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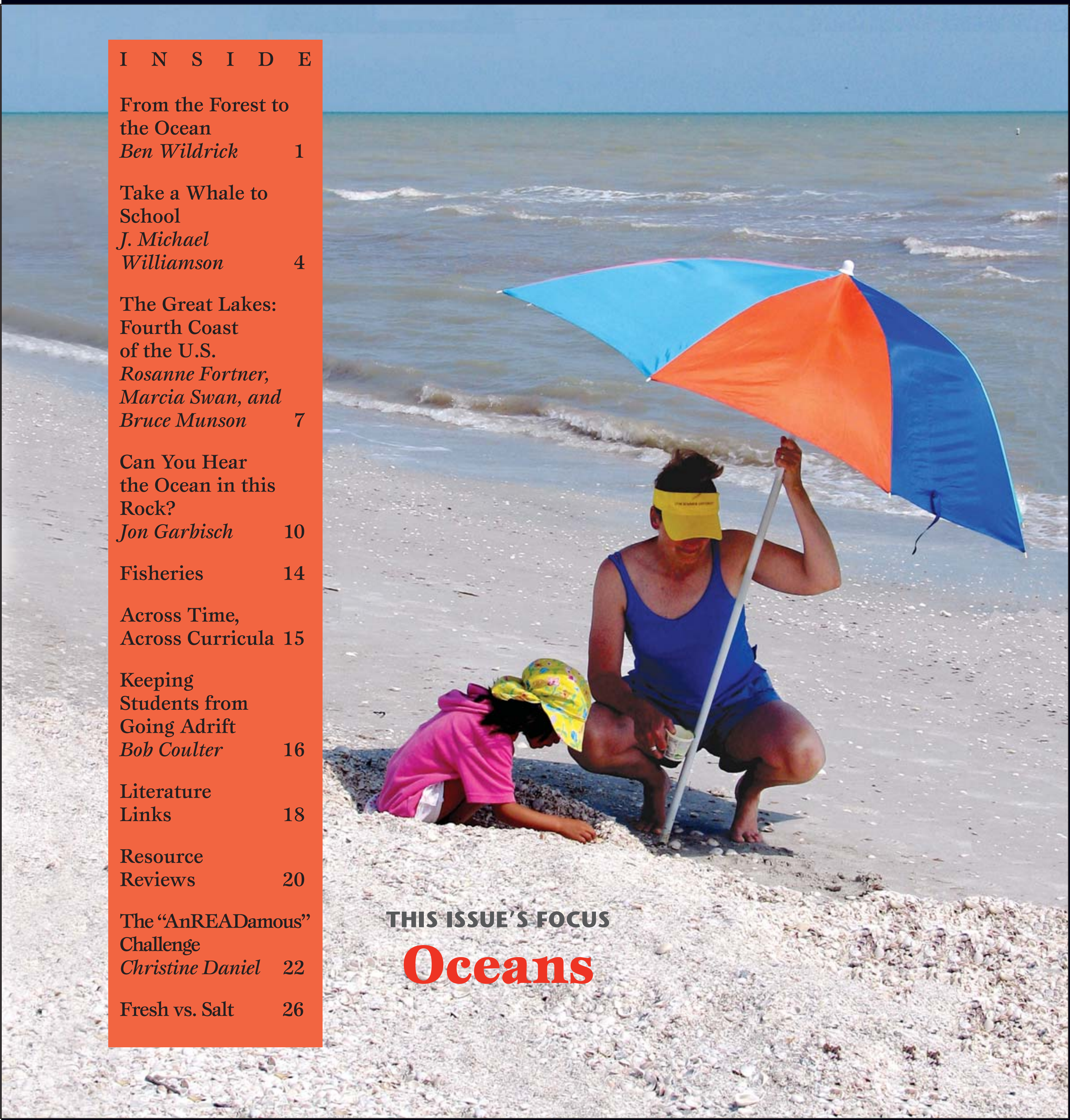
Teachers' Innovations in K–8 Science, Math and Technology

Connect®



INSIDE

THIS ISSUE'S FOCUS

Oceans

Oceans

What does the word ocean evoke in you or in your students? Is it a shoreline, sand and shells, as in our cover photo, or a vast region of unknown phenomena, discovery or danger? Some classes can take a quick field trip to the shore. Most cannot. Many can invite experts into the classroom. But if you are not in one of those fortunate positions, you will find new ideas and approaches in this issue of ***Connect***.

Authors explore links between fresh water and salt, including anadromous fish, as well as innovative uses of software, stories in the fossil record, mapping and modeling. Literature Links suggest books that can expand the thinking of younger and older students. Around the globe, cultures are moving from thinking of oceans as a vast unknown and as potential dumping ground towards a focus on oceans as crucial to life on Earth. These articles offer specific examples of curriculum and pose larger questions about how to pursue the study of oceans and their role in a constantly changing system.

Will her design withstand the incoming tide in this small bay?
FRIENDSHIP, MAINE

Connect©

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***Connect* is published five times per year (bi-monthly through the school year) and offers a wide range of practical, teacher-written articles. Each issue is thematic and supports hands-on learning, problem solving and multidisciplinary approaches.**

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From the Forest to the Ocean

Interdependence and Human Action

by Ben Wildrick

As the poet John Dunne observed, no man is an island. Yet, in our specialized world, we run the danger of becoming experts in a narrow field, isolated from others. It is easy to focus on our own areas of expertise, or our own plot of earth, to the point that we ignore a broader perspective.

My elementary science students, grades one through four, work to achieve a wide-angle perspective of the ecology that surrounds our small, suburban school campus. As these students grow, they follow the movement of water from an upland forest through our school yard and eventually to a salt marsh. By following a small stream, my students gauge the impact of the school community on downstream habitats. In addition, they recognize (and are often surprised) that the tiny headwaters in our forest wind their way to the ocean!

One habitat at a time

When I ask where these headwaters go, my students usually respond, "Away." At their age, this ingenuous reply is honest and appropriate. Yet many adults continue to apply the concept of "away" to their world. Curbside trash is taken "away." Wastewater goes "away." Herbicides and pesticides applied to our yards go "away." Fortunately, people are learning that there is no place called "away." As inconvenient as it is, all our actions have downstream effects. As teachers we need to introduce the concept of a global ecology to our students. And this happens one habitat at a time.

In my classes, the journey starts in first grade as students examine the layers of the forest. In the leaf litter they discover the precursors to soil. Under layers of shed leaves, decomposers are hard at work composting. Like a crowded hotel, rotting logs provide shelter for a veritable soap opera of interdependent organisms. After a fall rain, my students notice a series of "big puddles." "Where did they come from?" "This one is moving!" And with those questions our journey continues.

Towards the pond

Most of us have dropped a stick in a stream for the simple satisfaction of watching it float. It gets tossed by rapids and lulled by the deep, quiet sections. I have used the motion of a cork in our small stream to teach second-grade students about the movement of water. It doesn't really feel like teaching. We're having too much fun! The kids drop their corks into the stream and race to a still section. Their cries of joy and anguish increase as the corks either survive the rapids or get shot to the side of the creek, into a swirling no-man's-land. My students love to race. I wonder sometimes how far their corks would go if we didn't scoop them up with a net.

The stream leads to a small human-made pond, about 50 meters away. In addition to my second graders' boats, this stream carries sediment from the upland forest, dropping it in our pond as the waters slow.

Our entire school is drawn to the pond that over the years has sustained a varied community of organisms. My third-grade students frequent these waters in the fall and spring. They scream with glee when a green frog is sighted and are amazed at the large numbers of tadpoles that suddenly wriggle into view as they are touched by shadow, then just as magically disappear in the mud. Each fall these student chroniclers document our pond's

Each fall these student chroniclers document our pond's cycles. This is the work of budding scientists.

cycles. They splash, slip, spy, measure, interview, predict, guess, share and imagine. This is the work of budding scientists.

Oil spill!

