the news is good – the birds went from having fewer than 50 birds in the late 1940s to having almost two thousand soaring over the ocean off the coast of Alaska and Japan!

Objectives:
Students will understand the three major effects of marine debris on ecosystems: entanglement, ingestion, and toxic pollution. They will connect their personal consumer choices with the effects of marine debris on the marine environment, and design and evaluate ways to mitigate the ecosystem effects of marine debris. They will construct marine debris art pieces to illustrate the effects of entanglement and ingestion.

Concept:
Marine debris has many effects on marine ecosystems. The three main effects are entanglement, ingestion, and toxic pollution. Because plastics persist in the ocean environment for so long, they can have numerous impacts on marine life. Larger pieces of plastics pose a threat as they may entangle marine mammal. Smaller pieces of plastic and those that have photodegraded after exposure to the sun are more likely to be ingested. The longer plastic is in the water, the more likely it is to leach chemicals or attract a biofilm filled with pollutants.

Materials:
- Science notebooks
- Pencils
- Handout: Estimated Life Span of Plastic
- Sample of photodegraded plastic from gyre
- Laptop/computer and projector or SmartBoard
- Entanglement Challenge Station:
  - Photos of entangled animals
  - Rubber Bands
  - Stopwatch
  - Entanglement Challenge Student Directions
  - Entanglement Challenge Set-up Instructions
- Fishing Line Tug of War Station:
  - Large clump of monofilament or many 2-5 foot strands of monofilament
  - 2 thick pieces of rope
  - Fishing Line Tug of War Student Directions
  - Fishing Line Tug of War Set-up Instructions
- Top of the Ocean Mat Sculpture Station:
  - Pieces of blue and green netting
  - Pieces of blue and green rope
  - Blue and turquoise plastic bottles
  - 16 gauge wire
  - Scissors
  - Top of the Ocean Mat Sculpture sample
  - Top of the Ocean Mat Sculpture Student Directions
  - Top of the Ocean Mat Sculpture Set-up Instructions
- Feeding Frenzy Station
  (adapted from Learn About Seabirds Curriculum, US Fish & Wildlife Service)
  - Tarp or large piece of cloth
  - Spoons
  - 6 Fanny packs or grocery bags & twine
  - Popcorn
  - Foam packing materials or foam pieces from marine debris clean up
  - Feeding Frenzy Student Directions
  - Feeding Frenzy Set-up Instructions
- Albatross Bolus Investigations Station:
  - Albatross bolus sample specimen
  - Wide mouth (1.5 in) 12 oz. plastic bottles
  - Small pieces of plastic commonly found locally as litter/marine debris (lighters, legos, bottle caps, etc.)
  - Tray or shoe box
  - Photos of dissected boluses
  - Photos of ingested plastics
  - Handout: Bolus Contents Data Sheet
  - Handout: Albatross - Case Study Background Information Sheet
Stations: Effects of Marine Debris Continued

• Albatross Bolus Investigations Student Directions
• Albatross Bolus Investigations Set-up Instructions

Gyre Dangle Sculpture Station:
• Scissors
• Pieces of plastic marine debris (1-4 inches, Red, Orange, Yellow, Green, Blue, Violet & White)
• Pieces of blue rope from marine debris
• Fishing Line or 20 gauge wire
• Leather punch or drill
• Safety goggles
• Work gloves
• Gyre Dangle Sculpture sample
• Gyre Dangle Sculpture Student Directions
• Gyre Dangle Sculpture Set-up Instructions

Introduction:
Begin by showing the “What’s an Ocean Garbage Patch” video on youtube (http://www.youtube.com/watch?v=J-gqJAsXiKQ). At the conclusion of the video, ask students to write their reaction in their science journal.

Ask students to write predictions of how long different plastic products persist in the marine environment. Pass out the handout with the timeline of how long plastics last in the environment.

Compare the timeline to the predictions students made. Discuss that plastics photodegrade rather than biodegrade. That is, as plastics are exposed to ultraviolet rays, the secondary bonds (plasticizers such as phthalates) between the polymer chains are changed, causing the plastic to become brittle and break into smaller and smaller pieces. Pass around the sample of photodegraded plastics.

This is different than biodegradation. Things that biodegrade are broken into smaller pieces by bacteria or other biological actions. Biodegradation returns the object to compounds found in nature, whereas photodegradation breaks plastics down to the synthetic polymers, but not natural molecular compounds.

Procedures & Activities:
Ask students to brainstorm how wildlife and ecosystems are affected by marine debris. Have students record their ideas in their science notebooks, and write all of their concerns on the board.

Preparation:
Set up computer and projector or SmartBoard to show the “What’s an Ocean Garbage Patch” video on youtube (http://www.youtube.com/watch?v=J-gqJAsXiKQ). This video on youtube sometime begins with advertisements, so play through these during your preparation.

Prepare the 6 stations for rotation. Each station includes instructions for set-up and directions for students.

You will need a variety of marine debris items for the two sculpture stations. If you will not be able to conduct a marine debris clean up prior to this lesson, contact CACS for assistance acquiring appropriate materials.

Drill or punch ¼ inch holes in the plastic pieces for the Gyre Dangle Sculpture – or ask a volunteer to do it.
Stations: Effects of Marine Debris Continued

If they do not include entanglement, ingestion, or water pollution on the list, help them to add those concerns. Explain to students that all of these effects are important to consider and work to mitigate, but the three greatest concerns related to marine debris in marine ecosystems are entanglement, ingestion, and toxic pollution.

To learn more about these ecosystem effects, they will rotate through 6 stations:
- Entanglement Challenge
- Fishing Line Tug of War
- Top of the Ocean Mat Sculpture
- Feeding Frenzy
- Albatross Bolus Investigations
- Gyre Dangles Sculpture

Divide students into 6 groups and designate their starting stations.

Every 10-15 minutes, have students rotate to the next station. Tell students when there is 5 minutes left in each station so they have time to finish up their activities and science notebook responses.

Bring the groups back together. Lead a discussion about how students can affect these problems.

Talk about the CACS fishing line-recycling program as a great example of how potential entanglement items can be taken out of the environment. Also, the decreased occurrence of six-pack rings in marine debris is linked to consumer choices. Awareness that these products caused problems in the marine environment led to a significant reduction in the manufacturing of these harmful products.

Ask students to revisit their science notebooks and review the potential ecosystem effects of marine debris they wrote down at the beginning of the lesson.

Break students into small groups 2-5 people and have them work together to discuss potential ways to mitigate these effects. Encourage them to think not only of ways to clean up marine debris, but also ways to prevent certain types of marine debris (toxic, fishing line, etc.) from ever entering the ecosystem or ways to change the nature of marine debris (fishing line that breaks down more easily, etc.)

Have each group decide on their top two solutions and describe them in their science notebook.

Wrap-Up:

Come together as a class and have each group present their top two solutions. Discuss the pros and cons of each. Explain that every technology has both positive and negative effects, so the above all best thing they can do is reduce their use of single-use plastics such as plastic bottles, straws, utensils, take out containers, etc. The less plastic is thrown away, the less is available to make its way into the marine environment.

Extensions & Lesson Connections:

After working on the Gyre Dangles and Top of the Ocean Mat sculptures, students will likely want to finish the piece and share it with others. See the “Art Exhibit” Lesson for more information on finalizing the sculptures, writing artists’ statements, and preparing the art for public display.
Stations: Effects of Marine Debris Continued

A great extension to the Bolus Sorting activities is to dissect an actual albatross bolus. CACS has a few boluses available to loan to teachers for this purpose. The Bolus Content Data Sheet from the sorting activity can be used for a dissection too. Contact CACS for more information about bolus dissection and to access a bolus for class use.

You can also extend the Bolus Sorting activities by having students sort debris before putting it into the mock albatross stomach. Provide students with a variety of large and small debris objects that potentially could be eaten by an albatross (bottle caps, foam, plastic toys) and things less likely to be eaten by an albatross (cans, bottles, glass, larger pieces of plastics debris). Before having students test the amount of plastic necessary to create a bolus that is too large to regurgitate, have students sort the debris in the following steps:

1) Place the items in a tub of water. Albatross are surface feeders, so will only eat things that float near the surface. Eliminate objects that sink.

2) Take items that did float and try to fit them through a 1.5-inch diameter PVC pipe. Items that can’t fit through the PVC wouldn’t fit into the esophagus of an albatross chick. Eliminate the objects that are too large.

3) Use only the remaining items as you place objects into the bottle.

Evaluation:

Review student science notebook entries, including data entries and reflections from the stations and their list of ways to mitigate the effects of marine debris on the ecosystem. Their list of ways to mitigate the effects of marine debris on the ecosystem should be evaluated for synthesis and application of the material learned. The other entries can be evaluated for completeness and effort.
Albatross Bolus Investigations Set Up Directions

1. Place small, common debris items in a tub at the station.

2. Set six bottles with lids at the station. They should be wide mouth (about 1.5 inches) and approximately 12 ounces in volume to represent the stomach of an albatross chick.

3. Place the sample bolus at the table for display only. Keep it in the plastic bag so pieces are not lost.

4. Make 1 copy of the Bolus Sorting Data Sheet for every student. Leave these data sheets at the station.

5. Make copies of the Albatross – A Case Study background information sheet for the students to read at the station.

6. Arrange the photos of ingested plastic at the station.

7. Place the four Dissected Bolus photos along with magnifying glasses at the station. For younger students, use zoomed in photos so the objects are larger.

Lesson adapted from Winged Ambassadors Curriculum, Oikonos Ecosystem Knowledge. Used with permission. These high resolution images were created by National Geographic photographer David Liittschwager and donated for educational use only. The boluses from Tern Island and Kure Atoll were provided by U.S. Fish and Wildlife Service and the State of Hawaii Department of Land and Natural Resources. The contents were prepped by Hawaii Pacific University and Oikonos as part of a research study on plastic ingestion by Pacific albatrosses breeding in Hawaii. This program was created by NOAA’s Cordell Bank National Marine Sanctuary, Papahānaumokuākea Marine National Monument, and Oikonos Ecosystem Knowledge.
Albatross Bolus Investigations
Student Instructions

Model Stomach (activity #1)

1. Begin by reading the Albatross – A Case Study background information.

2. Choose a plastic bottle. This bottle will represent the stomach of an albatross chick. It is approximately the same size as an albatross stomach, and the mouth of the bottle is about as wide as an albatross throat.

3. Select 1-2 pieces of plastic debris from the tub and place them into your bottle. Close the “beak” by putting the bottle cap back on. Carefully shake the albatross stomach.

4. Open the beak, tip the stomach over, and see if the plastic pieces will empty out of the stomach like a bolus.

5. If the plastic comes out, put those pieces back in and add 2 more pieces. Close the beak. Shake the stomach. Open the beak. Empty the stomach.

6. Continue adding plastic until the bolus becomes so big that it gets stuck and cannot fit out of the throat.

7. Shake or poke inside of the stomach so you can remove the plastic pieces.

8. Count the number of plastic pieces and return them to the tub of marine debris. Place the empty bottle with lid back on the station table.

9. Answer the following questions in your science notebook:
   • How many pieces of plastic were in the mock bolus that was too big to be regurgitated?
   • What effects would a stomach full of plastic have on an albatross?

10. Move on to the Bolus Sorting activity.
Albatross Bolus Investigations
Student Instructions

Bolus Sorting (activity #2)

1. Take a moment to look closely at the sample bolus. Please do not touch it or take it out of the bag – it is fragile!

2. Look at the photos of plastic items found in birds. How do these photos make you feel?

3. Find a partner in your group and take a Bolus Contents data sheet.

4. With your partner, choose one of the photos of a dissected bolus to examine. Write the type of bird and breeding location at the top of your Bolus Contents data sheet.

5. Using a magnifying glass, examine the dissected bolus photo with your partner and record the items you see on your data sheet.

6. Answer these questions in your science notebook:
   • Were there more prey or non-prey items in the bolus?
   • What was the strangest non-prey item in the bolus?
   • Choose one non-prey item from the dissected bolus. Where do you think this debris originally came from? Have you used an object like this before?

7. If you have time left at this station, work with your partner to sort the contents of another bolus. Change one variable, so choose either a different species of albatross from the same island, or the same species of albatross at a different island.
Entanglement Challenge Set Up Directions

1. Arrange laminated photos of entangled animals at the station.

2. Place rubber bands and stop watch on the table.

3. Affix or place student directions sheet in an obvious place.
Entanglement Challenge
Student Instructions

Do This First: Photo Sorting

1. Take a look at the photos of entangled animals. As a group, sort them into categories based on the type of animal.

2. Answer these questions in your science notebook: What types of animals seem to be most affected by entanglement? Why do you think this is?

3. Sort the photos of entangled animals into categories based on the type of debris entangling the animal.

4. Answer this question in your science notebook: What types of debris seem to entangle animals most often?
Entanglement Challenge
Student Instructions

Now - Take the Entanglement Challenge

1. Put a rubber band around your pinky and forefinger over the back of your second and third fingers. Imagine you are a bird with plastic around your neck.

2. Put your other hand behind your back.

3. Start the stop watch.

4. Race the other people in your team to remove the rubber band only by wriggling your hand. You cannot use your other hand, body, or other people.

5. When you succeed in getting the rubber band of your hand, make note of the time on the stop watch.

6. Once everyone gets their rubber bands off, record in your science notebook how long it took to remove it and answer this question, “Why might it be difficult for marine animals to escape from marine debris once they are entangled?”
Feeding Frenzy Set Up Directions

1. Mix popcorn and foam pieces – you want about 3 pieces of popcorn for every piece of foam.

2. Spread the popcorn-foam mix onto the station table or a tarp or cloth on the floor.

3. Prepare 6 “stomach baggies.” For each one, use a fanny pack or string a shopping bag onto a piece of twine that is long enough to be tied around a student’s waist.

4. Set plastic spoons with stomach baggies next to the station.

5. Place a stopwatch and first page of student directions in a prominent place at the station.


7. The students will come get this page from you once they have completed the first round.
Feeding Frenzy
Student Instructions - Page 1

1. At this station, imagine that you are seabirds that feed on small fish and zooplankton like crab and mollusk larvae.

2. Pick up a “stomach baggie” (fanny pack or bag on a string) and tie it around your waist. This is where you will put all your food.

3. Pick up a spoon with one hand. This will be your “mouth.” You can only use this mouth to pick up food and transfer it into your stomach.

4. When every seabird is ready with their mouth and stomach, stand around the feeding area filled with popcorn. The popcorn represents small fish, a favorite food for seabirds.

5. One seabird must start the stopwatch, and then everyone has 1 minute to gather food.

6. Pick up food one piece at a time with your spoon-mouth and transfer it to your stomach.

7. You may not walk on the feeding area, but you can reach into it with your mouth.

8. At the end of one minute, everyone must stop.

9. Send one seabird from your group to get the next set of directions from the teacher.
1. Find a spot to carefully empty your stomach contents. Make sure they don’t mix with anyone else’s food.

2. Look closely at the things you ate. What do you notice?

3. Not all of what you gathered was food. Some is food: the popcorn plankton. But some is actually plastic pieces of marine debris foam.

4. Count how many pieces of foam you gathered as a seabird. Count how many pieces of popcorn plankton you gathered. Record this information in your science notebook.

5. Because foam can’t be digested it accumulates in the stomachs of seabirds and fish. Place the pieces of foam you gathered back in your stomach baggie. Scatter the popcorn back in the feeding area.

6. Once all the seabirds are ready, set the stopwatch for 1 minute and feed again. After one minute, stop feeding.

7. Count up how much food and foam is in your stomach.

8. Answer these questions in your science notebook:
   - How much foam was in your stomach at the end of the second round?
   - How much food did you have in your stomach at the end of the second round?
   - How did this compare to the first round?
   - Was it hard for you to collect food once you knew that some of it was foam?
   - How would a real bird be affected by having foam in its stomach?

9. Scatter the foam and popcorn back in the feeding area and place your stomach baggies and spoons alongside.

RETURN THIS PAGE OF DIRECTIONS TO THE TEACHER WHEN YOU’RE DONE!
Fishing Line Tug of War Set Up Directions

1. Choose an appropriate location for the tug of war. Be aware of what is behind your participants to ensure safety, as their goal is to snap the line. This works best outside, if at all possible.

2. Check the tug of war rope from the kit. It should have one loop of rope tied to either end of a clump of monofilament fishing line. Check to make sure the connections between the rope and fishing line are strong.