Three years ago our pond faced an environmental catastrophe. A snowplow punctured a heating fuel pipe. The resulting spill flowed into our creek, pond and beyond. Owing to the quick action of our physical plant staff and an equally speedy response by the Coast Guard, the environmental damage was minimized.

The following day we were greeted by men in yellow suits and respirators in our pond, laying squares of absorbent material on the surface! This potentially disastrous accident turned into an important and novel learning experience for our students. Based on their knowledge of our watershed, my students' concern first went to the pond, and then spread to the wetland and finally the salt marsh.

Because of health concerns immediately after the spill, we couldn't spend much time at the pond. However, we were able to use our noses (home heating oil has a distinctive odor!) and followed the flow of the accident. When my students found signs of oil in the salt marsh they were devastated. Back in the classroom discussions revolved around the effect of heating oil on pond, stream and salt marsh organisms. "How long will the oil stay around?" "How do they clean it up?" "Where do they take those 'diapers' in the pond once they're full of oil?" "How did this happen?"

To the salt marsh

As the rich waters of our pond continue their journey they pass through a wetland. The water spreads out and intermingles now with the earth, more intimately than before. Soil here smells different. Tree roots grow up and outwards to brace themselves in the mushy land. Plants like skunk cabbage and red maple thrive.

Imperceptibly the waters leave our wetland, purified, ready for the next destination. These waters collect and flow, under a roadway and into a salt marsh. Here the landscape changes radically. Trees and grass are replaced by salt hay and spartina. It's harder to move through this grass. There are no lawnmowers here, and boots are required. The flow that my students have followed seems to end. The muddy stream my first graders poked and prodded has gone through many transformations. Yet in a sense, the story of this flow is just beginning.

To the sea

Like the stream my students play and learn in, almost all rivers culminate in an ocean. While this may seem elementary, we are as a society ignorant of this fact and its implied consequences. A 2003 study by the Pew Oceans Commission clearly illustrated the link between ocean health and human activity along rivers. To study this link, the Commission focused on coastal Maine, the Gulf of Mexico and, oddly enough, the city of Des Moines, Iowa, some 1,000 miles from the nearest ocean! What the Commission discovered is startling: farm runoff has become the main source of pollution in the oceans.

Farmers in the mid-west use nitrogen to fertilize their crops. It's inexpensive and increases yield. But the fertilizer doesn't stay put. It seeps into groundwater and enters the Mississippi River as runoff. This process continues for over a thousand miles until the river dumps its load in the Gulf of Mexico. This is hardly a new issue. The National Oceanic and Atmospheric Administration (NOAA) studied this and issued a report in 1999. What are the consequences of this practice? The report's conclusions:

Nutrient overenrichment from human activities is one of the major stresses affecting coastal ecosystems. There is increasing concern in many areas around the world that an oversupply of nutrients from multiple sources is having pervasive ecological effects on shallow coastal and estuarine areas. These effects include reduced light penetration, loss of aquatic habitat, harmful algal blooms, a decrease in dissolved oxygen (or hypoxia), and impacts on living resources. The largest zone of oxygen-depleted coastal waters in the United States, and the entire western Atlantic Ocean, is found in the northern Gulf of Mexico on the Louisiana-Texas continental shelf. This zone is influenced by the freshwater discharge and nutrient flux of the Mississippi River system.[1]

The Gulf Coast region has already suffered wetland loss from oil and natural gas exploration and extraction. With the reduced storm-buffering effects of those wetlands, the coastal region is more susceptible to further damage from major storms. That the actions of a farmer in Iowa can influence the ecology of an ocean seems at first surprising. But the influence of ten thousand farmers?

In fact, all coastal ecosystems are threatened. According to the Pew Commission, more than half the U.S. population lives in coastal counties. The resident population in this area is expected to increase by 25 million people by 2015. Tens of thousands of jobs in fishing, recreation, and tourism in the U.S. depend on healthy, functioning coastal ecosystems. Clearly, this is a valuable resource worth preserving.

A fragile system

The Earth's oceans have always seemed limitless to humankind. Sailing and mapping them were the work of brave explorers who returned with tales that only heightened the awe and mystery surrounding these waters. The Pew report states with stark

Because of the benefits that estuaries provide, twenty-two of the thirty-two largest cities in the world are located on estuaries.

clarity, "What we once considered inexhaustible and resilient is, in fact, finite and fragile." (p.v)

Can racing corks in a stream help students develop a connection to the ocean? Did a fuel spill in our creek illustrate the precarious relationship we have with our downstream neighbors? Does squishy mud between your toes bring you closer to a relationship with your natural world? If the answer to any of these questions is, "no," I'd better start looking for another job! My aim is to help my students to, ". . . recognize the interdependence of land and sea and how easily activities far inland can disrupt the many benefits provided by coastal ecosystems." (Pew Commission, p. vii)

We live in an age when the scientist and the poet have reached consensus: no man exists outside the natural systems that govern life on our planet. No man is an island. ✐

Can racing corks in a stream help students develop a connection to the ocean?

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Ben Wildrick teaches science to first- through fourth-grade students at the Brookwood School. Located in Manchester, Massachusetts, Brookwood is a Pre-K-8 independent day school.

Take a Whale to School

by J. Michael Williamson

I have been teaching about the oceans and marine sciences since 1973, and I have been researching blue whales since 1980. In that capacity, I visit schools, make presentations, and spread the word about whales and the importance of the marine environment. Among other various questions, such as, "How close have you been to a whale?" students always ask, "How big is a whale?" I tired of the same mundane answer of, "They are as big as a school bus." So one day I decided to make a model that I could take to schools to show students how BIG a whale is.

An idea takes shape

While stuck in one of Boston's notorious traffic jams, I made a prototype of a model using an extra piece of paper and my Swiss army knife. I then enticed my senior seminar class at Wheelock College in Boston, Massachusetts to develop this project as part of a class activity on problem solving. Their challenge: Make a life-sized whale model that fits into a duffle bag and can be carried by one person.

Eventually Lucy was "born." Since that time hundreds more Lucies have been created. I not only made Lucy the Inflatable Whale for myself, but I also developed an instruction booklet that allows anyone who wishes to make his or her own inflatable whale.

Classes, community groups, church groups, and museums all over the country and world have constructed their own whales. Institutions such as the Boston Museum of Science and the Bermuda Underwater Exploration Institute have exhibited their own inflatable whale models.

When I began this project, I had no idea the impact that Lucy would have on students of all ages. Watching the students' eyes get larger as the inflating whale gets larger is an experience in itself. I now have Lucy III. The first two models saw at least 20,000 students pass through their interiors.

One day while visiting a school in Connecticut, a teacher came running up to me, grabbed my arm, and said, "You can't believe what just happened!" At this point in the day, after what seemed like the 200th fifth-grade class, I had no idea what might have happened. Excitedly and seemingly breathless, the teacher said that they had a student with autism who hadn't uttered a real word, much less a sentence, in two years; when the girl saw Lucy and the other students, she said to her teacher, "I want to go in the whale."

Lucy, The Inflatable Whale

Creating Lucy: you can do it!

The learning experiences begin with the problems of constructing the whale. Where do I begin? How do I interpret the instructions and organize the crew? It usually takes four or five adults about five hours to construct the whale. The more students you have helping the longer it takes, but that is part of the adventure.

The construction is like a sewing project in that you lay out patterns and cut pieces that are then assembled. In this case though, the 3- to 6-mil plastic pieces are joined with tape instead of fabric joined by thread. The instruction booklet provides complete directions and a materials list with everything you need to know to build your own whale. The guide has been field-tested, and I have had relatively few questions on construction. I am glad to help with any questions you might have.

The whale-building crew uses some math, some simple materials (like packing tape, plastic, string, measuring tapes, and a three-speed house fan), some problem solving, some organizational skills, and some ingenuity to complete the project. The first time the whale inflates is a real show stopper. The inflation of the finished whale is usually a media event for the school and the local papers. If you are building a whale, seize this opportunity!

Educational units on life science (whale anatomy), physical science (air pressure), and mathematics are included in the booklet. Students can research questions such as:

- How does the whale stay inflated?
- What is the surface area and volume of the whale?
- Why is the surface area to volume ratio (SA/V) so important to a whale?
- How is the SA/V ratio different from that of plant plankton (phytoplankton)?
- Why is the SA/V ratio different?

Within the instruction booklet, I include some seed activities that can lead to more investigations.

The students use proportions (Table 1 shows part of this chart) to determine the placement of the eye, the flipper and the dorsal fin, using data taken from actual whales. They use mathematics to calculate the surface area to volume ratio of the whale (Figure 2).

The eye is located about 22% of the whale's length back from the tip of the snout. How long is the whale model? So where does the eye go? The flipper is about 35% of the whale's length back from the tip of the snout. So where does the flipper go? The breadth of the flukes is about 23% of the whale's length (wow!!). So how wide do we make the flukes?

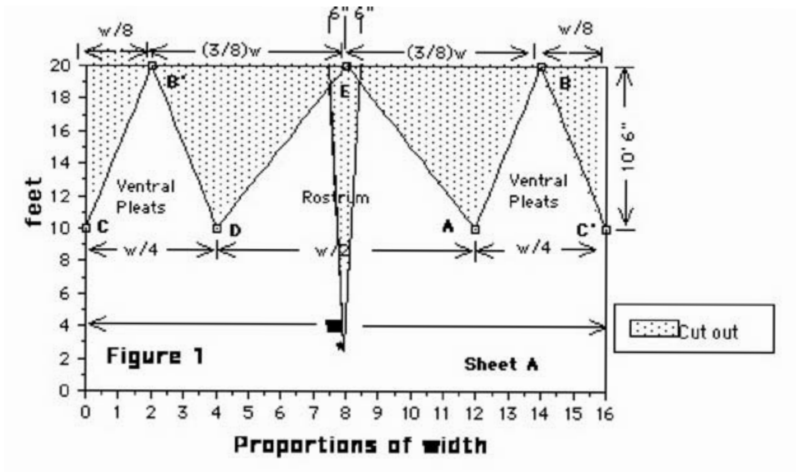

Figure 1: Construction of the head

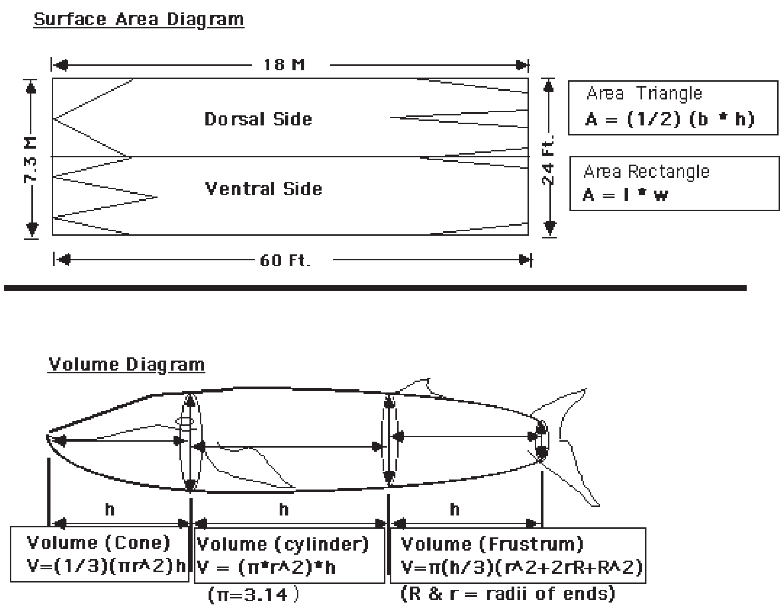

Figure 2: Mathematics–Surface area and volume

Table 1

ANATOMICAL DIMENSIONS FOR YOUR WHALE

Use the average body dimensions in percent body length of YOUR model.
Balaenoptera musculus *(based on available data from a whaling station)*

Specimen Number	14	19	3	4	1	9	20	12	21	22	24	Avg.
Sex	f	f	f	f	f	f	f	f	f	f	f	
Total Length (feet)	77	75	74	74	72	72	70	67	65	66	61	69.8
	%	%	%	%	%	%	%	%	%	%	%	
Tip of Snout to eye	21.8	21.7	21.6	22.1	20.9	21.5	20.3	21.6	20.	21.	220.	21.2
Tip of Snout to blowhole	18.9			18.8			17					18.3
Tip of Snout to posterior base of pectoral fin	34.4	34.7	34.1	35.4	33.8	35.5	34.4	36.2				34
Tip of Snout to posterior base of dorsal fin	76.9	77.3		78.9	72.0		75.7					76.2
Length of pectoral from posterior base fin	10.6		11.1	10.3	10.8	9.0						

Lucy should be the launching point, not the destination, of your learning journey.

The adventure

The voyage of learning should never be complete. Lucy offers one more leg of the journey. Lucy The Inflatable Whale offers a hands-on, minds-on, multidisciplinary adventure that most students and teachers never forget. The inflatable whale models have been used as reading rooms where upper class students read stories to lower classes, as senior projects in biology, as temporary classroom areas to study scientific concepts, as bible school's Jonah and the Whale activities, and other unique learning experiences. Remember, Lucy should be the launching point, not the destination, of your learning journey. It can be fun and exciting to teach science if you aren't afraid to answer a student's question at times with, "I don't really know, but I do know how we can find out."

You can visit WhaleNet at http://whale.wheelock.edu to download more educational resources and information on the marine mammals that inhabit the oceans of the world. WhaleNet offers real-time satellite tagging data on marine animals. There you can find active and archived satellite tracking data on over 100 other whales, dolphins, porpoises, seals and sea turtles. The Lucy page is at http://whale.wheelock.edu/whalenet-stuff/LucyPage.html. There you can order the instruction booklet ($10.00) and find links to providers of materials to make your very own Lucy. Log on and reap the educational rewards of the deep!

"Bob" The Whale in Vermont

J. Michael Williamson is the Director of WhaleNet and an Associate Professor of Science at Wheelock College in Boston, Massachusetts. He is also the Associate Director of the Mingan Island Cetacean Study (http://www.rorqual.com)*, and he has 30 years of experience in whale research.*

The Great Lakes

Fourth Coast of the U.S.

by Rosanne Fortner, Marcia Swan, and Bruce Munson

Hmm . . . a Great Lakes article in an issue focused on oceans? It's not such a stretch to see the connection for the Sea Grant educators on the fourth U.S. coastline. For decades we have been telling teachers that anything they want to teach about the ocean, they can teach with Great Lakes examples (except for echinoderms and elasmobranchs, and *even those* are found in fossils of the region).

The Great Lakes have surfing, beachcombing, fishing tournaments, invasive species, reefs, dunes, coastal erosion, huge storms, wetlands, and water level fluctuations that exceed some tidal ranges. We also have seaports and shipping, shipwrecks, chanteys, a Sea Grant, a Marine Protected Area, a Marine Sanctuary, a National Estuarine Research Reserve, and a Center for Ocean Sciences Education Excellence (COSEE)! The Great Lakes are recognized by Federal law as the nation's "fourth seacoast" (U.S. Commission on Ocean Policy, 2004).

For those who haven't visited the Great Lakes, their sheer volume and geographic scope can come as a great surprise. The watershed spans 7º30' of latitude and 16º of longitude, reaching more than 1200 km from east to west and some 724 km north to south. These vast freshwater seas have more than 16,000 km (10,000 miles) of shoreline, roughly the same as the Atlantic coast. The Lakes drain over 247,000 square km of watershed and hold 20% of the world's supply of fresh surface water. Finally, the eight Great Lakes states are home to 82 million U.S. citizens, more than one-quarter of the nation's population. That fact alone makes it important for *all* students to learn about this unique and important environment.

To dramatize how people and resources are distributed through the lakes and their watershed, COSEE Great Lakes uses an active lesson called, "How Big Is a Crowd," that involves the whole class. When students have completed the activity, they should be able to compare the relative sizes of the five Great Lakes and the distribution of their human populations, and describe some of the problems that arise when many people depend on a limited resource.