3. Assign a parent volunteer or teacher to supervise the station, reminding that this is not a traditional tug-of-war, but that they are using cooperation and teamwork to break the line.
Fishing Line Tug of War
Student Instructions

1. Carefully pick up the fishing line tied to the rope.

2. Find an area near your station that is clear of large objects.

3. Have each person in your group choose a partner.

4. One at a time, have partners line up on opposite sides of the rope.

5. Have partners CAREFULLY but FIRMLY pull on the rope, trying to break the monofilament. You should cooperate with your partner.

6. Let each partner group try.

7. If no one succeeds in breaking the fishing line, split everyone in your station group into two teams and line up along the rope.

8. Teams need to pull in opposite directions to try to break the fishing line.

9. Save time to answer the following questions in your science notebook:
   - What would make it hard for an animal to disentangle itself from fishing line?
   - What are three ways entanglement can hurt an animal’s ability to fill its basic survival needs?
Gyre Dangle Sculpture Set Up Directions

1. Use different colors of plastic marine debris that are no larger than the palm of a hand from a previous a marine debris clean up.

2. Use an awl, leather punch, or drill with a ¼ inch bit to create two small holes in each piece of plastic.

3. Hang the Gyre Dangle example from the ceiling or station table.

4. Set wire or string, wire cutters or scissors, tubs, and plastic debris on the table.

5. Post the following Artistic Criteria, if applicable to your class:

ARTISTIC CRITERIA TO POST:

1. Collect from the ocean beaches 1 – 4 inch sized plastic debris pieces that are three-dimensional and some that are recognizable objects.

2. Separate them by the rainbow colors of RED, ORANGE, YELLOW, GREEN, BLUE, PURPLE, AND WHITE.

3. Create strings of nicely balanced rainbow plastics that vary in length from 3 – 6 ft.

4. Look for a variety of textures, shapes and objects to create an interesting string of colors.

5. Use good craftsmanship by twisting the wires securely and neatly with no sharp points.

6. Attach the gyre dangle to the woven matted “Top of the Ocean” to create an evenly spaced yet random look that invites the viewer into the walkway.
Gyre Dangle Sculpture
Student Instructions

1. Separate the pieces of plastics by color in piles or clear containers. Be sure to follow the order of the rainbow, Red, Orange, Yellow, Green, Blue, Purple, and end with White.

2. While you are sorting the pieces, try to determine what they once might have been. Choose one piece and write about it in your science notebook:
   - Does the item look new or old?
   - Are there any clues of what it might have been used for?
   - Are there any clues to the place or date of origin (labels, etc.)?

3. Use fishing line or thin wire (3-6 feet long) to tie a red piece of marine debris at the bottom of the dangle.

4. Attach the plastic pieces to the wire by color, with about 6 inches of Red at the bottom, followed by Orange – Yellow – Green – Blue – Purple and ending with White. Be sure to pass the wire through both holes in the plastic pieces.

5. Create a loop in the fishing line or wire so the dangle can be attached to the “Top of the Ocean” mat.

6. Carefully set your dangle aside. It will be added to the larger sculpture later.
Top of the Ocean Mat Sculpture
Set Up Directions

1. Use blue, green, and turquoise marine debris from a previous clean up. You will need rope and netting. If you are located inland, yarn and strips of cloth can be used in lieu of rope, but you will still need some sort of netting. Contact CACS to request these materials if you did not pick up any during your clean up.

2. Place blue, green, and turquoise plastic bottles with the materials. As an example for the students, cut one in a spiral to form a long strip.

3. Hang the Top of the Ocean Sculpture example from the ceiling or station table.

4. Set wire cutters, scissors, tubs, wire, and plastic debris on the table.

5. Post the following Artistic Criteria, if applicable to your class:

ARTISTIC CRITERIA TO POST:


2. Create various lines that show movement and flowing, like water.

3. Use various analogous colors in blue to green hues.

4. Filling in negative spaces of the netting with woven and knotted rope and plastic bottle strips.

5. Use good craftsmanship by tying knots, twisting wire, and securing the edges.

6. Work collaboratively to have the final piece show unity and balance of color, texture, shape, and space.
Top of the Ocean Mat Sculpture
Student Instructions

1. Lay the netting out over a table and spread out around it as a group.

2. Separate thick rope into thinner strands. Put the rope in bins around the table so that everyone can reach. If any rope crumbles, throw it away in the trashcan. Rope that does this has photodegraded -- as plastic is exposed to sunlight, links between polymers in the plastic change and it becomes brittle, breaking into smaller and smaller pieces.

3. Cut bottles in a spiral from bottom to top, creating strips approximately \( \frac{1}{2} \) wide. Add these to the bins of materials you can use.

4. Tie one end of the rope to the net. If you are weaving a water bottle spiral, you can poke a hole in one end and tie it to the net with wire or string.

5. Weave the rope and plastic strips over and under the netting. Be sure to enter an adjacent square.

6. When you are finished, tie the rope onto the netting so it will stay in place. Poke a hole in the end of the spiral and tie it on with wire or string.

7. Work cooperatively with your group to create the top of the ocean mat.

8. Fill in the area as much as possible until it appears fairly solid and water like.
Bioaccumulation Tag

Objectives:
Students will understand that ingestion and toxic pollution are two major effects of marine debris. They will be able to describe the process of bioaccumulation as it relates to plastics and toxic pollutants attached to plastic.

Concept:
Marine debris has many effects on marine ecosystems. The three main effects are entanglement, ingestion, and toxic pollution. The effects of ingestion of plastic pieces and toxic pollution are magnified by the process of bioaccumulation, whereby top predators accumulate plastic or toxins when they consume prey that have ingested these plastics or toxins.

Materials:
- Science notebooks
- Pencils
- Masking Tape
- Markers
- Fanny packs or grocery bags and twine
- Poker chips, pieces of colored paper, or other game pieces
- Sample of photodegraded plastic from gyre
- Laptop/computer and projector or SmartBoard

Preparation:
Sort your game pieces. You will want approximately 100 or more of them. Of these, 80% should be one color, to represent plankton, and 20% should be another color, to represent plastic. If you’d like to make it even trickier, use more colors. Have all the colors except one represent plankton, with the final color being plastic. This way, students won’t be able to guess which color they should avoid during the game.

Introduction:
Ask each student to choose a marine organism that can be found in Alaska and identify the organism by writing the name on a piece of masking tape and wearing it like a nametag.

Ask the students to step forward if they are a type of phytoplankton. If no one steps forward, act surprised and explain that phytoplankton is the most important as these organisms produce their own food and are at the bottom of the food chain. Designate something green as phytoplankton. This is the producer.

Ask any organisms that eat phytoplankton to step forward. You may need to designate yourself as a type of zooplankton such as krill or copepods if no one steps forward. These are examples of a primary consumer.

Have students that eat primary consumers step forward (small fish, birds, and filter feeders such as baleen whales, clams, mussels, etc). These are your secondary consumers.

Finally, have the larger predators that eat the secondary consumers step forward (sea otters, seals & sea lions, walruses, toothed whales, large fish, sharks, octopus, etc.) as tertiary consumers.

Examine your food chain as a class. With just one little phytoplankton, will there be enough energy to travel through the food chain and support the large tertiary consumers? No!

You will need to create a “stomach baggie” for each student. This can be done using a fanny pack, or by stringing a grocery bag onto a length of twine that can be tied around the student’s waist.
Bioaccumulation Tag Continued

Discuss as a class what organisms need to be most abundant to keep a food chain like this healthy and strong.

Procedures & Activities:

Tell students you are going to play Food Web Tag. (This is a bit of misdirection, as this game is actually about bioaccumulation of plastic and toxins.) Pass out “stomach baggies” to everyone to put on.

Designate 2-3 tertiary consumers that can be orcas or humans.

Tell the rest of the students that they are secondary consumers, in this case fish.

Spread at least 100 game pieces across a wide area (80% of them should be one color for plankton, with 20% another for plastic).

Tell the fish that their goal is to collect as much “food” as possible and store it in their stomach baggies. Don’t mention that some of the chips aren’t zooplankton!

Explain that if the fish are tagged by a predator, they must give up their game pieces to the predator who will take the game pieces and put them in his or her own stomach baggie.

Begin the game. Allow fish to start collecting the food pieces.

Wait 30 seconds, and then allow the predators to go after the fish.

Once all the game pieces have been collected, stop play. Reveal that a certain color of game piece is actually plastic!

Have fish and predators count their game pieces and share how much food and plastic they have.

Discuss how primary and secondary consumers may not ingest enough plastic to affect them, but tertiary consumers accumulate the plastic from everything they eat.

Discuss how plastic that is ingested by one animal can make its way into that animal’s predator and so on up the food chain. This is called bioaccumulation, because the plastic—or other pollution—accumulates the farther you go up the food chain.

Wrap-Up:

Explain that the issue of bioaccumulation goes beyond the plastic itself. As plastic floats through the ocean column, it begins to provide unnatural habitat for tiny microbes that are attracted to plastics because the rough surface of the plastic provides an excellent surface to cling to. As these plastics become home for microbes, a biofilm forms on them.

This microbe biofilm absorbs Persistent Organic Pollutants (POPs) from surrounding seawater. These POPs are trace insecticides, pesticides, industrial chemicals, and other toxic pollution in the water. When these plastics are ingested by animals, the microbes are digested and POPs subsequently absorbed into the animal’s fatty tissue. Then the animal’s predator eats its prey, digesting that fatty tissue and accumulating the POPs into the predator’s fatty tissue.

Records of bioaccumulation of POPs through eating plastics have been recorded in sea birds and top predator marine mammals such as Orcas.
Bioaccumulation Tag Continued

Some toxins, such as lead and phthalates, are purposefully added to plastics when they are manufactured to make them more flexible or heat-resistant. These toxins, just like the POPs, can bioaccumulate through both ingestion and leaching into the water.

Ask students to draw a simple marine food web in their science notebooks and identify how plastics or toxins might be transferred up each level. Have them answer the following questions in their science notebooks:

- What marine animals are most likely to be affected by bioaccumulation?
- How could people be affected by bioaccumulation?
- What can I do to help minimize the problem of bioaccumulation?

Extensions & Lesson Connections:

This lesson works well as a follow up or introduction to the "Effects of Marine Debris on Ecosystems" station rotations.

Evaluation:

Review the science notebook entries, including the food web and route of plastics drawing and reflection questions to assess synthesis and application of the materials learned.
Fishing for the Future


Objectives:

Students will understand how technological advances can change individual success and overall sustainability in fisheries. They will simulate fishery activity using increasingly sophisticated technology, in different ocean areas, and likely experience a crash in the fisheries. Students will identify ways to use fish resources in a more sustainable manner.

Concept:

Fishing is an important part of Alaska’s history, culture, and economy. However, marine resources such as fish are often at risk of being over exploited. As technology improves, fish stocks become more susceptible to overfishing. Sustainable fishing practices must be adopted to ensure that fishing continues to be a cherished part of Alaska’s culture and economy in the future, and to maintain and restore the health of ocean ecosystems. Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive.

Materials:

- Science notebooks
- Pencils
- Handout: Halibut Cove Story
- Handout: Fishery Facts Sheet
- Handout: Fishing Log Template
- 2 bags of dry beans
- Cups, bowls, spoons, straws
- Stopwatch

Preparation:


Then print out the species profile for herring provided by the Alaska Department of Fish and Game (http://www.adfg.alaska.gov/index.cfm?adfg=herring.main)


To prepare for the game, count out the first round of beans and place them in cups or bags. Each group of three to four students will start with 20 kidney beans and 10 lima beans.

Introduction:

Read the Halibut Cove Story about how changing technology affected fishing in that area.

Ask what might happen to fish populations as the technology changes. Introduce and discuss the idea of sustainability:

“Sustainability is meeting the needs of the present without limiting the ability of people, other species, and future generations to survive.”

Then read the species profile for herring from the Alaska Department of Fish and Game. Are there any aspects of herring ecology that might
Fishing for the Future Continued

make this fish particularly hard to harvest in a sustainable way?
Discuss this quote from the profile “Herring population abundance trends are very dynamic and are subject to fairly substantial changes on both large and small geographic scales. The primary cause for such fluctuations in abundance is environmental change that affects herring growth and recruitment.”

How would you know if changes in fisheries reflect this dynamic abundance or larger problems such as overfishing or pollution?

Activities & Procedures:
Tell students that today they’re going to go fishing and find out more about sustainability and about how fishing success is affected by technology.

Divide the class into groups of three or four students and have each group choose a place to fish such as Bristol Bay, Kodiak Island, Cook Inlet, Prince William Sound, etc.

Have students set up a fishing log in their science notebooks by inserting the Fishing Log Handout or copying it over to their journals.

Give each group one serving bowl containing 20 kidney beans and 10 lima beans and each student one cup, one straw, and one copy of the Fishing Log per student.

Explain the game rules:
- Each student will be a “fisher” whose livelihood depends on catching fish.
- Lima beans represent halibut, and kidney beans represent salmon.
- Each fisher must catch at least two fish (large or small) in each round to survive (i.e., get enough fish to either eat or sell).
- When the fishing begins, students must hold their hands behind their backs and use the “fishing rod” (straw) to suck “fish” (beans) from the “ocean” (bowl) and deposit them into their “boat” (cup).
- The fish remaining in the ocean after each fishing season represent the breeding population, and thus one new fish will be added for every fish left in the ocean (bowl).

Play the game. Say “start fishing” and give the students 20 seconds for the first “season” of fishing.

Have each fisher count his or her catch in their cup) and record the data in a Fishing Log in their science notebooks.

Fishers who did not catch the two-fish minimum must sit out for the following round.

Add one new fish for every fish left in the ocean (bowl).

Allow fishers to use their hands on the straws during the second session to represent “new technology.”

After the second fishing season, give one fisher from each group a spoon or a small tea strainer representing more new fishing technology such as trawl nets, sonar equipment, etc. Continue the game for round three.
Fishing for the Future Continued

Ask, “What happened when ocean group [name] ran out of fish? How are the fishers going to survive now?” (One option is to move to another place in the ocean.)

Allow students to “invade” other ocean groups when their fishing place is depleted, but don’t tell them that they can do this beforehand. Fishers may either go as a group to another place in the ocean or they may disperse to other places.

Repeat fishing, recording, and replenishing fish stocks until either sustainable fishing is achieved or until all (or most) groups fish out their ocean.

Wrap-up:

Use the following sample questions to lead a discussion about the activity:

- How did you feel when you realized that you had depleted your fish stock?
- How did you feel when other fishers came to your fishing place?
- How does this activity relate to real ocean and fishery issues?
- What’s missing in this game? (Other predators on the fish such as sea lions, whales, and bears; a biologist counting the fish in the population and making predictions about the impact of harvesting.)
- How do changes in technology affect the success rate of the fishery? What happens to those who are still using the old technology?

Have students brainstorm ways to have a sustainable fishery. What rules could be developed?

(For example, limits on type of equipment allowed, amount and type of fish, shorter seasons.)

Read Fishery Facts and share information with students.

Ask students to write new rules for the fishing game, in their science notebooks. The objective of their new rules should be to make sure that the “fish” are never depleted and that no one has to sit out of the game.

If time permits, ask a volunteer to share their proposed rules, then discuss, adapt, and agree upon the new rules as a class.

Extensions & Lesson Connections:

Allow students to try the game using the new “sustainable” fishery rules they have developed. Compare the results.

Students can research which fish are harvested in a sustainable manner and which are being depleted. Have them do an advertising campaign in their school promoting the consumption of sustainable fish and avoiding the consumption of threatened fish. (This might include researching the kind of fish served in your school cafeteria, developing a system that protects threatened fish, and presenting it to your cafeteria staff, principal, and school board.) For recommendations about which seafood to buy or avoid, and why, from the standpoint of sustainable fisheries, check out the Monterey Bay Aquarium’s Watch Seafood Watch (for an overview, more links, and a downloadable pocket card for the West Coast http://www.seafoodwatch.org/cr/seafoodwatch.aspx).

This lesson pairs well with the "Fishing Over Time" and "Legend and Science of the Bidarki."
Evaluation:

Use students’ responses to class discussion and their new proposed game rules to assess their level of understanding. Ask them to write a response to each of the focus questions in their science notebook.

The following criteria could be used to evaluate students’ grasp of the concepts:

- Gives examples of older and newer fishing technology.

- Explains that with more efficient technology fewer people can catch more fish in a shorter time.

- Cites depletion of fishery resources as a possible effect of changing technology.

- Demonstrates an understanding of what is meant by “sustainability.”