On this map, major U.S. marine sounds and bays are superimposed to show the vast area of the Great Lakes.

> *". . . students understand land use and gain a sense of how our individual actions affect water quality along with development and industry."*

The Lakes and surrounding population

Outline the shapes of the five Great Lakes with strings on the floor or outdoors. For a class with up to 30 students, the lengths of string that will approximate the lake perimeters are: Lake Superior, 8.5 m; Huron, 6.0 m; Michigan, 6.0 m; Erie, 2.5 m; and Ontario, 2.0 m. In four of the lakes, a chalk line mid-way between the shores will represent the international border with Canada. Lake Michigan lies entirely within the United States, with no Canadian border.

Teacher Kathy Mattus has her students do research first to determine the relative sizes and order of the lakes from inland to the sea, and she has the students lay out the strings on the playground using what they have learned. The geography lesson

Students outline the lakes to scale on the floor.

is a dramatic one, especially for students who live on one of the lakes but know little about the others.

As the class gathers around the lake diagram, invite students to discuss differences in lake surface area. An advance Internet search can give them information on relative depths and water volumes of the lakes. While Lake Erie is not the smallest in surface area, for instance, it has the smallest volume because it is very shallow.

Next, assign students to represent people living on the shores of the lakes. The chart shows the relative population of the U.S. and Canadian portions of each lake's watershed. When students are assigned to a lake and country, they find their position and stand with one foot on the shoreline. Don't miss the chance to talk about how some of the lake shores are much more crowded than others. How do the students feel if they are alone on the shore, or crowded together? What kinds of land use might result in the population densities they are experiencing? Are more people living near the eastern or the western lakes? Are more people in the U.S. or Canada? Again, an Internet exploration using the Great Lakes Environmental Atlas would provide useful background information.

Small candies, representing fish and other resources that come from the lakes, are distributed to the "residents."

Relative Populations of Watersheds
U.S. / Canada

If the number of students participating is	**15**	**20**	**25**	**30:**
Lake Superior	0/0	0/0	0/0	1/0
Lake Huron	1/0	1/1	1/1	1/1
Lake Michigan	6/0	7/0	9/0	11/0
Lake Erie	4/1	6/1	8/1	8/2
Lake Ontario	1/2	1/3	2/3	2/4

Studying fish resources

To demonstrate the biological richness of the lakes, we distribute bags of resources representing fish in each lake. We like to use a food product that produces some waste when it is consumed, like wrapped candy bites or peanuts in the shell. (Be careful to avoid problems with food allergies in the class.) Tell the class that each item represents 50 tons of edible fish! Distribute bags with these numbers of resources: Lake Superior, 8; Michigan, 35; Huron, 5; Erie, 50; and Ontario, 2. If the group is very small you may wish to halve the resources. Either way, it should be very clear that some of the lakes are much more productive than others. Can students think why this may be the case? Discuss the ideas and make notes on what to look up on the Internet later.

Invite the students to consume the resources by passing the bag for their lake around with each person taking one "fish" until all are used. While the fish are being consumed, set the stage for the next discussion by discarding some wrappers or shells into the lake, making an offhand comment like, "we don't need this part," or, "it will sink." Students who have internalized the notion of recycling and not littering may complain (we hope!), and that can open a discussion on how people have behaved in the past, where we can still see litter, and what should be done to prevent the problem.

Continue to dispose of the waste and compare the concentration in each lake. Is the amount of waste related to the lake size, or to something else? In the early part of the 20th century, it was common for industries and towns to dump their wastes into lakes and rivers, observing that eventually it was no longer visible so it must have gone away.

In reality, pollution flows downstream. The student in Lake Superior should send the food waste to those in Lake Huron, and so forth, downstream to Lakes Michigan, Erie and Ontario. How do the students feel about having to deal with wastes created by others? By the time the amassed pollution reaches Lake Ontario, would the students want to eat fish from that lake? Introduce the idea that, "We all live downstream," and invite students to share their perspectives on what they have observed in this investigation and the earlier ones.

Teachers' reactions

We have used these approaches in teacher education programs through COSEE Great Lakes and the Sea Grant programs in the region, and many teachers apply them in their classrooms. They report extending the activities into math, graphing, and environmental education activities. Wendy Lutzke, for example, is grateful for a physical representation of more abstract ideas.

Teacher Terra Tomlinson says, "I like activities where the kids actually represent some of their own data that they are working with. I especially like the fishing data and would extend the activity to include some graphing of the people and fish populations of the lakes." Julio deJesus from Puerto Rico plans to add a measure of retention time, for how long the water (and its pollution) remains in each lake. Marie-Pierre Lamkin appreciates how the activity brings population and resource use into an interactive format, and Jill Hollowell claims, "It helps students understand land use and gain a sense of how our individual actions affect water quality along with development and industry."

Debra Zolynsky reported that after the activity her students came up with some very good ways to reduce pollution—one being to paint this message on storm drains, using stencils: "Drains to Lake." In Language Arts, teacher Carol Gutteridge uses "How Big Is a Crowd?" with a reading of Holling Clancy Holling's children's classic, *Paddle-to-the-Sea*.

Would Great Lakes studies like these be useful on our "salty" coastlines? Should students with access to Atlantic, Pacific or Gulf coasts devote time to understanding these vast bodies of fresh water, far away from their homes? Teacher Tim Marvin thinks so. After watching teachers do these activities in a workshop, he wrote, "I found this useful even at distant locations such as North Carolina. Many students have heard of the Great Lakes, but little more."

Research at the Ohio State University has shown that even in Ohio, students know more about the oceans than about the Great Lakes. COSEE Great Lakes is determined to increase student and teacher awareness of our Fourth Coast, the Inland Sea. This can be done through activities and investigations that comply with many state science education standards related to population, resources and environment.

Wastes from Superior, Huron and Michigan flow into the bounty of Lake Erie, the most productive lake.

Resources

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COSEE Great Lakes can provide string sizes and population numbers for larger groups of learners. You can watch an online video of doing this work through the free archives of http://www.coexploration.org/coseegreatlakes.

Our recommended reference for Great Lakes statistics is http://www.epa.gov/glnpo/atlas/intro.html.

Rosanne Fortner is a Professor Emeritus of Environmental Science Education at The Ohio State University. In retirement she directs the COSEE Great Lakes.

Marcia Swan is Manager of Technology Transfer at Moldflow Corporation, based in Ithaca, New York. She developed "How Big Is a Crowd" as part of her MS project in environmental education at Ohio State in 1988.

Bruce Munson is Professor of Science and Environmental Education and Head of the Department of Education at the University of Minnesota Duluth.

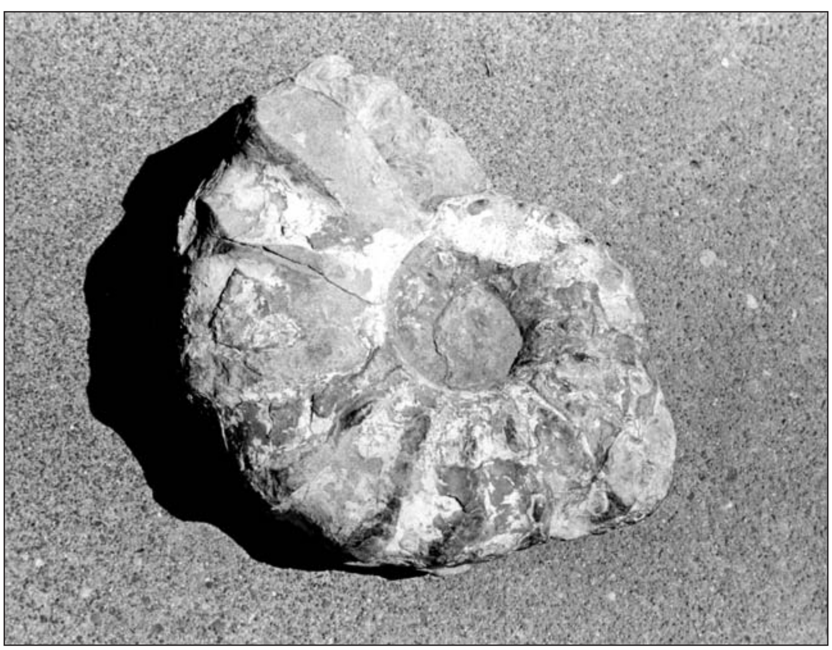
Can You Hear the Ocean in this Rock?

by Jon Garbisch

The very rocks under our feet record the history of the earth much like a planet-sized book. We can observe the creation of new rock as the product of basic physical and chemical processes and we assume that these basic physical laws are constant and have worked the same way in the past as they do today. This concept is called *uniformitarianism* or *actualism* and it is fundamental to the earth sciences.