- Acknowledges personal responsibility and willingness to alter behavior or use of technology for a more sustainable fishery.

- Shows understanding of at least three of the following means of sustaining fisheries:
  - Limits on allowable technology.
  - Limits on the number of fishers.
  - Limits on the amount of fish caught by each fisher.
  - Limits on the season or the time that fishing is allowed.
  - Allowing fishing only in some areas.
The Legend and Science of the Bidarki

Adapted from the Alaska Seas & Rivers Curriculum, Alaska Sea Grant (http://seagrant.uaf.edu/marine-ed/curriculum/home.html) and LiMPETS: Long Term Monitoring and Experiential Training for Students protocols (http://limpetsmonitoring.org/), with data from Anne Salomon, Simon Fraser University.

Objectives:
Students will understand how humans are connected to the ocean and other living things through our shared food resources. They will appreciate how traditional and local knowledge and scientific studies can help people better understand the dynamic forces at play in ocean ecosystems and make informed decisions about sustainable harvests.

Concept:
A case study of harvesting bidarki (katy chitons) in the Alaska Native villages of Port Graham and Nanwalek illustrates how complex factors can affect important marine resources. Drawing from traditional and local knowledge, archaeological data, and rigorous field research, the study helps illuminate how a variety of factors such as location and permanence of villages with strong subsistence practices, changing predator populations (especially sea otters), and shifts in availability of other marine invertebrates. Students have a chance to reflect on their own connections to the ocean and participate in a bidarki monitoring program in their local area.

Materials:
- Science notebooks
- Pencils
- Samples of local foods
- Handout: Bidarki Story
- Handout: Bidarki Data Sheet
- Laptop/computer and projector or SmartBoard
- Map of Alaska
- Bidarki photo or actual bidarki
- Rulers
- Clipboards
- Plastic coated paper clips
- 50 meter measuring tape
- Cones or other objects for marking boundaries

Preparation:
Collect samples of local foods such as berries, fish, or local plants.

Print out copies of the Bidarki Story for students: http://seagrant.uaf.edu/marine-ed/curriculum/grade-5/investigation-1.html#story

Visit a local intertidal area and determine an appropriate bidarki monitoring site. For your data to correspond roughly to the Anne Salomon’s data, you need to set up a monitoring zone that spans the “high zone” of bidarki abundance to the “low zone” of bidarki abundance. The high zone is defined by the red algae Endocladia muricata (also called wire brush seaweed, for good reason!) and encrusting coralline algae. The "low" zone is defined by the brown ribbon kelp Alaria marginata and brown sea cabbage kelp Hedophyllum sessile. Choose a permanent monitoring site that encompasses these two zones and has easy to identify permanent markers at the horizontal end (such as large rocks).

This lesson is based on the collaborative study and book entitled Imam Cimiucia: Our Changing Sea by Anne Salomon, Nick Tanape, and Henry Huntington. You can purchase a copy of
The Legend and Science of the Bidarki Continued

the book through [http://seagrant.uaf.edu/book-store/pubs/SG-ED-70.html](http://seagrant.uaf.edu/book-store/pubs/SG-ED-70.html) or the book may be available for loan from your local library. If you have access to the book, use photos and quotes to supplement the story parts included in this lesson.

**Introduction:**

Bring in some samples of a food (berries, fish, edible plants, etc) that are found in your area and have students try them. Briefly discuss food sources for Alaskans now, and how they differ from food sources 100 years ago.

**Activities & Procedures:**

Tell students that they are going to read a story about human use of a resource from the ocean and how the people and the ocean ecosystem are interconnected.

Show students an example of a photo of a bidarki (black leather chiton, katy chiton, Katharina tunicata), and locate the villages of Port Graham and Nanwalek on a map of Alaska.

Distribute the introduction to the “Legend of the Bidarki” story, and read it together as a class, then divide students into four groups.

Ask groups 1 and 2 to be “residents of Port Graham and Nanwalek” and give them part 2a and part 2b to read. Groups 3 and 4 will be “University Scientists” and read parts 3a and 3b.

Let students know that they will report to the class the section that they read, and assign parts. Give the students time to read.

Ask Group 1 to explain to the class what they read in part 2a of the story. They could take turns, with one student asking each of the questions that the villagers had about the bidarki.

Discuss that part of the story and ask if students have any additional questions to ask.

Ask Group 2 to report on part 3a of the story, telling the rest of the class why scientists wanted to study the bidarki.

Discuss methods that scientists might use to try to answer some their questions.

Group 3 will report on part 2b of the story. Ask students to take turns reporting each of the statements that the elders told the scientists.

Finally, ask Group 4 to report on what scientist Anne Salomon found as a result of her study, part 3b.

Distribute the conclusions to the story and read them together as a class.

Discuss the interconnections in the story using a graphic organizer: On the board or overhead projector, ask students to help fill in “bubbles” to represent the various parts of the ecosystem near Port Graham and Nanwalek, including:

- People who live in the villages
- Bidarki
- Sea Otter
- Sea Star
- Cod or Halibut (substitute subsistence harvest in times when bidarki were scarce)

As a class, draw arrows between the bubbles to indicate the type of interactions that took place in the story.
The Legend and Science of the Bidarki Continued

Each student should replicate (and/or add to) the graphic organizer in their science notebook as the discussion takes place. Talk about the problem that people in the villages face and possible solutions to that problem.

Then, explain that you are going to monitor the size and abundance of bidarkis (or other common subsistence food) in your local area.

Prepare for a field trip to the intertidal zone by reviewing safety and how to be a beach steward. See the "Be a Beach Steward" lesson for more information. Bidarkis inhabit the mid- to low-tide zone of rocky areas, so you’ll want to go to a rocky beach at low tide. It is important to allow students some time for guided exploration of the area before conducting intensive monitoring projects, so consider including components of the Coast Walk Lesson if your class hasn’t participated in another recent field trip to the intertidal zone.

Explain that students will use scientific protocols to count and measure all the individuals of bidarkis in a designated area. This area will be marked or documented with photographs so that it can be surveyed again in the future.

Ask students to consider whether they think the bidarkis on this beach have high abundance and are large in size. What factors might be influencing this?

Have them write a hypothesis in their science notebooks about bidarki size and abundance on this beach relative to other Alaskan beaches.

Begin by finding and pointing out a bidarki to the entire group. Demonstrate how to use the rulers (or if in a crack, the paper clips) to measure the length of the individual.

Mark the boundaries of your monitoring plot with cones or tape measures.

Break students into teams of two or three, and have them systematically search the whole permanent study area for bidarkis.

They should designate one person in each group as the recorder. This person is responsible for completing the data sheet. The others should be searching—and should tell the recorder what they see as they see it. The team should look carefully in cracks and crevices and under ledges.

Remind students to also calculate the area in square meters for the monitoring plot by multiplying the length in meters by the width/height in meters.

Wrap-up:

Once the groups have collected their data, gather together as a class either at the beach or back in the classroom.

Have students share the data collected, and work together as a class to calculate the average total abundance of bidarkis by drawing from each group’s data.

To get abundance per square meter, divide this number by the area of the monitoring plot.

Then, calculate the average abundance for each size class designated on the data sheet.
The Legend and Science of the Bidarki Continued

Finally, calculate the average size of bidarkis in the designated area.

Was their hypothesis supported? Do bidarkis seem abundant on the beach? Do they seem to be large in size? This is difficult to decide without something to compare it to, so provide students with data from past surveys on the beach or from other locations.

Anne Salomon’s study of bidarkis near Port Graham and Nanwalek revealed a mean size of approximately 42.5 millimeters in 2003 and 2004. A small survey in China Poot Bay revealed a mean size of approximately 80 millimeters on a beach that is closed from any harvesting by people. Contact the Center for Alaskan Coastal Studies for access to bidarki surveys from other areas and to add your data for comparison with other sites.

Extensions & Lesson Connections:

Using data from past years, have students graph the abundance and average size of bidarkis over time.

Have students create poster or powerpoint presentations on the data collection process and analysis to share with others. This can be incorporated into the "Celebrate the Sea Party" described in Unit 6.

Have students conduct community interviews about changes in technology, natural resources, and ecosystems with a focus on how subsistence and commercial resources have changed over time. See the "Community Interviews" lesson for guidance.

This lesson pairs well with the "Fishing over Time" and "Fishing for the Future" lessons.

Evaluation:

Ask students to reflect in their science notebooks on these questions:

1. How did modern technology affect the way that the people in Nanwalek and Port Graham used the ocean?

2. What factors might influence the abundance and size of bidarkis on this beach?

3. Whose responsibility is it to take care of the ocean and its resources?

4. How do scientists help solve problems of conserving the ocean’s resources?

Assess student understanding as demonstrated by their completed graphic organizers and science notebook responses, observations, and hypotheses. Observe student cooperation, effort, and adherence to protocols and safety guidelines during data collection.
Ocean Acidification Lab

Objectives:
Students will measure and compare the acidity or alkalinity of everyday substances to develop an understanding of acids and bases. They will understand that substances with a high pH are basic, and substances with a low pH are acidic. They will observe how the addition of carbon dioxide (CO2) can change the pH of a solution and understand why increases in atmospheric CO2 are causing ocean acidification. Students will examine how acidic solutions effect clam shells and understand that different marine organisms are affected differently by changing concentrations of CO2 in the ocean.

Concept:
Concerns about the effects of increasing levels of atmospheric carbon dioxide on the climate are well-known. However, changes in atmospheric carbon dioxide can also have significant impacts on the pH of the ocean. Decreasing ocean pH, or ocean acidification, may change the ocean in dramatic ways. Some marine animals, like oysters and clams, may have trouble forming shells with decreases in ocean pH. Other animals, like crabs and lobsters, may actually be able to construct shells more easily if there is a higher concentration of CO2 in the ocean. Scientists do not fully understand what organisms will be affected and how. This is definitely an area where more research is needed to better understand the processes, effects, and steps that can be taken to mitigate or adapt to ocean acidification.

Materials:
- Science notebooks
- Pencils
- pH test strips
- Eye droppers
- Beaker
- pH meter
- Sample bottles with the following substances:
  - Soapy water
  - Mountain Dew
  - Baking soda in water
  - Vinegar
  - Lemon juice
  - Ocean water
- Purple cabbage
- Water
- Blender
- Graduated cylinders
- Straws
- Floating candles
- Lighter/matches
- Aluminum foil or plastic wrap
- Calcium based shells and products
  - Clam, mussel, or oyster shells
  - Clean pieces of egg shell
  - Small pieces of chalk
  - Tums/Antacid tablets
- Permanent markers
- Laboratory scale
- Handout: 20 Facts About Ocean Acidification
- Handout: “Ocean Acidification: A Risky Shell Game” Article
- Handout: Acid/Base Lab
- Handout: Make Your Own Acid Ocean Lab
- Handout: Changing Shell-ters Lab

Preparation:
Pour solutions (lemon juice, baking soda in water, etc.) into sample bottles. Place an eyedropper with each solution.

Combine cabbage leaves and water in a blender. For every 2 cups water, add 1 large leaf from a red cabbage. You should plan on making at least 1 cup of indicator for every 2 students. Liquefy well in the blender. Pour the purplish cabbage liquid through a strainer to filter out all of the...
big chunks of cabbage. This liquid is your cabbage indicator. You may create this cabbage juice indicator ahead of time, or let your students help you make it. You may also choose to skip the cabbage juice altogether and use a universal pH indicator solution.

Make copies of the student directions for each experiment. You will need one copy per group.

Make 1 copy per student of “20 Facts About Ocean Acidification” compiled by scientists at the Ocean Carbon and Biogeochemistry Project, United Kingdom Ocean Acidification Programme, and European Project on Ocean Acidification.

**Introduction:**

Ask students what an acid is. Brainstorm a list of acids on the board. What happens when something is a really strong acid?

Then make a list of bases. What happens when something is a really strong base?

Show the students the pH scale and explain that pH is a way to compare how strongly acidic or basic something is. If something is measured as “1” it’s the strongest possible acid. If it’s measured as “14” it’s the strongest base. In the middle scale, it’s neutral, neither acid nor base.

Explain that the pH of a substance can be measured using pH paper, which will change color depending on how strong an acid or base the substance is. With pH paper, the color of the paper is matched to a color table that tells the pH number.

For older students, explain that pH measures the concentration of OH- ions in the water. If the ratio of OH- to H+ ions is high, the higher the pH and more basic the solution is. Conversely, if the ratio is reversed and there are many more H+ ions than OH- ions, the pH will be lower and the solution more acidic.

**Activities & Procedures:**

Explain to students that they are going to begin by exploring the pH of some everyday substances.

Show them how to use the pH strips. Take a strip out of the pH tube. Use the eyedropper to place a small amount of the sample on the pH strip. Then compare it with the color scale on the pH tube. Explain to students that because the strips are somewhat expensive, they should try to do 3-4 tests on different parts of each strip.

Divide students into groups of 2-4. Give each group of students a tube with pH color scale on it and some pH test strips inside.

Using the Acid/Base Experiment directions, have students complete the experiment and record the data in their science notebooks.

Now, explain to students that as carbon dioxide mixes with seawater, the seawater becomes more acidic.

Pass out the “20 Facts about Ocean Acidification” hand out.

View one or more of the following videos: “The Other CO2 Problem” created by Ridgeway School students (http://www.youtube.com/watch?v=kvUsSMa0nQU), “The Other Carbon Dioxide Problem” from NOAA (http://www.youtube.com/watch?v=9EaLRCVdTBM&feature
Continue

Conduct Experiment #2 using the “Make Your Own Acid Ocean” student directions. For this experiment, each group will need a beaker or cup with cabbage juice and each person will need a straw.

Ask groups to share their results after the experiment. What happened to the cabbage juice as CO2 was added? (It became more acidic.) Is this how CO2 enters the ocean in real life? (Not really. It isn’t directly injected into the ocean – like with the straw – but is instead mixed from the atmosphere. As CO2 levels in the atmosphere increase, more ends up in the ocean).

Demonstrate the effects of increased atmospheric CO2 by placing a floating candle in a new beaker of cabbage juice.

As the candle burns, oxygen will be converted to CO2. Light the candle, and seal the top of the beaker with foil or plastic wrap (make sure it is far enough from the candle that the plastic wrap won’t melt).

The candle will go out in a few seconds as it runs out of oxygen. Keep the container sealed so some of the CO2 can transfer to the cabbage juice.

Have the class observe any color changes in the cabbage juice.

After 30-60 minutes, return to the demonstration and use a pH strip or pH meter to measure the pH of the cabbage juice.

Discuss the results. How did the increase in atmospheric CO2 affect the pH of the cabbage juice?

Ask students to think about how changing ocean pH might affect marine organisms. Reflect back on the video(s) you watched earlier.

If you’d like, have students use this animation from the Woods Hole Oceanographic Institute to learn how animals build their shells: http://www.whoi.edu/page.do?pid=110417&cid=55243&cl=38052&article=52990&tid=5782

Divide students into groups of 4-6 to conduct experiment #3, “Changing Shell-ters” using the student directions.

Each group will need 6 petri dishes, 3 pieces of shell, and 3 calcium product and access to the sample solutions from experiment #1. You can have different groups test different types of shells and calcium, but they should be the same within the group.

This experiment works best if you can let the shells/calcium sit in solution for a few days, even up to a week or more. Store the petri dishes in a safe location and check on them periodically to make sure the solutions have not evaporated.

After the allotted days, have students remove shells/calcium to a paper towel to dry before weighing them on the scale.

After students have weighed them, discuss the results. (Shells that were in strong acidic solutions should weigh a little bit less than shells in basic or
neutral solutions. Some of the calcium products may have dissolved significantly.)

Have students compare the pH of the solutions that caused thinning of the shells with the current pH of seawater and predicted pH of seawater. Many scientists predict an ocean pH of about 7.7 in one hundred years. Is this more or less acidic than the solutions the shells thinned in? (Most of the solutions – vinegar, lemon juice – are significantly more acidic than the predictions for the ocean.) Would they expect to see more or less dramatic results in the ocean? (The results in the ocean would be less dramatic and immediate, but could still have major impacts on marine organisms.)

Wrap-up:

Following experiment #3, or during the waiting period, have students read “Ocean Acidification: A Risky Shell Game.” Ask students to discuss the article with a partner, focusing on what surprised them in the article and questions they have.

Discuss the article as a class. What types of animals will likely be affected the most by increased CO2 in the ocean? (Those that build calcium shells). What animals will be affected negatively? (The research suggests animals like clams, mussels, and pteropods will be affected negatively.) What animals will be affected positively? (The research suggests that animals like crabs and lobster might be able to build exoskeletons more easily).