The epeiric seas

Shallow oceans called *epeiric seas* covered much of the North American continent at least six times in the past 600 million years. An epeiric sea is a shallow marine ocean that extends over the stable interior of a continental plate, and these seas are thought to be the result of massive global sea level rise. As each epeiric sea flooded and then retreated from the continental interior, it left behind a distinctive sequence of rock layers. These rocks are full of marine fossils and extend across the mid-continent, helping us to envision an ancient ocean.



These were not small oceans as at times only the emerging mountain chains were dry land first to the east (Appalachians), then the south (Ouachitas) and the youngest to the west (Rockies); all else was shallow tropical sea.

Current theory attributes large-scale global sea level change to:

- How fast heat and rock is moving deep in the earth's mantle;
- The movement of the continental and oceanic plates;
- A group of factors external to the Earth, mostly how much sunlight the Earth receives.

We can observe evidence of widespread shallow oceans covering North America. The interstate highway system that loops through Kansas City cuts through white limestone rocks full of marine fossil types that are incredibly similar to what we see today in the Bahamas. One can squint a bit and easily imagine an azure blue, tropical sea of crystal clear water and white sand beaches. Like in the Bahamas today, these beaches are composed of fragments of marine animals—though the actual suspect, the crinoid, is today found in much deeper water than was present in Kansas some 305 million years ago. The Atlantic is a long way from Kansas today!

Evidence of past oceans

We can place evidence of an epeiric sea in the hands of students. This can reinforce two important earth science concepts: that life on earth has changed through time, and that plate tectonic theory is a possible explanation of the evidence for an ancient ocean where there is none today.

We can do this in two ways: move the student to the mountain and put their hands on the rock exposed in a local ditch, road side exposure, etc., or bring that mountain into your class room by finding pieces of ancient sea floor you can bring into the class room (i.e., rocks with fossils). The expensive and least satisfying way in my opinion is to open the *Wards Scientific Catalog* and order some fossils and fossiliferous rocks. My view is that purchased specimens in a box are often not all that convincing as gut-level evidence of an epeiric sea, but they will do the job. A much better option is local material collected with some local help. These are rocks just like your students might also find in their back yard or neighborhood. Always the best option, however, is taking your students to an appropriate outcrop. In many parts of the continental interior, this isn't hard at all and I find that rock discovered nearby has a much higher experiential value for the student.

Collecting materials and knowledge

The field of geology and paleontology is full of famous amateur scientists, people who collect fossils in their back yard and publish what they learn through observation and repeated testing of their assumptions. They have a good knowledge of the local rock and the vast majority love to share that knowledge. Your state geological survey, a local fossil club, the geology department at your local university or the local natural history museum or nature center usually has a person who is formally or informally assigned to public education. They can help you find free fossil material or will help teach the session and bring their own material.

Many museums have rock and fossil kits that they will loan out to your school; these usually include teaching aids as well as specimens. Many areas in the mid-continent are rich in fossiliferous shales and limestones. A gallon of the appropriate shale layer often contains thousands of different kinds of small fossils in the one-centimeter-and-smaller range. Outcrops of weathered limestone and shale are often covered with a fine layer of fossil material that can be swept up with a sturdy broom (consult your local geologist).

Collect about five gallons of material for every twenty students. Wash this material through some sort of screen to remove the mud but keep the larger parts (bigger than one millimeter). Ideally, you and the class go out and do the collecting. A 7x to 10x handlens for each student can be very useful.

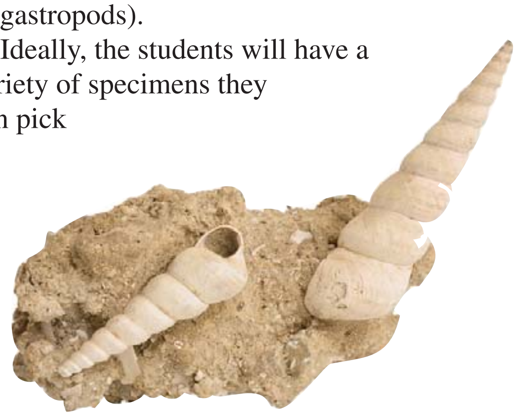
We can place evidence of an epeiric sea in the hands of students.

Preparing the students

A general knowledge of sedimentary rocks and the environments in which they form is very useful. Depending on the age and experience of your students, you might want to introduce the major invertebrate phyla.

Your students could keep a lab notebook, with drawings of representative organisms from each group and a list of features that distinguish that group from others. The students could use the notebooks to identify fossils in later exercises. For example: the student could draw a snail, labeling the opening and spire portions, also listing features such as: spirally coiled shell, interior is a single open chamber (which distinguishes most snails or gastropods).

Ideally, the students will have a variety of specimens they can pick



The Earth's surface is not static. We can observe constant and dramatic changes.

up and examine closely. Ask questions that make the student think about the specific features that determine which phyla a fossil belongs in.

The indoor field trip

If you have access to fossiliferous limestones and shales in your area that can be collected as described above, the following exercise is almost as good as a field trip.

Spread a thin layer of this material out in a tray and have the students (groups of two to three) pick and identify the major groups of fossils they find. As an incentive let them keep anything they can identify. This activity works well after the major fossil groups (such as clams, snails, brachiopods, echinoderms, etc.) have been introduced.

The students are doing exactly what many paleontologists spend a great deal of time doing. It helps if each student can have a magnifying glass for the exercise, a tray or surface to spread out the material and a zip-lock plastic bag to put the fossils in to take them home. Good bright light is very important.

The limestones of ancient epeiric seas often occur as thin (two to three centimeters), interbedded layers of shale and limestone. The limestone surfaces are original sea floor preserved under a thin layer of mud, perhaps a storm deposit. These thin plates or flagstones are often covered with fossils and a good alternative to loose material.

Connecting organisms and environments

First, students identify the various fossils; next they can note the association of certain organisms with certain types of rock. For example, modern corals live in a marine environment. If you find fossil corals in the local rocks, this is evidence that the area was under an ocean when the coral was alive, and maybe the area was once a little like the Bahamas are today. Have the students read about modern coral reefs and the ocean around the Bahamas or the Florida Keys. Have them think about the kinds of organisms that live in the ocean today and whether they are similar to the fossils they are learning about. Is it reasonable to think that hundreds of millions of years ago the mid-continent was like the Bahamas?

A student might pick a favorite specimen and do a small research project. They could find out where the same kind of animal lives today and what type of environment it prefers. Many paleontologists are more interested in what the fossil can tell about the ancient environment than in the fossil itself. The students can give a short talk to their classmates about the fossil. For example, if they have a fossil coral they can say it probably lived in warm, clear water somewhere near the equator. If the fossil was collected in mid-continent, how could there have been coral reefs here in Kansas? The Earth's surface is not static. We can observe constant and dramatic changes.

Does this really work?

I have found that these exercises work well for second or third grade right up to Elderhostel. For background, students need to have only a general knowledge of nature. Often the student can collect, and keep for their very own, invertebrate fossils they have found near their home. Like a dinosaur, an invertebrate fossil is something from the distant past; some are hundreds of millions of years older than the earliest dinosaurs. Even the youngest students can imagine the ancient ocean that once covered the mid-continent when they find a fossil that looks much like a modern seashell. Yes, you can hear the ocean!