Ask students to reflect in their science notebook about ocean acidification:

- What is ocean acidification?
- How will marine animals be affected?
- What can people do to mitigate or adapt to ocean acidification?

Extensions & Lesson Connections:

This lesson can be extended with a virtual lab through Stanford University about the development of urchin larvae in acidic waters: http://virtualurchin.stanford.edu/AcidOcean/AcidOcean2.htm.

NOAA’s data on ocean surface pH can be used for classroom investigations, http://dataintheclassroom.noaa.gov/DataInTheClassRoom/SitePages/oa/index#.Uu_8zvZRn6Q, and their Ocean Acidification simulator is a powerful tool to visualize the effects of different levels of atmospheric CO2 on various aspects of ocean acidification: http://dataintheclassroom.noaa.gov/DataInTheClassRoom/SitePages/oa/simulation.

Evaluation:

Check science notebooks for accurate and thorough observations and data collection from the experiments. Assess the student reflections for understanding and application of the main concepts. Evaluate student participation during discussions and cooperation during group work.
1. Take 1 pH strip out of the tube.

2. Use an eyedropper to carefully place 1 drop of a sample solution on the pH strip. Place the eye dropper next to the sample solution. Do not use the same eye dropper for a different solution!

3. Wait 30 seconds and compare the color to the color scale on the pH tube.

4. Decide what color is most closely matches the color of your test on the pH strip. Record the pH number associated with the color in your science notebook along with the name of the solution.

5. Use a different part of the pH strip to test a different solution. You should be able to fit 3-4 tests on each strip.

6. Work with your group to test all of the substances and record your findings in your science notebook.

7. Discuss the following questions with your group and record your answers in your science notebook:
   - What was the most acidic?
   - What was the most basic?

8. Pour ¼ cup of the small amount of the cabbage juice indicator into 3 small beakers. Cabbage juice works like the pH strip, but you’ll have to figure out for yourself what color indicates acid and what color indicates base.

9. Add 5 drops of the most basic solution (highest pH) to one of the beakers of cabbage juice and carefully swirl the beaker to mix. Note what happens to the color.

10. Add 5 drops of the most acidic solution (lowest pH) to a different beaker of cabbage juice and carefully swirl the beaker to mix. Note what happens to the color.

11. Arrange the beakers from lowest pH (beaker with acid added) to highest pH (beaker with base added). The beaker of cabbage juice should be in the middle. You will use this scale in the next experiment.
Make Your Own Acid Ocean Lab

1. Test the pH of the cabbage juice indicator with a pH strip or pH meter. Record the initial pH in your science notebook.

2. Use a watch, clock, or stopwatch to keep track of time during this experiment.

3. One person in your group should place their straw into the beaker of cabbage juice indicator and carefully blow. As the person exhales, they are releasing mostly Carbon Dioxide, which is being moved into the cabbage juice through the straw.

4. After about 10 seconds, rotate your source of CO2. Have a different group member blow through their straw into the cabbage juice.

5. As you rotate through group members, keep an eye on the cabbage juice. At what point does the cabbage juice begin to change color? Record this time in your science notebook, but make sure a group member keeps blowing through the straw.

6. Continue blowing through the straw until it seems like the cabbage juice has stopped changing color. Record the time.

7. Compare your cabbage juice with added Carbon Dioxide to the cabbage juice color samples you created in the earlier experiment. Which sample is it closest in color to – the low, medium, or high pH?

8. Now check your results with a pH strip or pH meter.

9. Answer these questions in your science notebook:
   - Did the pH of the cabbage juice increase or decrease when CO2 was added?
   - Does this match your color samples for cabbage juice?
Changing Shell-ters Lab

1. Weigh one sample of shell. Record the weight in your science notebook as “Sample #1” and put it into a petri dish that you label #1.

2. Do the same with Samples #2-#6. You will use a type of shell for samples #1-#3, and a type of calcium product for samples #4-#6.

3. Choose 3 solutions from experiment #1 – one that has a low pH (very acidic), one that has a medium-low pH (somewhat acidic) and one that has a pH around 7 (neutral).

4. Use the eye droppers to cover each sample with one of the solutions you have chosen. You should have a shell covered with very acidic solution in a petri dish, a shell covered with somewhat acidic solution in a petri dish, and a shell covered with neutral solution in a petri dish. You should have the same three samples for the calcium product.

5. Record in your science notebook the name of the solution you add to each shell and calcium product.

6. Cover the petri dish after you’ve added the solution.

7. Observe in your science notebook any immediate effects on the shell/calcium product in each solution.

8. Make a hypothesis in your science notebook about what will happen to each shell/calcium product as it sits in the solution.

9. Make another round of observations 30 minutes and 1 hour later.

10. When your teacher directs you, carefully remove the shells/calcium products from the petri dish and place them to dry on a paper towel. Make sure to label the number of each one on the paper towels.

11. Weigh them and record in your science notebook.

12. Answer the following questions in your science notebook:
   - Do any shells/calcium products lose mass? If so, what solutions were they in?
   - Look at your data from Experiment #1. What was the pH of the solutions that caused the shells/calcium products to lose mass?
   - Why do you think some of the shells/calcium products lost mass?
   - Which lost more mass – the shells or the calcium product? Why do you think that is?
   - What might happen to shells in the ocean if it becomes more acidic?
   - What animals do you think will be affected most by ocean acidification?
Melting Glaciers and Silty Salmon


Objectives:
Students will understand that melting glaciers affect stream flows, erosion, and habitats for fish and wildlife. They will analyze repeat photographs of glaciers and observe stream table simulations to identify types of changes in the local environment. Finally, they will apply the knowledge they have gained to understand current and potential effects on fish and wildlife.

Concept:
Changes in physical environments can significantly affect our ecosystems and communities. Melting glaciers affect stream flows, erosion, and habitats for fish and wildlife. Analysis of repeat photographs of local glaciers and observations during stream table simulations help to illustrate how these changes can affect local ecosystems. A story about small fish fry in silty waters highlights one way that melting glaciers can have significant effects that ripple throughout ecosystems and communities.

Materials:
- Science notebooks
- Pencils
- Handout: Alaska Glaciers
- Foil pan
- Sand
- Soil
- Gravel (optional)
- Watering can
- Pitcher
- Funnel
- Piece of hose or other soft tubing
- Blocks, brick, or books to prop stream table up

Preparation:
Print copies of the Alaska Glacier photos or choose your own from the National Snow and Ice Data Center Repeat Photography of Glaciers: http://nsidc.org/data/glacier_photo/index.html. You will need to have enough copies so that each partner group can have a set of photos for at least one glacier. The set should include an historic photo of the glacier along with a more recent one.

Create a stream table. Cover the bottom of a foil pan with a layer of sand and gravel. Use books or a block to prop one end of the pan up about 3 to 5 cm. Use your finger to roughly etch out a stream starting at the headwaters.

Introduction:
Ask students to think about land ice-glaciers. Offer the opportunity for them to share what they might know about glaciers. Review how glaciers are formed, and how they move.

Students should be familiar with the terms “advance” and “retreat.” If students are unfamiliar with glaciers, have them find out more about glaciers using the PBS Learning Media resources about glaciers: http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.glaciers/glaciers/.

Ask students if they know where the most glacier ice is located in the world. (Most glacier ice is in two places – Greenland and Antarctica. Alaska’s glaciers only make up a small percentage of the world’s glacier ice).
Melting Glaciers and Silty Salmon Continued

Share the 7-minute video from NOVA about Greenland’s Jakobshavn glacier: http://www.pbs.org/wgbh/nova/earth/fastest-glacier.html. Explain that although Jakobshavn glacier may be the most extreme example, glaciers in Alaska are changing too.

**Activities & Procedures:**

Divide students into pairs. Explain that they will analyze a variety of glacier photos to observe changes in landscape over time.

Pass out one set of glacier photos to each group. Draw a Venn diagram on the board, using two circles.

Ask students to copy it into their science notebooks, writing the year the first photo was taken at the top of the circle on the right and the year the second photo was taken at the top of the circle on the right. They also should write the name of the glacier and number of years between the two photos.

Have students list the common features of each photo in the middle, and note the differences in each of corresponding sections. Finally, they should note the major changes at the bottom of the page.

If time allows, have students trade photos with another group and complete another Venn diagram for a second glacier.

When all students have finished analyzing their photos, ask them to share their observations and predict what might happen in the next 50 years if the glacier continues to recede. Make a list of the major changes between the two photos noted by each pair of students.

Ask students to think about the glacier photos that they analyzed. What were some of the changes to the landscape they observed after the glacier had receded? In addition to exposing land that was previously covered by ice, the water released can change the landscape and the quality of water in streams.

Show them the stream table and explain that you can use it to show the effects of a stream on the land. Ask students to closely observe the stream table before you begin, noting how the surface appears.

Have a student volunteer use a watering can to simulate "rainfall" by holding it slightly above the “headwaters” of the stream table.

Observe the small streams that form in the sand and drain into the original stream you etched out.

Ask students to watch the flow of water as it erodes the sand. What do they notice? How are the different grain sizes affected by the water flow? How is the water flow affected by different size sand or rock particles?

Ask them to sketch the resulting landscape and write an explanation of how a stream can erode the land.

Place the tubing in the lower end of the stream channel and place the funnel below the end to direct the flow into a bucket.

Have the student keep “raining” on the sand until water runs off into the bucket. What does the runoff look like?
Melting Glaciers and Silty Salmon Continued

Next, carefully add a 1-2 cm layer of soil to the “headwaters” area to explore how runoff and turbidity change with a different sediment.

Have a different student volunteer simulate “rainfall” by holding it slightly above the “headwaters” area.

Ask students to watch the flow of water as it erodes the soil. What do they notice? How are the different grain sizes affected by the water flow? How is the water flow affected by different size soil or rock particles?

Place the tubing in the lower end of the stream channel and place the funnel below the end to direct the flow into a bucket.

Have the student keep “raining” on the soil until water runs off into the bucket. What does the runoff look like? How does it compare to runoff from the sand?

Ask them to write a description of what happened. Ask them to consider how muddy water might affect the plants or animals that live in the water.

To model the effect of increased flows that would occur with accelerated glacial melt, use the watering can for a set period of time and keep a sample of the runoff.

Then directly pour water from the pitcher for the same amount of time and take a sample of the runoff.

Compare the two samples. Which is more cloudy or muddy?

Explain that when glaciers move, the ice scrapes over the ground or bedrock and grinds it up into very fine particles called glacial silt. When the glacier melts, this silt is washed out beneath the glacier and is deposited into the streams and lakes. It is so fine that it does not quickly settle to the bottom and can be suspended in the water, causing the water to appear cloudy or turbid.

Ask students to help develop definitions of transparency and turbidity: Water without any sediment in it would be completely clear, and light would pass right through it. Any soil, silt, or sand floating in water scatters and absorbs light. Turbidity measures the relative amount of light scattered and absorbed by water. It is a way to tell how cloudy the water is.

Distribute the Peninsula Online news article, "Small fry may be big problem" to students and ask them to read it to themselves. Then ask, "To what do scientists attribute to the small size of the salmon fry in Skilak Lake?"

Ask students to recall what happened in the stream table when the water was poured over the soil.

Divide students into groups of 2 or 3, and give them the following list of terms:

- Changing Climate
- Glacier
- Hurricane
- Sediment
- Transparency
- Turbidity
- Light
- Phytoplankton
- Zooplankton
- Salmon
- Humans

Students should write each term on sticky notes and arrange a concept map on a piece of paper.
Melting Glaciers and Silty Salmon Continued

After discussing the relationships of these ecosystem elements and developing their concept map, each student should copy the concept map into their science notebook, along with any questions they have.

Ask students to also answer the following questions in their science notebooks:

1. How do you think turbidity (the cloudiness of the water) might affect:
   - The amount of light that will pass into the water column and be available for photosynthesis by marine or aquatic organisms?
   - The amount of zooplankton available as food for young salmon and other fish?
   - How fast salmon fry and smolt can grow and their size at migration from fresh water to the ocean?

2. Do you think that rapidly-melting glaciers are most likely to increase or reduce water transparency in glacial lakes and streams?

Wrap-Up:
When all the groups have finished, share and discuss the group responses to the questions as a class, and correct misconceptions.

Each student should return to the concept map in their notebook and revise it, adding new terms and connections, and changing it as needed.

Extensions & Lesson Connections:

One possible extension is to use a Secchi disk to measure the transparency of local water bodies, taking measurements over time. It may be interesting to see how the turbidity changes after a big storm or a hot, dry spell.

Have students construct a standard Secchi disk (20 cm diameter for lakes and 40-50 cm for marine waters) using these instructions: http://waterquality.okstate.edu/uploads/wq_programs/homemade%20secchi%20disks.pdf

Another way to extend this lesson is to play the “Glacier Game” described in Grade 8, Lesson 2E of the Alaska Seas and Rivers Curriculum: http://seagrant.uaf.edu/marine-ed/curriculum/grade-8/investigation-2.html

Link the input of freshwater from melting glaciers to what students learned about density driven currents in the "Density Differences: Water" and "Currents & Coriolis" lessons.

Evaluation:
Walk around and listen as students describe their observations about the glacier photos to each other as a formative assessment. Check science notebooks for accurate and thorough observations and sketches about from the stream table. Assess the completed concept map to evaluate student understanding of the main concepts.

As a summative assessment, use an exit ticket strategy, “Point of Most Significance.” Students write down the most important points learned from the lesson on an exit ticket to turn in when they leave.
Oily Experiments

From the Alaska Oil Spill Curriculum, Prince William Sound Regional Citizens Advisory Council, Written by Bonnie Jason

Objectives:
Students will examine the basic characteristics of oil and identify how oil affects a variety of materials. They will understand how the characteristics of oil make it difficult to clean up and dangerous for ecosystems.

Concept:
Oil has unique characteristics that make it both useful for people and dangerous to ecosystems. Without an understanding of the properties of oil and water it is difficult for students to understand how oil can affect an ecosystem and why it is difficult to clean up an oil spill. This activity allows students to feel, smell, see, and manipulate oil and oily materials. Students then discover the effects of oil on a variety of materials.

Materials:
- Science notebooks
- Pencils
- Sample of motor oil
- Vegetable oil
- Black tempera paint
- Water
- Various containers or basins (2 per group)
- Paper towel or rags
- Fur scraps
- Feathers
- Sand
- Gravel/pebbles
- Shells
- Pieces of wood
- Seaweed
- Grass
- Newspapers
- Old shirts/aprons
- Whiteboard or posterboard
- Dry erase markers or colored markers
- Ruler
- Stopwatch
- Tablespoons

Preparation:
Set up this activity outside if possible. If not, use old newspapers to cover the floor. Mix vegetable oil and black tempera paint and beat well to create pretend crude oil students can safely work with.

Introduction:
Begin by passing around a vial with a small amount motor oil in it. Open the vial just a bit and allow students to smell a small whiff of the oil. Ask students to describe what the oil smells and looks like in their science notebooks. Then record their words on the board.

Activities & Procedures:
Have students put on old shirts or aprons. Divide students into groups of 3-5. First students need to create a table in their science notebooks similar to the following:

<table>
<thead>
<tr>
<th>Time Elapsed</th>
<th>Diameter or Width &amp; Height</th>
<th>Area</th>
</tr>
</thead>
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<tr>
<td>0 seconds</td>
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<td></td>
</tr>
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<tr>
<td>1 minute</td>
<td></td>
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<tr>
<td>2 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oily Experiments Continued

While students are creating this table, place 2 basins of water near each small group.

Explain that their right hand will go only in the water basin, and that their left hand will go only in the oily basin.

Give each group some of the oil/tempera paint mixture, a tablespoon, and a ruler.

Have someone from each group drop a tablespoon of oil into the water.

Have the group measure the approximate diameter of the spill (if approximately circular) or length and width of the spill (if more rectangular) and record in their science notebooks.

Measure the spills again at 30 seconds, 1 minute, 2 minutes, and 3 minutes. Students should then calculate and record the approximate area of the spill at each time marker by either:

- multiplying Length x Width
- OR
- dividing Diameter/2 to get radius and plugging this value into the equation area = \( \pi \times \text{radius}^2 \)
  
  \[(\text{multiply radius by itself and then by 3.14})\]

Ask each student to place one hand in each container and swish it around. Have them describe how it feels.