Jon Garbisch promotes field-based education at the university level at the University of Georgia Marine Institute on Sapelo Island, Georgia, http://www.uga.edu/ugami. *The Marine Institute's research focus is coastal ecology. He also teaches Physical and Historical Geology at the local community college. He has lived in Wisconsin, Mississippi, Kansas, The Bahamas, Texas and now Georgia; all areas with great fossil-rich rocks.* sapelo@uga.edu

Resources

Rhodes, F. R. T., H. S. Zim, and P. R. Shaffer. *Fossils: A Guide to Prehistoric Life*. Golden Press, New York, 1962. A little dated on some fossil groups and concepts but the core marine invertebrate part is specific to the mid-continent and an excellent resource with good illustrations.

Older but still usable is the paper below. It is part of a larger web site full of hands on sorts of exercises for earth science educators. http://www.beloit.edu/~SEPM/Fossil_Explorations/Hunting_Invertebrates.html

Field Geology

Jon Garbisch comments on field geology and applying the scientific method:

Geology is a very accessible science. I see sandstone and in it are fossil shells, the sand is preserved in obvious layers much like we see form on a modern beach, the shells look a lot like shells we remember from a recent trip to the beach. On the next level this is not just basic observation but rather it is a hypothesis that can be tested. Can I find modern examples of this sort of sandstone or these types of shells existing in some environment other than a shallow marine?

My view of the scientific method is that it is no more than careful, methodical observation, and the generation of multiple hypotheses (guesses based on what I observe) that can be simultaneously tested for falseness. I mean by this: even one example of my sandstone in all its details and components above forming in something other than a ocean beach puts the entire hypothesis in doubt. Perhaps I need to discard that hypothesis and spend more time observing the rock. We are testing for evidence of a shallow marine environment; marine as in salty like the modern oceans. Our best evidence for this is the animals that live in modern oceans and specifically animals that today never live in fresh water, and so we look for these kinds of fossils in the rocks.

Fossils or evidence of past life can also be evidence of past oceans. The objective is a good selection of the major invertebrate groups; that is eight-plus groups (phyla) common in the ancient marine environment and preserved in your region: *protozoans* (microfossils), *sponges*, *coelenterates* (corals etc.), *bryozoans*, *brachiopods*, *annelids* (mostly just worm tracks or borings), *arthropods* (trilobites, insects, crustaceans, etc.), *echinoderms* (sea urchins, starfish, crinoids, etc.), *mollusks* (snails, clams, cephalopods, etc.). The underlined groups are common in epeiric seas. These fossils are direct evidence for an epeiric sea, just as structures in the surrounding rock are also good evidence for the presence of a prehistoric marine environment.

This is just invertebrate biology except that the emphasis is on animals that have hard parts, which preserve in the fossil (rock) record. The plan: learn to recognize common marine invertebrate fossils, associate these fossils with specific marine environments (uniformitarianism), interpret this evidence to imagine the epeiric sea that left these fossils in the mid-continent, a long distance from any modern ocean.

Fisheries

Catching More than a Meal

Commercial fishing is one of those "real-world" topics that can offer you and your students opportunities to examine several viewpoints at once, and to integrate several core subject areas. That tuna fish sandwich or breaded fillet has traveled a long way and through many processes before being served in your school cafeteria.

The fishing industry is an example of the overabundance that is made possible through advances in technology. These advances were developed to make life better for the fishermen and for us, the consumers. We like having access to seafood and feeling that we're getting a bargain when shopping. But there are often much greater costs for these products than the market price suggests.

The shrimp you or I eat at one meal represents the potential loss of leatherback and loggerhead turtles, thousands of which are casualties of shrimp fishing each year. Shrimp and fish farming can devastate ecosystems through promoting monoculture and using fish meal as feed—made from ocean fish that are sometimes harvested using other detrimental practices.

To catch pollock, the most common source of frozen fish sticks, forty-mile-long "longlines" studded with hooks are dragged behind giant ships. These can entangle other species like right whales who sustain lasting ill-effects: limited movement of flippers, injured or impaired mouths that can no longer effectively feed.

Fishermen throughout coastal communities who have made their living from the sea are troubled by the federal limits placed on their catches, feeling that their business is endangered and their way of life is threatened. Their catches need to be processed, transported, and sold, which means that their hard work supports other jobs and is a stimulus for the economy. On the other hand, without limits on fishing, how long will a given population of fish exist? The newer technologies, using GPS, sonar, trawler nets, gill nets and longlines, do so well at catching fish that they can haul in as much as 30% unintended (and discarded) catch or "bycatch," much of which is simply dumped overboard.

Technological advances, however, also offer solutions to these problems. Scientists are working with fishermen to design nets more specifically engineered to catch only certain species. This work and other projects help to create practices that are less damaging in the long run. Online databases track the catch by year and can show trends in populations.

What innovations might the creative minds of your students come up with? For older students (sixth grade and up), there are many resources for study and examples in current events. It is important to consider the impact that the information might have on your students, and the potential for them to effect change when taking on a topic as rich and controversial as fishing.

The GEMS (Great Explorations in Math and Science) guide, *Only One Ocean*, reviewed on page 20, does a good job of balancing their presentation of problems with examples of solutions. Rutgers Marine and Coastal Sciences' Coastal Ocean Observatory Laboratory (C.O.O.L.) Web site offers projects for students to analyze data and make recommendations for finding fishing areas: http://www.coolclassroom.org/home.html. The National Oceanic and Atmospheric Administration's Office of Oceanic and Atmospheric Research has a Web site on fisheries especially for kids at http://www.oar.noaa.gov/ k12/html/fisheries2.html. For an explanation of different fishing gear and problems resulting from them, see http://www.oceana.org.

Across Time, Across Curricula

Just mention the word *ocean* to a group of first graders or middle school students and their responses will suggest a vast number of interdisciplinary learning opportunities. From showing off a shell collection to studying deep-diving robots, to exploring the many forms of literature about the sea, the options are amazing.

Mathematics is everywhere from the area of sail on a racing boat to subsurface mapping, pressure gradients at various depths, data on ships and shipping. Weather data alone offers many practical math opportunities. Compare the weather on land to the data from automated buoys anchored at sea. Track storms as they move across oceans.

The science and math learning that can be found in any study of oceans can also help us to look at human history and at many cultures. When the "land bridge" existed, connecting modern Siberia to Alaska, many humans migrated across it to North and South America. Why were ocean levels so low at that time, permitting a crossing? Where was all that H_2O?

What were the navigation skills used by Pacific islanders to travel vast distances to other islands? What do we know about the amazing Chinese exploring fleets whose ships were far bigger than European boats of the time?

The Egyptians, Greeks and others were skilled at sailing the Mediterranean both for trade and for war. They fished extensively as have almost all cultures with access to the sea. What did they trade for? What fish did they catch? How did they preserve those fish and other foods?

Centuries later, as trade grew to global proportions, people imagined digging vast canals and eventually completed them: the Erie and others that moved products to a seaport, then the Suez and Panama to connect seas. In studying canals alone, the science, math and technology opportunities are huge, as are the historical elements. In the age of European empires, ocean-going ships were the main means of transport to and from colonies. How did canals between oceans change these empires? What is the value of the same canals today?

These topics and questions are only hints and any one of them can be approached on a simple level or with greater complexity. Ask your students for their ideas about oceans. Your studies could take you in any direction!

Fijian Canoe, c.1865

Keeping Students from Going Adrift

by

BOB COULTER

Engaging students in meaningful learning about oceans can be quite challenging: On the one hand there is an inherent fascination with all of the flora and fauna to be found, from the shores to the deep sea. In that regard, there is a built-in "hook." The challenge arises when students' natural interest in the exotic runs into an all-too-limited amount of time given to the study. At the same time that science is having a hard time holding curriculum space in a tug of war with more tested areas such as reading and math, we are increasingly aware of ocean-related conservation and climate issues.