List all of their descriptive words on a poster or whiteboard, under the appropriate headings “oil and water” or “water.”

Have students wash and dry their hands and record their observations in the science notebooks.

Give each group some of the following items to submerge in each of their basins: shells, feathers, pieces of wood, fur scraps, sand, gravel, pebbles, seaweed, grass, or anything else you can think of.

Have each group hypothesize what will happen to these items once they are submerged in the water and in the oily water, and write their hypotheses in their science notebooks. Provide the following example to students, if needed:

*I predict that (material) ______________ will:

________________________________________________________________________

*when dipped in the water and will:

________________________________________________________________________

*when dipped in the oil and water mixture.*

Allow students to investigate the changes that occur in the texture of these materials.

Again, ask students to describe how they feel and look, and have them record their observations in their science notebooks, noting whether their hypotheses were supported or refuted.

Ask each group to choose one way of changing the oil by adding ice cubes, hot water, or soap, or by mixing the tub.

Have the groups form and record in their science notebooks a hypothesis about how the oil will change, answering the following questions:

- What are you going to do to change the oil?
Oily Experiments Continued

• Make a hypothesis about how the oil will change.

• Why do you think the oil will change in these ways?

Have students complete the experiment, and record their observations of how the oil actually changed and whether their hypothesis was supported or refuted.

Wrap-Up:

Discuss whether or not the hypotheses were supported by the experiment results. How would students expect ecosystems to be affected by oil? How might some of the characteristics of oil be affected by changes in temperature, weather, etc.?

Extensions & Lesson Connections:

This activity works very well in conjunction with “Critter Clean-Up” and “Sheen-Oil-Mousse.” In fact, the oily water from the tubs can be saved for use in the “Critter Clean-Up” activity.

Evaluation:

Review science notebooks for completeness and understanding. Notebooks should include observations of crude oil appearance and smell, table and calculations for oil spill size over time, descriptions of oil and oil in water, hypotheses and observations of different materials in water and oily water, and hypothesis and observations of how oil in water reacts to a change. Pay special attention to their “changing oil” hypothesis, experiment design, and observations as formative assessment.
Sheen-Oil-Mousse

Objectives:
Students will examine the basic characteristics of oil and identify the three fractions of spilled oil. They will understand some of the potential impacts of spilled oil on ecosystems.

Concept:
Oil undergoes changes in marine ecosystems. When oil is spilled, it begins to change both physically and chemically. Some amount of the lighter, volatile compounds turn to gas and disperse in the air. The remainder of the toxic oil usually spreads out from the main slick as fingers of very thin, iridescent sheen on the surface of the water. As oil on the surface is agitated by wind and begins to weather, it changes. Within about two weeks it begins to form mousse: a thick, gel-like mixture of oil, air, and water. Both the mousse and sheen can be deadly to sea-birds and other marine life, especially those that spend time on the surface or in intertidal areas.

Materials:
- Science notebooks
- Pencils
- 1 cubic centimeter motor oil or crude oil
- 1 quart sea water
- Hand whisk or egg beater
- 1 large bowl
- Eye dropper
- Graduated cylinder
- 2 bowls, 6” in diameter
- 1 large flat pan or tray
- 4 seabird feathers
- 4 small rocks
- 1 oil absorbent pad
- Rulers
- Pens or pencils
- Paper
- Calculators
- State or U.S. map with scale

Preparation:
Set up this activity outside if possible where there is good ventilation. The tools and kitchen supplies used in this activity should not be used for food ever again. Oil is a toxic substance and should be treated as such. See the background information for more details.

Introduction:
Remind students that oil is toxic; they should not try to inhale large amounts of the volatile compounds and should avoid touching the oil.

Pour a layer of salt water about 1 inch deep into each of the bowls.

Have a student use the eyedropper to drop a single drop of motor oil onto the surface of the water in one of the bowls.

Examine the sheen that forms and describe it as a group. Explain that when oil spills, it often spreads in a thin sheen such as this.

Ask students if they think such a thin sheen could affect animals. Why or why not?
Sheen-Oil-Mousse Continued

**Activities and Procedures:**

Have a different student dip two feathers into the bowl of plain saltwater as the control.

Remove the feathers and place them on top of each other in a well-ventilated or sunny spot to dry.

Then have someone else dip two new feathers into the bowl containing the oil sheen. Remove the feathers. Can anyone see the oil?

Place the feathers on top of each other next to the control feathers to dry. Save the oiled saltwater and move on to the next steps as the feathers dry.

Demonstrate the way oil leaking from a tanker, pipeline, or drilling rig, or from a small spill on a boat or release of oily bilge water spreads out to form a slick on the surface of the water by pouring a layer of sea water into the large, flat tray and dropping a cubic centimeter of oil on to the water’s surface.

Have students compute the area in centimeters of the slick that forms.

Then compute the area of a slick that could be formed by a liter of oil – just multiply by 1000.

The Exxon Valdez Oil Spill was measured in gallons. There are 3.785 liters in one gallon, so students can calculate the size of a slick formed by one gallon of oil simply by multiplying the slick formed by a liter times 3.785.

Approximately 11,000 gallons of oil were spilled in the Exxon Valdez Oil Spill, so have students multiply by 11 million.

Finally, students can convert the slick size to square centimeters – divide their answer by 929 (1 square foot = 929 square centimeters) and then divide by 27,900,000 (1 square mile = 27,900,900 square feet).

Record this final number as a projection of the slick size for an 11,000,000 gallon oil spill. A review of these steps follows the lesson.

Provide students with copies of a local or U.S. map. Have students identify the scale of the map.

Calculate the scaled size of the projected slick (divide the projected slick size in square miles by the scale mile:inch or mile:centimeter). Have students color a scaled oil spill on the map. What areas would be oiled?

Take the oiled water from previous experiments and pour into a large bowl.

Mix with an egg beater for at least twenty minutes.

While this is happening, revisit the feathers. What happened? Did both sets of feathers dry at the same rate? Are any of the feathers matted together?

Discuss how even a tiny amount of oil may cause bird feathers to mat together. In this condition, feathers cannot be fluffed for warmth and birds may die of hypothermia.

After twenty minutes, skim of the froth of oily mousse that forms.

Have students measure it. Is it more or less than the amount of oil that was poured into the bowl?
Sheen-Oil-Mousse Continued

(1 cubic centimeter of oil plus one drop of oil went into the bowl) What happens to an oil slick at sea that is agitated by high winds and strong seas for 2 weeks or more?

That is what happened to the Exxon Valdez oil in the Gulf of Alaska, and it formed mousse. Thick foamy mousse blew ashore and remained in the intertidal areas.

Blow and pour some of the mousse onto a few dry rocks to illustrate how it clings to shore rather than washing back out to sea. Save the oiled water for “Critter Clean Up” activity.

Begin a discussion or have students write in their science notebooks about the potential effects of mousse on intertidal life, including some or all of the below questions:

- What happens to animals such as chitons, snails, and limpets which normally crawl across the surface of the rocks looking for food? Do you think they can remain attached and move with gooey mousse covering the rocks?

- Barnacles attach themselves to rocks and reach their fragile legs out to capture food from the water. What happens to the barnacles if they are covered with mousse?

- Clams and mussels filter food out of the water by pulling water into their siphons? What would happen if they were covered with mousse?

- Many shorebirds and ducks feed on barnacles, clams, and mussels. What happens to these birds if their foods are covered in mousse?

- There are many kinds of crabs that live on the shore. Crabs breathe by means of gills, which are located just under the top shell. What will happen if mousse gets in their gills?

- Many people harvest chitons, snails, limpets, clams, mussels, crabs, or birds. How would people be affected by mousse?

Wrap-Up:

Ask students if they have ever seen oil in the water. Discuss sources of small amounts of oil pollution, such as fuel oil spills or oily bilge water on recreation and commercial boats, as well as oil leaks on land from cars, trucks, ATVs, etc. How can these sorts of small spills be prevented?

Extensions & Lesson Connections:

Follow-up with a trip to the harbor or a large parking lot to look for evidence of tiny oil spills and learn more about prevention, as described in “Cleaner Harbor Tour.” This activity also pairs very well with “Critter Clean Up.”

Evaluation:

Review science notebooks and maps for completeness, accurate computations, and understanding.
## Review of Math Steps

<table>
<thead>
<tr>
<th>Step Description</th>
<th>Formula/Calculation</th>
</tr>
</thead>
</table>
| Area of slick formed by cubic centimeter of oil:                                 | \[ \text{cm}^2 \times 1000 \]
| Predicted area of slick formed by liter of oil:                                   | \[ \text{cm}^2 \times 3.785 \]
| Predicted area of slick formed by gallon of oil:                                  | \[ \text{cm}^2 \times 11,000,000 \]
| Predicted area of slick formed by 11 million gallons of oil (cm\(^2\)):          | \[ \text{cm}^2 \div 929 \]
| Predicted area of slick formed by 11 million gallons of oil (ft\(^2\)):          | \[ \text{cm}^2 \div 27,900,000 \]
| Predicted area of slick formed by 11 million gallons of oil (mi\(^2\)):          | \[ \text{cm}^2 \div 27,900,000 \]
Oil Spill in A Pan

From the Alaska Oil Spill Curriculum, Prince William Sound Regional Citizens Advisory Council

This lesson plan is a compilation of several similar activities:
• by Bonnie Jason
• by Kara Johnson, Prince William Sound Science Center
• and adapted by Elizabeth Trowbridge from Alaska Science and Marine Science Project: FOR SEA Poulsbo, Washington, 98370
• with background information provided by Bruce McKenzie, Alaska Clean Seas

Objectives:
Students will experiment with ways to contain and clean an oil spill and will use that hands-on experience to evaluate the challenges and efficiencies of various clean-up techniques. They will compare the success of different technologies under different conditions.

Concept:
It is difficult and expensive to contain and clean up an oil spill. This hands-on activity is meant to simulate the challenges of containing and cleaning up an oil spill. This version of the activity has been adapted from many sources and includes an economic component as well as habitat and climate comparisons. It can be simplified for use with younger students or shorter duration.

Materials:
• Science notebooks
• Pencils
• Vegetable oil
• Black tempera paint
• Tablespoon
• “Habitat” materials:
  • Grass
  • Mud
  • Rocks
  • Sand
• Clean up materials:
  • Nylon net
  • Nylon hose
  • Styrofoam
  • String
  • Straw or sticks
  • Fur or hair
  • Detergents
  • Seaweed/pondweed
  • Absorbent pads
  • Spoons, etc.
  • Eye dropper
• Large disposal containers (coffee can, etc.)
• Saltwater
• Freshwater
• Ice cubes
• Hot water
• Handout: Clean-Up Cost Sheet
• Newspapers
• Aluminum pans or plastic bins (3 per group)
• Stop watches
• Fan (optional)

Preparation:
Set up this activity outside if possible. If not, use old newspapers to cover the floor.

Mix vegetable oil and black tempera paint and beat well to create pretend crude oil students can safely work with.
Oil Spill in a Pan Continued

Fill two tubs per group with saltwater.

Leave one tub as only water, but include “habitat” materials along one side of the other tub to represent intertidal habitats such as marshes, sandy beaches, and rocky intertidal zones. Give each group a different type of intertidal habitat: rocky intertidal (large rocks), sandy beach (sand), salt marsh (grass), mud flats (mud/clay), cobble beach (small rocks/pebbles), etc.

Set up a clean-up material purchase station along one table.

**Introduction:**

Break students into groups and have each group gather around a tub of water.

Introduce the lesson to students by explaining that you are going to create an oil spill in each pan. Their challenge is to investigate various containment and clean-up techniques.

Discuss with them various clean-up products and methods, such as: skimmers and booms, dispersants (detergents), oiled seaweed or pom-poms, absorbent pads, suctioning (eye dropper) and collecting with buckets.

Each of these clean-up techniques comes with a cost: the cost of the material itself and the cost of disposal. Explain to students that each group has a $100,000 budget for their clean-up and oil disposal.

Allow students to list alternative methods and experiment with them during the clean-up. Have students answer the following questions in their science notebooks:

- How do you think oil will interact with the coastline and the plants and animals that live there? Write a hypothesis, an educated guess.
- Which materials do you think will work best to clean up the oil? Write a hypothesis, an educated guess.

**Activities and Procedures:**

Begin by placing a tablespoon of oil in the “open ocean.” Start the timer for one minute.

As you wait for the oil spill response to begin, explain to students that they are trying to contain and remove the oil from the open ocean bin. If oil touches the edge of the open ocean bin, then it has moved into intertidal habitat – when this happens, you will place 1 tablespoon of oil into the tub with intertidal habitat.

The students’ task is to contain, remove, and dispose of the oil as quickly as possible while staying within their $100,000 budget. If the oil cannot be contained and makes its way into the intertidal habitat, their task expands to include cleaning the habitat as best as possible.

After the minute passes, let the containment and clean-up begin! Students can send one representative per group to the purchase station to pick up materials and note the purchase on their cost sheet.

After two to three minutes, simulate a storm in each ocean tub by blowing or using a fan to move the oil around.

Check tables to add a tablespoon of oil to the intertidal habitat bin as needed if the oil reaches
Oil Spill in a Pan Continued

the edge of their open ocean tub. *(If any group is successful in containing and removing the oil before it reaches the edge of the tub, congratulate them on their efficiency, but still give them a new challenge by placing a tablespoon of oil in their intertidal habitat tub.)*

Continue the activity for 25 minutes, or until groups have reached their limit of clean-up activities.

Have groups tally up their clean-up cost and estimate what percent of the oil was removed from the open ocean and intertidal habitat bins.

Students should record this data in their science notebooks and answer the following questions:

- Describe what happened. Were your hypotheses accurate?
- Were you able to stay within your budget?
- Write a conclusion about your experience cleaning up an oil spill with your funds and equipment.

Have students share their data and record it on the board. What containment and clean up techniques seemed to be most successful? Which ones were least successful? Which techniques seemed to clean or contain the most oil for the least amount of cost? Did different techniques work better in different habitats? Did students develop any new materials or techniques?

Analyze cost and percentage cleaned data to identify mean, median, and mode. As a group, identify the three most successful techniques that worked across habitats.

Now, it is time to change the climate and location of the spill. Allow each group to choose a new climate/location: warm saltwater with the same intertidal habitat type (80 degrees Fahrenheit), ice-filled seas (ice cubes), or a land-based spill (grass/dirt on either sides of the tub with a freshwater river or lake in the middle).

Spill 1 tablespoon of oil into each tub, wait one minute, and then let students begin the clean-up with a new $50,000 budget and 15 minutes of time (since they only have one tub to clean). Be sure to simulate another storm by blowing on the tubs or using a fan. In the terrestrial habitat, sprinkle freshwater to simulate rain.

Have students tally up their cost, estimate the percent of oil they removed, and answer the following questions in their science notebooks:

- Describe what happened.
- How were the characteristics and interactions of oil different in the new climate or location?
- Did you the effectiveness of the clean up techniques change in the new climate or location?
- Were you able to stay within your budget?

Share this data with the class. Were the same techniques successful in different climates and locations?

Wrap-Up:

Lead a class discussion, or have students reflect in their science notebooks about their experience. Have them first summarize what they learned about oil spill clean-up and identify the major challenges that they faced. Were they realistic challenges? What environmental factors influence clean-up and oil composition?
Oil Spill in a Pan Continued

In a new paragraph, ask students to state their opinion of the best techniques to clean up an oil spill. Are these techniques better than no response?

Extensions & Lesson Connections:

This lesson works well in conjunction with "Sheen-Oil-Mousse," "Oily Experiments," and "Critter Clean-Up."

Ask students to respond to the prompt, “How clean is clean enough?” This is an area of debate among scientists, agency representatives, and local people who disagree about what “clean” really is. Ask students to explain in their science notebooks how they would determine if an area affected by a spill was sufficiently cleaned and restored.

Evaluation:

Review clean up cost sheets for participation and understanding. Assess student responses in science notebooks for comprehension and application of the information they gathered through the oil spill in a pan experiments.
Objectives:
Students will identify ways oil spills can adversely affect animals. They will gain an understanding that it is difficult to clean oiled animals through experiments with different cleaning methods.

Concept:
The impacts of pollution are often difficult to see, but a major oil spill provides dramatic evidence of effects on wildlife. Potential effects include damage to feathers, killing of embryos if oil seeps into eggs, suffocation of fish if gills are clogged, and death to marine and terrestrial animals if they ingest food or water contaminated by the oil. After such spills take place, people try to clean up, but it is a difficult, challenging, and expensive process.

Materials:
- Science notebooks
- Pencils
- Heavy weight motor oil
- 5 hard-boiled eggs
- Small container
- Rubber gloves
- Cooking oil
- Black tempera paint
- Funnel
- Water (leftover slick from Oil Experiments/Sheen-Oil-Mousse works too)
- Three types of detergent
  - mild hand soap
  - powdered laundry detergent
  - grease-cutting dishwashing detergent
- Feathers
- Leather
- Fur
- Hand lenses or microscopes
- Newspapers
- Oil absorbent pads
- Funnel

Preparation:
Set up this activity outside if possible. If not, use old newspapers to cover the floor.

Mix vegetable oil and black tempera paint and beat well to create pretend crude oil students can safely work with.

Fill five bowls with water. In the first bowl, pour a slick of the vegetable-tempera oil, or add the leftover oil slick from Sheen-Oil-Mousse. If you use the leftover oil slick, remember that it contains motor oil, which is toxic. Students will need to wear gloves while working with it.

Leave the second bowl as plain water, and dissolve 1-2 tablespoons of one dispersant into each of the remaining bowls. Do not let the students see which solution is in each bowl.

Introduction:
Ask students to brainstorm ways animals might be affected by oil. List their ideas on the board.
Critter Clean Up Continued

If students didn’t think of damage to embryos and eggs, mention this idea and ask them if they think oil could actually get inside of an egg.

**Activities & Procedures:**

Put enough motor oil in a small container to submerge the hard boiled eggs.

Put on protective gloves. Roll one egg briefly in the oil and then leave it on a newspaper for 30 minutes.

Submerge 3 other eggs in the oil and leave them there.

Remove one egg from the oil after 5 minutes. Examine it. Remove the excess oil from the outside with an absorbent pad. Carefully peel off the shell. Have students record observations about the egg in their science notebooks.

Remove the second egg after 15 minutes and the third egg after 30 minutes. Examine each one carefully before, during, and after peeling and record observations in science notebooks.

Compare the results with the fourth egg that was only dipped in oil, and the fifth egg that didn’t touch oil at all. What effect might an oil spill have on the eggs of birds nesting near the water?

What other effects might oil have on birds and animals? Have students examine samples of feathers, leather, and fur with a hand lens or microscope and sketch what they see in their science notebooks.

Then dip each item into the bowl of clean water for 1-2 minutes and examine again.

Students should sketch the items again and compare to the original observations.

Finally, place each sample in the bowl with vegetable-tempera for 1-2 minutes. Students should then examine, sketch, and compare these samples.

Have students try to clean each oily sample with plain water. Record what happens to each sample. (Make sure the oily water is disposed of properly.)

Have students try to clean their samples in each of the detergent solutions. Try one sample per detergent.

Ask students to write down which detergent (solution #1, solution #2, or solution #3) worked the best. Let the students compare the results and record them.

Look at the samples once more under the hand lens. Discuss the changes in the samples after exposure to oil and then to the detergents. What effect could these changes have on normal animal activities?

Reveal the names of the detergents and show the students the containers they were in. Which detergent was the most effective? The bird and otter rescue centers in Alaska used Dawn Detergent. Does this match what you found?

Discuss what might happen to a bird, otter, or seal in an oil spill. Why are feathers, fur, and leather important to wildlife?

Explain the importance of feathers and fur for warmth, and how birds and otters continuously clean and fluff their feathers. How do birds and
**Critter Clean Up Continued**

Sea otters clean their feathers? What would happen to a bird or otter if it ingested oil?

Discuss how people try to clean animals affected by oil spills. Ask students to brainstorm some problems cleaning might cause for the animals? Possibilities include stress, loss of waterproofing, injury, disease, etc.

Examine the ingredients listed on the detergents. Could any of them be harmful for the animals? Ask students if cleaning an animal is the best option.

Have students reflect on these questions in their science notebooks. Would euthanasia – the intentional and painless killing – be better for heavily oiled animals? What are some factors that need to be taken into account when deciding the best action for animals caught in oil spills?

**Wrap-Up:**

Discuss possible impacts of oil on other animals, humans, and the ecosystem. Ask students about other examples of human-caused pollutants that can have negative consequences for wildlife, people, and ecosystems. Have students brainstorm ways to prevent and clean up pollution that might affect animals, people, and ecosystems. Put one of these plans, such as a marine debris clean up, into action as a class.

**Extensions & Lesson Connections:**

To demonstrate why sea otters and sea birds need clean fur and feathers for insulation, have students participate in the “coldwater challenge” by seeing who can leave their hand in submerged ocean temperature water (about 45 degrees Fahrenheit for southcoastal Alaska) for the longest. Ask the winning student to try to write on the board with their cold hand.

This lesson works well as a follow up to “Sheen-Oil-Mousse,” “Oily Experiments,” and "Oil Spill in a Pan."

**Evaluation:**

Evaluate science notebooks for complete, accurate, and neat data recording. Review notebooks for thoughtful and complete reflection on the best options for animals affected by oil spills.
Unit 6: Stewardship of Marine Ecosystems

Essential Questions:
How are people connected to coasts and oceans?
How do people affect coasts and the ocean?
How can people protect coasts and the ocean?
What is the role of technology in protecting our coasts and the ocean?

Enduring Understandings:
- Everyone is responsible for caring for the ocean.
- Connections between humans and the ocean are important.
- Plastics and other pollution knowingly or unknowingly introduced into the ocean by people can have negative effects on marine ecosystems.
- You can reduce the solid and liquid pollution you are introducing into the ocean.
- Making informed decisions as a consumer helps to protect the ocean.
- You can minimize the solid and liquid pollution you are introducing into the ocean.
- You can create new ways to care for the ocean and get others involved.
- Technology can have unintended consequences.

Lessons in this unit:
- Marine Debris Masks
- Human Coastal Connections
- Designing Debris Solutions
- Upcycle Hats
- Community Meeting
- Art Exhibition
- Celebrate the Sea Party
Designing Debris Solutions

Objectives:
Students connect their own consumer and community choices to the four sources of marine debris and design solutions to the marine debris problem.

Concept:
Marine debris has existed for thousands of years, since people have been creating and disposing of tools and clothing. Until the invention of synthetic plastics, most marine debris was biodegradable. Plastics are a unique and relatively recent technology, and have vastly magnified the problems caused by marine debris. There are four main sources of marine debris: land-based/personal use, marine industries & recreation, container ship spills, and natural disasters. Individuals have great power to change their own consumption and disposal habits; influence others to minimize plastic waste; and prepare for, rebuild, and clean up after large- and small-scale natural disasters.

Materials:
- Science notebooks
- Pencils
- Whiteboard, Flipchart, or SmartBoard with appropriate tool to write on it
- Large sheets of paper and/or graph paper

Introduction:
Explain that marine debris is made up of items that are discarded both directly and indirectly into global ocean. Marine debris has existed since people have been creating tools.

Ask students to think of what the first marine debris items may have been. For thousands of years, marine debris was composed primarily of readily biodegradable items (wooden tools, hemp or linen ropes, cotton or hide clothing). Next, glasses, metals, and paper products were added to the mix, and finally plastics. Long-term marine debris monitoring and clean up efforts have shown changes in marine debris over time. Worldwide, about 80% of marine debris is now made up of plastic items. Explain that this debris comes from many different sources.

Activities & Procedures:
Explain that marine debris comes from many sources and these sources can be organized into many different categories. Explain that categories that are sometimes used are: Land-Based/Personal Use, Marine Industries & Recreation, Container Ship Spills, and Natural Disasters.

If you have not already addressed the topic in another lesson, spend some time discussing how natural disasters can be linked to debris. Since the 2011 Tohoku Earthquake and Tsunami in Japan, marine debris clean ups along the Gulf of Alaska, Prince William Sound, and Southeast Alaska have collected significantly higher amounts of polystyrene and polyurethane foam that are likely linked to aquaculture buoys that were ripped away during the tsunami and insulation from homes that were destroyed. Take a moment to recognize the immediate tragedy of the disaster, and the long-term effects this marine debris might have. Explain that smaller scale weather events can create marine debris too.

Work toward solutions to the marine debris problem. Explain that some technological innovations, such as synthetic ropes that replaced biodegradable ones, have magnified the marine debris problem. However, other innovations...
Designing Debris Solutions *Continued*

have addressed the problem by replacing common debris items, preventing them from entering ocean, or enabling better clean ups.

Designate different parts of the room for each source category of marine debris (land-based/personal use; marine industries & recreation; container ship spills; and natural disasters; OR categories defined by the students).

Have students move to the category they would like to focus on and individually brainstorm new technologies that could replace plastic products that often become marine debris, prevent debris from entering the ocean, or equip clean up efforts.

Then, students should work collaboratively with their focus group to choose one promising product and draw a draft blueprint of the product or technology, labeling important features and explaining key characteristics and uses. Allow at least 20 minutes for this process.

**Wrap-Up:**

Have each group present their technology to the class. Ask classmates to provide constructive criticism in a critique sandwich: begin with an item of positive feedback, followed by a suggestion for something that can be improved, and finally another positive remark.

**Extensions & Lesson Connections:**

Have students refine their blueprints to present them at a "Celebrate the Sea Party."

This lesson works well as a follow-up to "Graphing Marine Debris" or "Marine Debris Source Sorting Relay" lessons.

**Evaluation:**

Observe students in focus groups as they develop ideas for innovative technologies or products, paying special attention to their ability to work collaboratively and participation in group discussions and creation of the blueprint. Assess student understanding and critical thinking during presentations and delivery of constructive criticism.
Community Meeting

From the Alaska Oil Spill Curriculum, Prince William Sound Regional Citizens Advisory Council

Written by Katie Gavenus, Children of the Spills, (http://childrenofthespills.org)

Objectives:
Students will analyze and formulate opinions about the relative importance of protecting various components of local ecosystems. They will discuss different values and priorities in the context of protecting local areas from oil spills and other pollution.

Concept:
In this activity, students participate in a mock community meeting in response to an oil spill. They have to identify and prioritize areas for protection based on their knowledge of the local areas. Many important parts of ecosystems, economies, and communities could be changed by an oil spill or other form of pollution. When faced with an impending disaster, communities must prioritize areas and resources for protection.

Materials:
- Community Meeting Scenario Cards
- Science notebooks
- Pencils
- Whiteboard/Posterboard
- Markers
- Excerpts from interviews with children affected by oil spills
- Computer & projector, TV, or SmartBoard

Preparation:
Visit http://www.childrenofthespills.org/index.php/people to choose excerpts of video interviews with children affected by oil spills. A DVD of video excerpts is also available upon request through the Children of the Spills website.

Introduction:
Briefly explain some of the facts of the Exxon Valdez Oil Spill and other oil spills. The Exxon Valdez Oil Spill occurred in Prince William Sound, Alaska on March 24, 1989. About 11 million gallons of crude oil were spilled into the Sound after the Exxon Valdez oil tanker ran aground on Bligh Reef. Storms carried the oil throughout Prince William Sound and almost 500 miles southwest to the Gulf of Alaska, Cook Inlet, and Kodiak Island.

Ask students, “Could something like this happen here?” Explain that it could indeed happen, and in many places, it has happened in the past.

Ask students, “If YOU were in charge, what places would you want to protect?”

Explain to students that they are going to do a mock City Council or Village Council meeting to respond to an oil spill.

Procedures and Activities:
At this point, accept a nomination for one student to run the meeting (this will be the Mayor).

Ask for a volunteer or assign a student to assist the mayor (this will be the Clerk).
Community Meeting Continued

Select a student with good handwriting to be the secretary and write ideas on the large paper pad. Everyone else will be council members.

Have volunteers read scenario cards 1, 2, and 3.

Proceed with a mock council meeting.

Give students 1-5 minutes to develop their own list of priorities for protection and write them in their science notebooks.

Then, the Mayor should call on all council members to speak in turn. The Secretary writes down ideas.

The mayor then provides an opportunity for discussion of the ideas, if time permits.

After 30 minutes, a list of top 3 priority sites should be ready for submission to response team.

Wrap-Up:

At the end, ask if anyone suggested protecting anything that wasn’t a coastal ecosystem/habitat.

What about other things important in the community that could be affected by the spill and clean-up efforts? What about recreation? What about foods? What about children?

Play video excerpts from interviews with children affected by oil spills that highlight some of the less obvious effects.

Ask students if they want to add anything to the list.

Have students reflect in their science notebooks about why they chose these priorities for protection.

Extensions & Lesson Connections:

Ask students how they would feel if one of their listed areas or resources was damaged. Look at the list that the class has chosen as priorities for protection. Have students create a list of ways that these areas are already protected or threatened. Have students brainstorm actions they can take to protect these places without waiting for an oil spill happen or other pollution or disturbance to be introduced to the area. Implement one (or more) of these ideas.

Ask students to photograph, draw, paint, or write about their priorities for protection. Display their work in a public place, or as part of an "Art Exhibition" or "Friends of the Sea Party" as described later in this unit.

Evaluation:

Review science notebooks for complete lists of priority areas for protection and thoughtful reflection. Evaluate students on participation and respectful discussion during the mock meeting.
Marine Debris Masks (Cardboard)

Objectives:
Students will connect their personal consumer choices with the effects of marine debris on the marine environment. They will understand that plastics break into smaller pieces through photodegradation. They will create an aesthetically powerful personal mask from collected debris with the purpose of informing and connecting others to the issue of marine debris.

Concept:
Plastic in the marine environment is photodegraded by exposure to the sun. These small pieces of plastic can have serious effects on marine and coastal ecosystems. This activity removes plastics, and other marine debris, from the beaches and transforms them into powerful art pieces that help to illuminate the story of marine debris, highlighting how everyday products used in our personal lives and industries can become marine debris if not disposed of properly.

Materials:
- Handout: ICC Data Sheets
- Bags or collecting buckets
- Gloves, ideally re-usable
- Pencils
- Clipboards
- Science Notebooks
- Small pieces of marine debris
- Photos of marine debris on beaches
- Photos of masks from local area, worldwide
- Elmer’s Squeeze-n-Caulk or hot glue guns*
- Toothpicks
- Paper plates
- Thick Cardboard
- Exacto Knife
- Sand
- Food coloring
- Paint brushes
- Wire, yarn, string to hang masks

*The Squeeze-n-Caulk Glue will take 24 hours to set, but is the only glue that should be used with younger students. Regular Elmer’s glue will not adhere to plastics. Older students can use hot glue guns.

Preparation:
Ideally, you will be able to take your class to a nearby beach, lakefront, riverbank, or wetland to collect debris. You can also marine debris collected at an earlier time or you can contact the Center for Alaskan Coastal Studies if you need help acquiring marine debris pieces.

It is critical that students remain safe during this activity, so be sure to explain that they should leave potentially dangerous marine debris (such as needles or broken glass) behind. It is recommended that at least one person in each group have rubber gloves, preferably reusable, to handle rusty and otherwise ‘iffy’ marine debris.

If you have younger students and few adults available, you can prepare cardboard mask templates beforehand by cutting eye and mouth holes.

Introduction:
Before you begin the clean up, brainstorm as a class the possible effects of marine debris on the ecosystem. Then explain that you are going to be stewards of a local beach and the global ocean by collecting marine debris so it cannot affect this or other ecosystems.

Procedures & Activities:
Split students into small groups and provide them with bags or collecting buckets, ICC data
sheets with clipboards, and gloves.

Use the ICC Data Sheet to record what you find. Set aside small (less than 4 inches), flat clean pieces of marine and coastal debris. Photo-degraded pieces are great to use, and you should discuss how plastic breaks into smaller pieces when it is exposed to sunlight.

Analyze what type of marine debris is being found (usually plastics and polystyrene foam) and discuss how they came to be on the beach.

Have each student identify a piece of marine debris that could be connected to a product they personally use (for example, bottle caps, polystyrene foam take out containers, straws, etc.).

Record the list of products, and discuss which of these products can be recycled and reused, and which can be replaced with reusable products.

Explain that students will be using some of the marine debris they collected to create personal masks that will help others better understand and connect with the issue of marine debris.

Inform students that they must use at least type of marine debris in their mask that could be connected, directly or indirectly, to their personal consumer choices (such as plastic bottle cap if they drink bottled water, soda, juice or tea; fishing net if they fish themselves or consume fish; polystyrene coffee or tea cups).

Cut out oval shaped scrap cardboard pieces the size of a head. Holes for eyes and mouth can be cut out by adults or older students with an exacto knife. Use the exacto knife or a sharp object to carefully work a hole into the sides of the mask by hand.