From the plight of manatees to the threat of global warming inundating our coastlines, there is no shortage of environmental issues to examine with your students. Time is the much greater challenge. One teacher I worked with lamented wryly that she "had an entire week to do the oceans." While most school curricula aren't that restrictive, the perennial challenge remains to select learning resources that interest your students and meet curriculum goals. The easy answer, of course, is to turn science into a vocabulary exercise, but that defeats your efforts toward engagement.

Two free resources are presented here that foster students' connection to oceans while promoting solid academic content. The potential each offers for a multi-disciplinary focus gives you hooks into other subjects, enabling ocean studies to spread across the curriculum.

Digital geography

Google Earth (http://earth.google.com) is used for a wide variety of purposes from exploring your neighborhood to getting driving directions. A particularly creative teacher I work with conceived of using it as a way to link her students to the ocean. Being mid-continent, most students we work with in the St. Louis region don't have a strong connection to the ocean. Multi-day field trips would be one option, but not likely to fit most school budgets. Instead, this teacher used Google Earth to have students navigate on screen from their local creek to the Gulf of Mexico. This created a powerful visual link that we are all connected to the oceans. It made readings about agricultural runoff and other forms of non-point pollution that end in the Gulf's "dead zone" much more real for the students. In turn, this created a connection to her chemistry learning goals, as students tested the water quality in the local creek fully aware that what they found locally would eventually reach the Gulf. In this way, a simple tool forged a link between the local community and the distant sea, and integrated traditionally separate curriculum areas.

Coastal images as inquiry

A second resource to investigate is the collection of activities and images found at the Carolina Coastal Science Web site (http://www.ncsu.edu/coast/). The imagery includes still photographs and QuickTime 360º panoramas taken from the North Carolina coast, and some ecological challenges for students to consider. As a teaching guideline, the imagery can be useful in helping students in any grade to visualize the coast most haven't seen; the ecological challenges typically require more sophisticated thought and are probably best used for upper-elementary or middle school students.

Entry-level discussions can be structured around the "Inquiry Images" resources. In that section, three different images are presented as starting points, linked to questions that can provoke thoughtful discussion. For example, one presents a soda can found with living organisms on it. Students are challenged to consider what to do with the can. Should it be left as habitat, or disposed of as trash? This is a small-scale version of what is done elsewhere as tire dumps and sunken ships become home to ocean creatures. As students discuss the best way to handle the can, they are developing skills relating to a number of key science content and process goals. Beyond considering habitat and pollution issues, they are formulating positions and supporting them with logical arguments, responding to positions held by their peers, and looking to balance conflicting views.

Extending your students' studies, two coastal management challenges are presented. One asks students to consider the pros and cons of moving a historic lighthouse, while the other centers on how to manage a shifting inlet that is threatening a local resort. For each, a set of guiding questions and Web resources are provided, along with a glossary of key terminology. The Shell Island resort activity goes further in placing students in the roles of different stakeholders, prompting them to see the issue from a particular point of view. This capacity to see multiple sides of an issue will serve students well as they take on greater citizenship roles in the future.

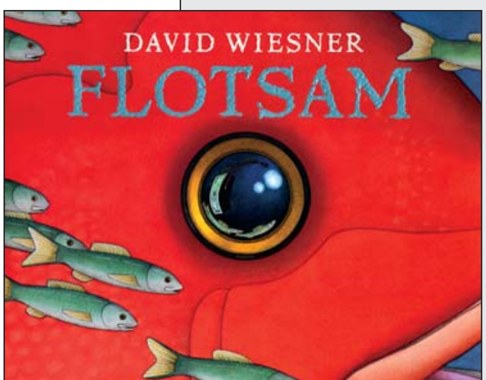
Parallels with other topics

Both of these dilemmas provide students with opportunities to deepen their understanding of fundamental ocean processes such as coastal erosion, as well as the difficult choices involved in balancing human development and natural processes. In that context, your ocean study can be linked back to other locally significant issues. In the St. Louis region, retail and housing development in flood plains presents issues that have a strong parallel to the issues presented at the Carolina Coastal site. In other regions, suburban development into areas subject to wildfires presents similar dilemmas. Throughout, the challenge remains to engage students in thoughtful study of the world around them and consideration of their place within it.

Bob Coulter is director of Mapping the Environment, a program at the Missouri Botanical Garden's Litzsinger Road Ecology Center that supports teachers' efforts to enhance their science curriculum through use of the Internet and geographic informations system (GIS) software. Previously, Bob taught elementary grades for 12 years. bob.coulter@mobot.org

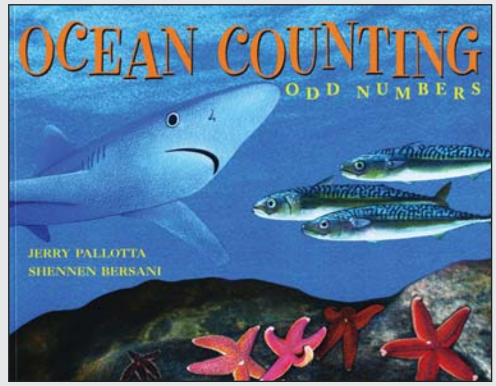
Literature Links

Flotsam, by David Wiesner (Clarion Books, 2006), is a wordless picture book that tells the story of a boy finding a camera that has washed up on the shore. He takes the film to the photo shop and looks with astonishment at the developed pictures. The surreal images can prompt discussions of "what's wrong with this picture" as children look closely at giant starfish walking over whales, octopi relaxing at home, aliens outside their ship, surrounded by seahorses. Students from second to fifth grade can also use this as a writing prompt to create captions or a storyline to accompany the images. The storyline ultimately hints at the cycles of renewal in the way that waves toss up new and old objects. This is a provocative book with many illustrations of different sea creatures.



Buoy: Home at Sea, by Bruce Balan (Delacorte Press, 1998), is an endearing story about the friendship between a buoy, a seal and a seagull. They meet all manner of creatures passing by: people, whales, crabs and sharks. Each has a distinct personality that is expressed in simple and poetic language. This is a quiet and patient sort of text, with many evocative passages that recall the feel of being at sea, what it's like to have friends, to be bored, to long for something you can't have, and to celebrate what you do have.

Ocean Counting: Odd Numbers, by Jerry Pallotta and Shennen Bersani (Charlesbridge, 2005), is a fun and richly illustrated counting book. Twenty-six different species are introduced with brief facts or bits of folklore included. The illustrations contain the correct number of objects, so students from kindergarten through third grade can

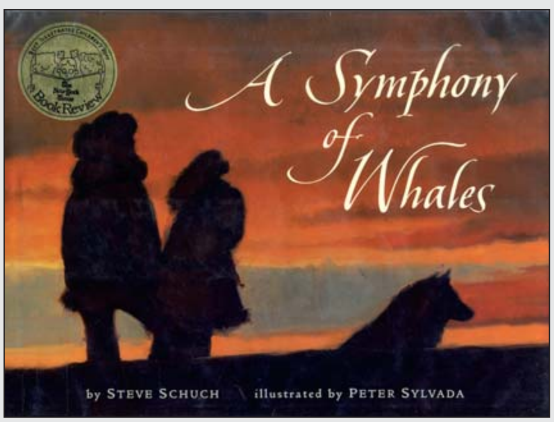


practice counting. Also included are facts about odd numbers (and even numbers). This is a great book to add to a class study of oceans while effectively integrating math studies.