Have students string wire, yarn, or elastic through the holes for hanging or wearing the mask and then try out different designs for their mask by placing, but not gluing, plastic onto the mask. Display photos or examples of cultural masks and masks by other people to get ideas.

Explain that creating a line of objects around the eyes, mouth or nose can be very effective. Forehead and chin decorations with interesting shapes and lines can also be visually appealing.

Students should try to arrange the objects around the holes and edges and attempt to have a somewhat symmetrical arrangement to the plastic pieces.

Students should select a color scheme of 4 – 6 colors that will be repeated on the mask.

These recommendations, of course, are only that. If a student tries several designs and is excited to make an asymmetrical mask with only two colors, by all means encourage the creativity!

Once students have decided on their design, they should gently lift one piece at a time and place a dot of squeeze-n-caulk glue under the piece with a toothpick by squeezing a small amount of glue onto a paper plate and transfer it onto the mask with a toothpick.

Give students the option of using sand to decorate between the plastic pieces once the plastic pieces have dried. Provide groups of students with plates of sand and bottles of food coloring. Demonstrate how they can color the sand by carefully mixing 1 small drops of food coloring with the dry sand. Instruct students to work together in their groups to choose and create 1-3
colors they would like to use.

Then have students carefully brush the glue between the pieces and sprinkle sand over the top.

**Wrap-Up:**

Have each student brainstorm in his or her science notebook some of the potential origins and paths the marine debris pieces followed to arrive at the beach, and ultimately in the mask.

Then students should record one plausible idea each for at least 4 pieces of marine debris on their masks, and post these origin/path theories around the mask in a bulletin board display.

Ask students to pay special attention to the type of marine debris that could be connected directly or indirectly to their consumer choices.

**Extensions & Lesson Connections:**

Ask students to write in their science notebooks a piece of creative fiction, which features the character illustrated by the mask in a tale of marine debris. Or, have each student write an artist’s statement that includes details about the problem of marine debris, how and where the marine debris was collected, how they feel about marine debris, and why he or she decorated the mask in that way. One final possibility is to have students write a Haiku about the form and meaning of the mask.

You can have students post their stories or statements to accompany their masks in a bulletin board display, or share them with the class while presenting their masks, or display them during an "Art Exhibition" or "Celebrate the Sea Party" as described later in Unit 6.

**Evaluation:**

Review the origin/path theories that students recorded in their science notebooks to evaluate student understanding of the origin and ecosystem effects of marine debris. Observe their effort and craftsmanship during the creation of the masks, and their communication of important concepts during the presentation of masks. If you would like to evaluate students on artistic criteria, post the following before beginning the lesson:

**ARTISTIC CRITERIA TO POST**

1. Create a face shaped base with cardboard or plaster tape that has clean edges
2. Select interesting flat on one side plastic marine debris.
3. Stay within a color scheme of 4 – 6 colors that are repeated in a pattern or at random.
4. Use symmetrical placement of the marine debris emphasizing the eyes, mouth and nose.
5. Consider forehead and chin decorations.
6. Use implied lines of touching shapes to create unity to the design.
7. Use good craftsmanship by not having overlapping glue and ragged edges.
8. If sand is used to create a finished effect make sure it is spread evenly without globs of glue.
Objectives:
Students will connect their personal consumer choices with the effects of marine debris on the marine environment. They will understand that plastics break into smaller pieces through photodegradation. They will create an aesthetically powerful personal mask from collected debris with the purpose of informing and connecting others to the issue of marine debris.

Concept:
Plastic in the marine environment is photodegraded by exposure to the sun. These small pieces of plastic can have serious effects on marine and coastal ecosystems. This activity removes plastics, and other marine debris, from the beaches and transforms them into powerful art pieces that help to illuminate the story of marine debris, highlighting how everyday products used in our personal lives and industries can become marine debris if not disposed of properly.

Materials:
- Handout: ICC Data Sheets
- Bags or collecting buckets
- Gloves, ideally re-usable
- Pencils
- Clipboards
- Science Notebooks
- Small pieces of marine debris
- Photos of marine debris on beaches
- Photos of masks from local area, worldwide
- Elmer’s Squeeze-n-Caulk or hot glue guns*
- Toothpicks
- Paper plates
- Exacto Knife
- Sand
- Food coloring
- Paint brushes
- Wire, yarn, string to hang masks
- Plaster tape
- Old scissors
- Dishes or small containers
- Water
- Modeling clay
- Petroleum jelly
- Awl or screw with screwdriver

*The Squeeze-n-Caulk Glue will take 24 hours to set, but is the only glue that should be used with younger students. Regular Elmer’s glue will not adhere to plastics. Older students can use hot glue guns.

Preparation:
Ideally, you will be able to take your class to a nearby beach, lakefront, riverbank, or wetland to collect debris. You can also marine debris collected at an earlier time or you can contact the Center for Alaskan Coastal Studies if you need help acquiring marine debris pieces.
Marine Debris Masks (Plaster) Continued

It is critical that students remain safe during this activity, so be sure to explain that they should leave potentially dangerous marine debris (such as needles or broken glass) behind. It is recommended that at least one person in each group have rubber gloves, preferably reusable, to handle rusty and otherwise ‘iffy’ marine debris.

If you have younger students and few adults available, you can prepare cardboard mask templates beforehand by cutting eye and mouth holes.

**Introduction:**

Before you begin the clean up, brainstorm as a class the possible effects of marine debris on the ecosystem. Then explain that you are going to be stewards of a local beach and the global ocean by collecting marine debris so it cannot affect this or other ecosystems.

**Procedures & Activities:**

Split students into small groups and provide them with bags or collecting buckets, ICC data sheets with clipboards, and gloves.

Use the ICC Data Sheet to record what you find. Set aside small (less than 4 inches), flat clean pieces of marine and coastal debris. Photo-degraded pieces are great to use, and you should discuss how plastic breaks into smaller pieces when it is exposed to sunlight.

Analyze what type of marine debris is being found (usually plastics and polystyrene foam) and discuss how they came to be on the beach.

Have each student identify a piece of marine debris that could be connected to a product they personally use (for example, bottle caps, polystyrene foam take out containers, straws, etc.).

Record the list of products, and discuss which of these products can be recycled and reused, and which can be replaced with reusable products.

Explain that students will be using some of the marine debris they collected to create personal masks that will help others better understand and connect with the issue of marine debris.

Inform students that they must use at least type of marine debris in their mask that could be connected, directly or indirectly, to their personal consumer choices (such as bottle caps if they drink bottled beverages; fishing net if they fish themselves or consume fish; foam coffee cups). Begin by splitting students into partners. Together, they should prepare the work area by laying down newspapers or a drop cloth to protect the workspace and floor and then cut bandage plaster into strips.

Have students make 10 strips that are about 2-3 inches wide by 3 inches long for each mask and cut two base layer strips, 1 inch wide and 3 inches long. These will form your base layer.

Have one partner lay down flat on the floor, face up. Have the other partner rub petroleum jelly all over the subject’s face, especially at the hairline, on the eyebrows, and around the sides of the nose.

**Warning:** If you skip the petroleum jelly, your subject will experience serious pain when the mask is removed!

Have students begin the first layer of the mask by dampening one of the 1-inch (2.5 cm) strips
Marine Debris Masks (Plaster) Continued

and lay it diagonally along the nose, starting above the left eyebrow and ending next to the right nostril (\).

They should continue layering, dampening the other 1-inch strip and placing it diagonally in the opposite direction (/), forming an "X" across the bridge of the nose. Then have them place the forehead strip, by dampening and laying a larger strip across the forehead, overlapping the tops of the "X", smoothing the plaster as they go.

Have students add the remaining strips, cutting any strip to size as needed. Instruct them to avoid the triangle from the tip of the nose to the midpoint of the upper lip.

Examine the base layer for weak areas. Check to see if any skin shows through. Check to see that the pieces are overlapping properly and are not too spread out.

Once the mask has been checked, students should start the second layer, focusing first on any weak areas. This time use 2 inch x 3 inch strips as much as possible to create a uniform layer.

Then have students take a break and let the mask set. You want the mask to set, but not start drying, so have students cut strips or clean up a bit before applying the third layer.

Then it is time for students to commence the third layer. For the third layer, explain that students should begin at the edges, and fold the tails of the strips down around the edges of the mask to smooth them out. This gets rid of the sharp corners left by the initial layers.

Also encourage students to begin to build any prominent features. For example, a bigger nose, eyebrow ridges etc. can be created by adding narrowing pieces in layers and smoothing them down.

Next, have students allow the mask to dry until it begins to feel itchy. At this point, the subject should begin to gently move his or her face by lifting eyebrows, crinkling the nose, wiggling the lips.

Have the partner carefully remove the mask. When the subject no longer feels "stuck" to the mask, the partner should gently slide fingers along the edges to lift it away, moving fingers inward toward the center of the mask as it is lifted.

Place the mask on a rack to dry. Let it dry completely (overnight is best) before adding more features.

Explain that students can attach additional large elements with more strips, using the same overlapping techniques used for the base. Things that they may wish to attach include such appendages as a beak (fold a paper plate in half) or horns (create a cone out of cardstock), or big bumps (scrunched up newspaper).

For more detailed changes, such as higher cheekbones, a bulbous nose, or a ridged forehead, paper-based modeling clay is the medium of choice. Instruct students to spread a base layer of the clay onto the mask, then add pieces strategically until the mask feels and looks right. Allow the mask to dry overnight again before painting, sanding, decoupaging, or drilling.

Use an awl or screw with screwdriver to carefully make holes on either side of the mask. String wire, yarn, or elastic through the holes for hanging or wearing the mask.
Have students try out different designs for their mask by placing, but not gluing, plastic onto the mask. Display photos or examples of cultural masks and masks by other people to get ideas.

Explain that creating a line of objects around the eyes, mouth or nose can be very effective. Forehead and chin decorations with interesting shapes and lines can also be visually appealing.

Students should try to arrange the objects around the holes and edges and attempt to have a somewhat symmetrical arrangement to the plastic pieces.

Students should select a color scheme of 4 – 6 colors that will be repeated on the mask.

These recommendations, of course, are only that. If a student tries several designs and is excited to make an asymmetrical mask with only two colors, by all means encourage the creativity!

Once students have decided on their design, they should gently lift one piece at a time and place a dot of squeeze-n-caulk glue under the piece with a toothpick by squeezing a small amount of glue onto a paper plate and transfer it onto the mask with a toothpick. Continue until the mast is complete.

Give students the option of using sand to decorate between the plastic pieces once the plastic pieces have dried (preferably overnight).

Provide groups of students with plates of sand as well as bottles of food coloring. Demonstrate how they can color the sand by carefully mixing 1 small drops of food coloring with the dry sand.

Instruct students to work together in their groups to choose and create 1-3 colors they would like to use.

Then have students carefully brush the glue between the pieces and sprinkle sand over the top.

Wrap-Up:

Have each student brainstorm in his or her science notebook some of the potential origins and paths the marine debris pieces followed to arrive at the beach, and ultimately in the mask.

Then students should record one plausible idea each for at least 4 pieces of marine debris on their masks, and post these origin/path theories around the mask in a bulletin board display.

Ask students to pay special attention to the type of marine debris that could be connected directly or indirectly to their consumer choices.

Extensions & Lesson Connections:

Ask students to write in their science notebooks a piece of creative fiction, which features the character illustrated by the mask in a tale of marine debris. Or, have each student write an artist’s statement that includes details about the problem of marine debris, how and where the marine debris was collected, how they feel about marine debris, and why he or she decorated the mask in that way. One final possibility is to have students write a Haiku about the form and meaning of the mask.

You can have students post their stories or statements to accompany their masks in a bulletin board display, or share them with the class while presenting their masks, or display them during an "Art Exhibition" or "Celebrate the Sea Party" as described later in Unit 6.
Evaluation:

Review the origin/path theories that students recorded in their science notebooks to evaluate student understanding of the origin and ecosystem effects of marine debris. Observe their effort and craftsmanship during the creation of the masks, and their communication of important concepts during the presentation of masks. If you would like to evaluate students on artistic criteria, post the following before beginning the lesson:

ARTISTIC CRITERIA TO POST

1. Create a face shaped base with cardboard or plaster tape that has clean edges

2. Select interesting flat on one side plastic marine debris.

3. Stay within a color scheme of 4 – 6 colors that are repeated in a pattern or at random.

4. Use symmetrical placement of the marine debris emphasizing the eyes, mouth and nose.

5. Consider forehead and chin decorations.

6. Use implied lines of touching shapes to create unity to the design.

7. Use good craftsmanship by not having overlapping glue and ragged edges.

8. If sand is used to create a finished effect make sure it is spread evenly without globs of glue.
Upcycle Hats

Objective:
Students will create a hat decorated with marine debris. Students will understand other uses for items that would otherwise be thrown out.

Concept:
Marine debris harmful solid waste in the ocean, is a byproduct of personal choices, and can be prevented through a change in those choices. Marine debris and other items thrown in the trash can be upcycled, and used for something new.

Materials:
- Wide masking tape
- Plastic Wrap or shower caps
- Newspapers
- Hot Glue or tacky glue
- Paint (optional)
- Marine debris pieces
- Scissors

Introduction:
Begin discussing with the students the idea of upcycling, creating new things out of old things that would otherwise be thrown away. If you would like a further discussion of why upcycling is important watch this 20 minute video, “The Story of Stuff” by Ann, which discusses the life of a product from extraction to landfill: https://www.youtube.com/watch?v=9GorqoigqM&noredirect=1.

Activities and Procedures:
Have the students divide into groups of three.

They will work together in these groups to create a hat for each person in their group. To create a hat:

First, cover the student’s hair and forehead with plastic wrap (almost like a shower cap.)

Second, wrap a band of masking tape, sticky side out, around the student’s forehead. Try to place the tape where the band of a baseball cap would sit on the student’s head.

Third, use 3-4 sheets of double page newspaper (not single pages like ads or inserts) for each student’s hat. Place the center of the newspaper on the center of the student’s head. Then carefully flatten down the newspaper until the bottom paper is stuck to the masking tape around the student’s head, and the other newspapers are tight around the student’s head.

Fourth, wrap another line of masking tape around the outside of the newspapers. Try to line up the tape to be even with the tape under the newspapers. While the newspapers are still on the student’s head, carefully fold up the extra flaps of newspaper to create the brim of the hat. Take the hat off the student’s head.

After all the students have helped the others
Upcycle Hats Continued

in their groups and all have created a hat, have them shape the brim of their hats.

The students can trim the brims into the shape they desire. Have the students leave the brims about 2 inches longer than they desire.

Next, have the students roll the brims of their hats and glue the rolled portion down. This will create a solid brim, and prevent the newspapers becoming separated and the brim too floppy.

Now it is time to decorate the hats! If you would like the students to paint the hats do so now to allow the paint time to dry. Be sure the paint is not applied to heavily to the hats, or the newspaper may collapse or melt.

Next, have the students create the band of the hat, which will be the major portion of the hat which is decorated.

Have the students fold a piece of newspaper into a 2-3 inch tall band (this will be glued to the hat where the masking tape is on the outside). Be sure the bands are long enough to fit around the student’s hat.

Then have the students select pieces of marine debris to glue to the band for decoration. Encourage the students to use both recognizable pieces (such as a bottle cap) and unrecognizable small bits.

Also encourage students to cut the marine debris in creative ways before gluing them to their hat bands. For example a plastic water bottle can be cut to look like a flower, or into spirals that hang off the brim of the hat.

Have the students glue their pieces of marine debris onto the hat bands. If using tacky glue, before gluing the bands onto the hats, have the students write in their science notebooks to allow the glue to dry.

Wrap-up:

Have the students write in their science notebook about ideas for other upcycling uses for things people normally throw away, or marine debris found on the beach. If the students need some examples show them some picture of houses and walls built from plastic water bottles around the world. Here is a good source for pictures: http://www.inspirationgreen.com/plastic-bottle-homes.html

Extensions & Lesson Connections:

As an extension, have students create other wearable items or musical instruments from the larger pieces of marine debris.

You can have students where their hats in an "Art Exhibition" or "Celebrate the Sea Party" as described later in Unit 6.

Evaluation:

Observe student engagement and participation in their groups to create their hats. Review their hats, looking for creativity in the style of hat and debris used. Also review the student’s science notebooks for ideas on creating other items with marine debris or other people’s trash.
Art Exhibition

Objectives:
Students will connect their personal consumer choices with the effects of marine debris on the marine environment. They will understand that certain types of marine debris can entangle marine organisms, and that small pieces of debris are often ingested by animals. They will finalize a collaborative sculpture from marine debris representing the surface of the ocean choked with intertwined debris and dangling pieces of photo-degraded debris to help people understand and connect with issues of marine debris.

Concept:
Long and circular pieces of pieces of marine debris such as nets, ropes, strapping bands, and plastic bags can pose significant risks of entanglement to marine animals. Smaller or broken pieces of marine debris are often consumed by animals that mistake them for food. This activity uses small-scale marine debris sculptures made during the Ecosystem Effects Station Rotation lesson to create an interactive sculpture that people can walk through to experience the perspective of animals trying to evade entanglement and find prey in a sea of plastic. Artists’ statements prepared by the students help to synthesize what they have learned and communicate it with the public.

Materials:
- Science Notebooks
- Pencils
- Gyre Dangles from Ecosystem Effects Station Rotation
- Top of the Ocean Mat from Ecosystem Effects Station Rotation
- 16 gauge wire
- Scissors
- Laptop/computer and projector or SmartBoard

Preparation:
Prepare technology for viewing video in classroom, by loading and testing video on a smartboard, computer with projector, or individual computers for students to view. Both a short video PSA and longer video about entanglement of Steller sea lions in marine debris can be found on the NOAA Fisheries Alaska website (http://alaskafisheries.noaa.gov/protectedresources/entanglement/pinnipeds.htm) The shorter PSA is 30 seconds and may be more suitable for younger classes, while the longer video is more appropriate for older classes and a more in-depth understanding of entanglement of Steller sea lions in Alaska.

Also load clips from the Gyre Expedition or 5 Gyres Institute as a class. They can be found at http://newswatch.nationalgeographic.com/2013/08/14/gyre-expedition-probes-impact-of-plastic-pollution-on-remote-beaches/, http://vimeo.com/71161144, and http://vimeo.com/24020595.

Introduction:
Bring the Top of the Ocean Mat sculpture out. Gather in a circle around it. Ask students to imagine what it would feel like to be an animal entangled in marine debris.

As you talk and share as a group, pass the spool of wire around the circle. Students should weave the wire into the edges of the sculpture netting, moving the wire from hand to hand around the circle so that the whole sculpture is reinforced by wire.

Ask students to brainstorm ways that entanglement can hurt animals.
Art Exhibition Continued

If they need help, encourage them to think about basic animal survival needs and how entanglement can hinder their ability to fill these needs.

As a class, discuss the different effects of entanglement that students brainstormed.

Procedures & Activities:

Attach the completed Top of the Ocean Mat to the ceiling where you will be displaying the sculpture. Try to arrange the sculpture in an area where a good amount of light is blocked by the dangles.

Have students retrieve their Gyre Dangles. Use a loop of fishing line or wire to attach the dangles to the Top of the Ocean Mat.

Once the dangles are attached to the “Top of the Ocean” mat, have each student move through the sculpture.

As students make their way through the sculpture, have them imagine what it might be like to be a fish or a bird searching for food in this environment, or phytoplankton in need of light to photosynthesize.

Have students reflect in their science notebooks on the experience and what they felt as they navigated through the garbage patch.

Ask students to research the impact of marine debris “garbage patches” in gyres on marine organisms, and particularly the effects of ingesting plastics and entanglement.

One way to do learn more about gyres is to watch clips from the Gyre Expedition or 5 Gyres Institute as a class.

For more information on entanglement, your class can watch the short PSA or longer video about entanglement of Steller sea lions as a class.

Because these videos focus on marine debris originating from sport, commercial, and subsistence fisheries, it is important to explain to students that there are other sources of marine debris that can entangle animals (soda six-pack rings, packing bands used in shipping, plastic bags, etc.) Discuss how animals can become entangled in marine debris.

Have students visit the website for the Fur Seal Disentanglement Project on the St. Paul Island: http://www.tribaleco.com/entang/index.html.

Ask the students to write an artist’s statement to accompany the sculpture they have created and record it in their science notebook.

Have them create one unified artist statement that addresses issues of marine debris through both entanglement and ingestion, or split the class in half. Have one group write an artists’ statement that focuses on entanglement and the other group craft a statement that focuses on ingestion.

The artist’s statement should explain where the materials for this project came from and the effects these materials could have on organisms living in the gyres, focusing on ingestion and/or entanglement.

After they write their artist’s statement, have each student share it with a partner and then underline an important sentence in their statement.

Ask students to share their most important sentences with the class. Record them on the board,
Art Exhibition Continued

discuss what is missing and create a unified artist statement to display with the sculpture.

Choose a day and time to share your sculpture with family, friends, and community members.

Prepare for the art opening by splitting students into groups to focus on different aspects of the art opening, including such things as:

- Flyers (create and hang flyers about the exhibition around the school and community)

- Invitations (create and distribute personalized invitations to leaders in the community)

- Refreshments (choose and buy simple refreshments and supplies for the art opening)

- Display (print the completed Artist Statement, display near sculpture, arrange lighting)

- Welcome Speech (write a short speech for a student to give at the opening)

Celebrate the hard work and artistry of the students with a grand opening for the art exhibit!

Wrap-up:

After the opening, debrief the experience as a class. Have students reflect in their science notebooks about the experience of displaying their sculpture publicly. They should answer the following questions:

- What was your favorite part of the art opening?

- What was the most challenging part of using art to teach people about marine debris?

- What is one thing a person who attended the opening might have learned about marine debris?

Extensions & Lesson Connections:

This lesson builds on the work done in the "Stations: Effects of Marine Debris on Ecosystems" at the Gyre Dangle and Top of the Ocean Mat sculpture stations. You can also use this format for creation of an exhibition for "Marine Debris Masks."

Evaluation:

Review the artist statements and personal reflections that students recorded in their science notebooks. These can be used to assess student understanding of the ecosystem effects of marine debris. Observe student participation during the art opening and cooperation during the planning process.
Celebrate the Sea Party


Objectives:
Students will discuss stewardship actions and develop an action plan that they will carry out as a class. They will encourage others to get involved in marine stewardship and share the results of their coastal monitoring and investigations.

Concept:
There are many ways to become a steward of marine ecosystems. Because these ecosystems are so closely connected to the culture and economy of Alaskan communities, getting other people involved can be a powerful way to make a real difference. In this activity, students host a “Celebrate the Sea” party to involve the school and community in their stewardship efforts.

Materials:
- Science notebooks
- Pencils
- Graphs or displays from coastal or ocean monitoring data
- Photos or illustrations from field studies
- Art supplies, decorations, food for celebration as needed
- Supplies for stewardship project as needed

Preparation:
Consider possible stewardship projects, do any needed research, and revise the list of possibilities for student choice if desired.

Choose possible dates, times, and facilities (if other than classroom) for your celebration.

Collect the materials needed.

Introduction:
Review the stewardship issues that students have learned about throughout the unit. Analyze the data you collected during CoastWalk or other coastal monitoring work to identify local stewardship challenges. Brainstorm ideas for a stewardship action project that the class can carry out.

Activities & Procedures:
Choose a stewardship project to do as a class. It might be:

- A public information campaign to include fliers, posters, news articles, and/or radio spots.
- A letter and/or petition to elected officials requesting a change in policies or regulations that affect the health of the ocean, with signatures collected from the community.
- A community-wide cleanup campaign that might include a cleanup day, placement of trash cans in strategic places, etc.
- Plans for collection of materials that can be recycled.
- Plastic bag reduction efforts such as distribution of cloth shopping bags, re-use of plastic bags.
Celebrate the Sea Party **Continued**

- Another project that is important to the class or the community.

Set a date for a school/community event to be hosted by your class for a “Celebrate the Sea” party during which you will share your research and involve the school and community in your stewardship project.

Make a plan for getting the project accomplished. List the tasks that will need to be completed and sketch out a timeline.

Develop committees for supplies, communications, art, decorations, food, or whatever else is needed.

Carry out the plan.

Host the Celebrate the Sea party and share the coastal monitoring projects and other research your class has been involved in.

Explain the stewardship project to the attendees with a presentation, flyers, a poster, sign-up sheets, distribution of bags, and/or other means.

Eat seafood, play games, and celebrate the sea!

**Wrap-Up:**

After the stewardship project has been completed, have students reflect on the process in their science notebooks, and then debrief as a class.

Some possible writing and discussion questions might be:

- What went well?
- What could have worked better and why?

- Were there difficulties you faced in trying to change peoples’ habits?
- How did you handle disagreements or differences of opinion?
- How would you expand and extend the project?
- How did the use of scientific data help your project?

**Extensions & Lesson Connections:**

This lesson is designed to be a culmination of many activities included in this curriculum. It is a chance for students to share their understanding, experiences, research, action plans, and artwork.

**Evaluation:**

Discuss what students have learned through their coastal monitoring and preparing for the “Celebrate the Sea” party. Ask them to write a paragraph or two about each of the following “Enduring Understandings” in their science notebooks, demonstrating the important things they have learned from the unit:

- Connections between humans and the ocean are important.
- Everyone is responsible for caring for the ocean.
- Science is a way to help us study the many connections in our world.
- Traditional knowledge, culture, stories, and long-term observations are important ways to learn more about marine ecosystems.
Glossary

Abiotic factors: physical parameters, such as temperature, pH, salinity, humidity, etc.

Abundance: number, or amount, of organisms that you can count.

Adaptation: the gradual changing of structure, form or behavior of a plant or animal to increase its chances of survival and reproduction.

Alga (AL-guh) [plural algae (AL-jee)]: a photosynthetic, plant-like protist.

Arthropod: An invertebrate with a jointed body case.

Bilateral symmetry: a type of symmetry in which the body can be divided, down the midline, into two equal halves.

Biota (by-OT-a): species of all the plants and animals occurring within a certain area or region.

Biodiversity: The variation in life on Earth reflected at all levels from various ecosystems and species to the genetic variation within a species.

Blade: The leaflike part of many seaweeds.

Carnivore: an animal feeding on the flesh of other animals.

Cnidarian (Nigh-dare-ee-in): An invertebrate with a digestive cavity that has only one opening.

Community: a group of plants and animals living in the same area and depending on one another for survival.

Competition: occurs when a number of organisms of the same or of different species compete for common resources that are in short supply, such as food, space, or mates.

Density: number of individuals in relation to the space in which they occur.

Desiccation: when a plant or animal is exposed to the sun or wind and is unable to maintain needed moisture, and dries out.

Detritus: small particles of dead plant and animal matter.

Distribution: where the organisms live in an area, e.g., high intertidal vs. low intertidal, or over their whole range.

Dynamics: in population ecology refers to the study of the reasons for changes in population size.

Echinoderm: (EE-kine-o-derm): An invertebrate with an internal skeleton and fivefold symmetry.

Ecology: the study of how organisms interact with the physical (nonliving) and biological (living) parts of their environment.

Ecosystem (EE-koh-sis-tum): biotic community and its abiotic environment.

Endo-: a prefix referring to something that is internal.

Exoskeleton: an external skeleton, as in crustaceans and other arthropods.

Filter Feeder: an animal equipped with hairs, tentacles, sieves, or other devices for straining plankton and minute particles of detritus from the water (e.g., clams, oysters, mussels, tube worms, and barnacles).

Food web: interconnected feeding relationship of who eats whom in an ecosystem, starting with autotrophs - algae and plants - and ending with the carnivores.

Foot: in molluscs, the organ used for crawling, digging, and some other functions.

Frond: the blade-like or leaflike expansion of seaweeds in which the functions of a stem and leaf are not distinguished.

Holdfast: a structure anchoring seaweeds to rocks and other hard surfaces.

Intertidal: the area between the high tide mark and the low tide mark on a seashore.

Kelp: large, brown seaweeds with strong holdfasts.
Glossary

Limiting Factors: influences on an organism's ability to maintain its population (e.g., food, water, shelter, space, temperature, light, salinity, oxygen, type of bottom; as well as predators, competition, pollution and overharvesting).

Mantle: in molluscs, an outer sheet of tissue that secretes the shell and encloses the cavity within which the true gills (if present) are located.

Mollusc: A soft-bodied invertebrate that is often protected by a hard shell.

Monitor: to study an area in a way that gathers data relating to changes (or lack of changes) over time, i.e., changes in species abundance, composition, distribution, etc.

Muscular Foot: the wide, flat-ended or wedge-shaped muscle used for crawling or digging (found on snails, limpets, chitons, abalones and clams).

Nematocyst: in cnidarians, a stinging capsule.

Niche (NICH): the role played by an organism on a community; its requirements for food and shelter, special behaviors, as well as its function (e.g., predator, decomposer, scavenger, and how it performs that function).

Phylum (FYE-lum) (plural phyla): a taxonomic category within Kingdoms; e.g. sponges, arthropods, echinoderms within animals, phyla are divided into classes.

Population: group of individuals of a single species.

Quadrat: not a recognized word in Webster’s Dictionary but a word ecologists have been using for years. Refers to a grid (of pvc pipe usually) you place in an area to count organisms.

Radial symmetry: a type of symmetry in which the structures of the body are arranged around a central point, so that the animal can be divided into several equal parts (as in jellyfishes, sea stars and sea urchins).

Radula: a rasping, tonguelike structure used for scraping food from rocks and sometimes for boring holes through shells.

Random: chosen with no specific pattern, haphazard.

Sample: when you go into the field and collect data

Sessile: attached to an object or fixed in place (e.g., barnacles), in contrast with sedentary (rarely moves) and motile (moves from place to place).

Species (SPEE-seez): a particular kind of organism, its members having similar anatomical characteristics and the ability to interbreed.

Stability: absence of fluctuations in populations, the ability to withstand perturbations without large changes in composition.

Stipe: the stem-like part of many seaweeds.

Stratified: a sampling pattern where you have some level of separation between plots, e.g., the mid and low intertidal zone are considered separately and you sample randomly within each area, or when you are sampling only flat surfaces and not pool.

Tidal height: the height of the tide on the shore above or below a fixed level, can be measured with a stadia rod and eyepiece.

Tidepool: a pool of sea water isolated in the rocky intertidal when the tide goes out; also tide pool.

Transect: a line across an area to be sampled, marked by a tape measure (you bring the tape in the field with you each time and don’t leave it in the field); it is good to put permanent markers at the ends of the line so when you bring in the tape measure out each time, you can easily find your transect line over time.

Tube feet: special attachment appendages for movement and for collecting food: as in sea stars, urchins and cucumbers.

Zonation: an arrangement of plants and animals in horizontal levels on the shore.
Bibliography & Resources

Marine Invertebrate Identification Guides


Curricula and Teaching Guides


Videos


The Shape of Life. Eight-part series, each focused on a different marine invertebrate phylum and body plan. Produced for PBS. Available as two-CD set.

Websites

A Coastal Journey: [www.poulsbomsc.org/tutorial.htm](http://www.poulsbomsc.org/tutorial.htm)

Enchanted Learning: The Intertidal Zone: [www.enchantedlearning.com/biomes/intertidal](http://www.enchantedlearning.com/biomes/intertidal)

Life in a Massachusetts Tide Pool: [www.old.umassd.edu/Public/People/Kamaral/thesis/tidepools.html](http://www.old.umassd.edu/Public/People/Kamaral/thesis/tidepools.html)

PBS: Life at the Edge of the Sea: and Shape of Life. [www.pbs.org/wnet/nature/edgeofsea](http://www.pbs.org/wnet/nature/edgeofsea)

Marine Biodiversity Pages: [www.oceanlink.island.net/oinfo/biodiversity](http://www.oceanlink.island.net/oinfo/biodiversity)

LiMPETS: [http://limpets.noaa.gov](http://limpets.noaa.gov)

BRIDGE: Ocean Science Teacher Resource Center: [www.vims.edu/bridge/](http://www.vims.edu/bridge/)

Woods Hole Sea Education Association: [www.seaedu/k12LessonPlans/k12pgmtop.htm](http://www.seaedu/k12LessonPlans/k12pgmtop.htm)

Bamfield Marine Station: [www.oceanlink.island.net](http://www.oceanlink.island.net)

Science Standards with Integrative Marine Science at UCLA: [www.msc.ucla.edu/sswims/marinelinks2.htm](http://www.msc.ucla.edu/sswims/marinelinks2.htm)

GLOBE: [www.globe.gov](http://www.globe.gov)

EVOS/GEM: [www.evostc.state.ak.us/gem/](http://www.evostc.state.ak.us/gem/)

National Science Standards: [www.nas.edu](http://www.nas.edu)