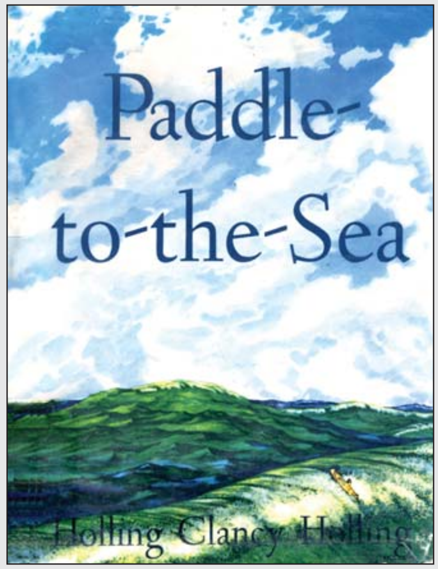
Salmon Stream, by Carol Reed-Jones (Dawn Publications, 2000), is a patterned, rhyming text (like, "This is the house that Jack built") that packs in a lot of information about the life cycle, behavior and habitat of many salmon. "This is the tiny fish that hatched / (and has its dinner, still attached), / from the egg of a salmon, born to travel, / that hides in the nest of rocky gravel. . . ." Illustrations by Michael S. Maydak are informative and just as dynamic and beautiful as the salmon themselves. A factual section follows the illustrated text. Kindergarten through fifth-grade students will find this a captivating story.

Salmon Forest, by David Suzuki and Sarah Ellis (Greystone Books, 2003), tells the story of a girl and her father walking a Pacific Northwest woodland stream where salmon return to spawn. Investigating both land characteristics and wildlife connected to the salmon, Katy and her dad uncover the story of "mysteries, merry-go-rounds, and millions of babies." Life cycle, habitat, food webs, connections to humans and some history are included. Katy and her dad meet a Native family who are catching and preserving salmon for the year. They share fresh, fried salmon and cups of tea. Second through fourth graders will gain a lot of information from this book.

A Symphony of Whales, by Steve Schuch (Harcourt Brace & Company, 1999), is a moving story based on actual events. Along a stretch of sea across the Bering Strait from Alaska, a young Chukchi girl can hear the calling of whales. She follows the call to find more than a thousand beluga whales trapped in waters that are closed off from the ocean because of advancing ice. Her village radios an ice-breaker to come and make a channel for the whales to journey back to sea. But the whales won't follow the huge ship through the channel. The crew tries playing whale songs and other music to lure the whales out of the ice. Ultimately they succeed. Rich paintings by Peter Sylvada lend an ethereal quality to the story. This is a great example of positive interactions between humans and creatures, appropriate for grades one through five.



Following the Coast, by Jim Arnosky (Harper Collins, 2004), is a beautifully illustrated natural history guide that was inspired by his travels up the coast from Florida to Delaware. The author's paintings and sketches embellish text that describes features of particular organisms and biomes. Arnosky also explains the intricate interconnection of all elements in various ecosystems, for example: "All [large sea mammals] depend on the protected waters of coastal marshes." Breeding grounds, protected space for young to develop, and food supply depend on marshes. Second through fifth graders will find useful information in this book and perhaps be inspired by the artwork and careful observations.

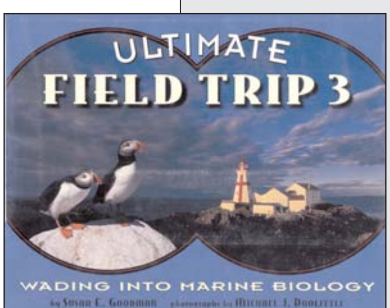


Paddle-to-the-Sea, by Holling Clancy Holling (Tandem Library, 1999), is the story of a carved wooden toy boat, placed in the melting spring snows above Lake Superior. As the season progresses, "Paddle" travels down brook, pond, river and lake. He travels past beaver dams, saw mills, fishing wharfs, canals and forest fires. Large color illustrations depict the dramatic scenes, and often the margins serve as more of an atlas, showing maps, diagrams and facts of the regions the boat passes through. Although originally published in 1941, this is still an excellent book to use when discussing major routes of transportation, history, shipping and the connection between major rivers and oceans for first through sixth graders.

Resource Reviews

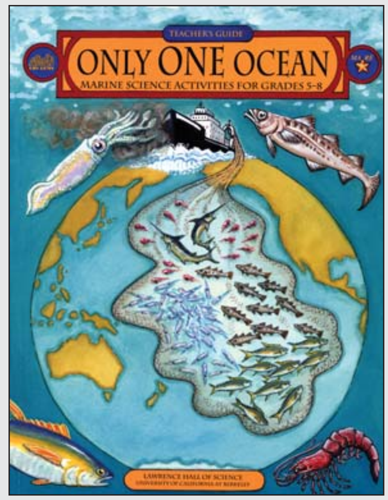
The Seaside Naturalist: A Guide to Nature Study at the Seashore, by Deborah A. Coulumbe, is like a field guide but with much more information about marine biology concepts. Black-line illustrations (which could be used as coloring-book pages) give clear pictures of anatomy and important identifying characteristics. Developed by the Odiorne (New Hampshire) Nature Center, this guide is particularly well suited for the Atlantic coast. Includes a metric conversion chart and extensive glossary. 246 pages.
The Seaside Naturalist: A Guide to Nature Study at the Seashore *($16.00) is available from local and online booksellers, or you may order directly from Simon & Schuster at* http://www.simonsays.com.

Ultimate Field Trip 3: Wading into Marine Biology, by Susan E. Goodman, tells the story of a group of middle-school-aged children who attend a week-long program exploring the Bay of Fundy. Photographs by Michael J. Doolittle document their studies while sailing, fishing, exploring tidal pools and collecting all kinds of data. The Cobscook Bay, Maine, tides are among the highest in the world. This book gives a great picture of what it is like to explore the shore. 48 pages.



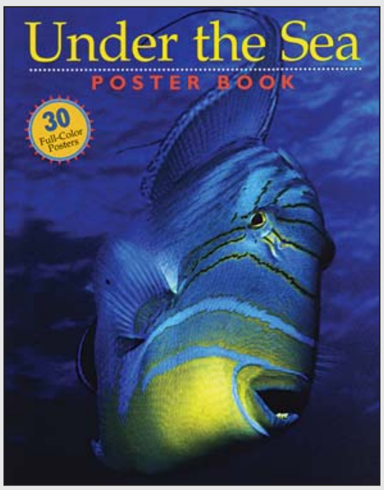
Ultimate Field Trip 3: Wading into Marine Biology *is available used and new from online booksellers such as* http://www.abebooks.com.

Whales in the Classroom, Volume 1: Oceanography, and ***Getting to Know the Whales***, by Larry Wade, are both excellent resources for study with nine- to fourteen-year-olds. Simple line drawings by Stephen Bolles illustrate the text which includes lots of information and suggestions for sequential activities. Fold-out pages provide plenty of workspace for the reader. Wade examines the importance of oceans and large sea mammals in a way that is accessible to learners no matter their geographic location. Approx. 130 pages.
Whales in the Classroom, Volume 1: Oceanography*($ 14.95), and* ***Getting to Know the Whales*** *($23.95) are available from Singing Rock Press, PO Box 1274, Minnetonka, MN 55345. Call 952-933-2492, online at* http://www.whalebooks.com.



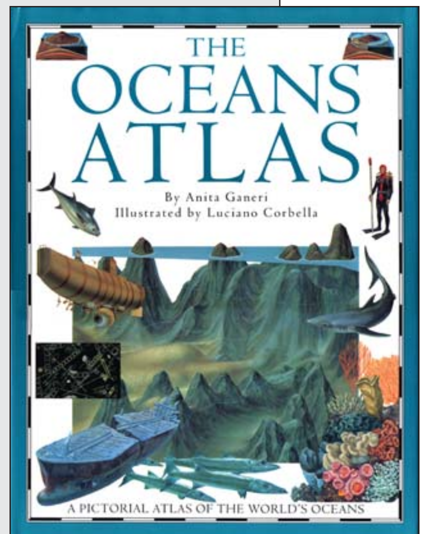
Only One Ocean: Marine Science Activities for Grades 5–8, and ***Ocean Currents***, by Lawrence Hall of Science, are excellent GEMS guides (Great Explorations in Math and Science). GEMS guides are known for their success as classroom-tested guides, with clear, step-by-step instructions, assessment suggestions, literature connections, and background information for the teacher. ***One Ocean*** explores the ocean's critical impact on all life on Earth. ***Currents*** explores how currents affect the Earth's environment and the course of human history. Both of these guides are appropriate for fifth through eighth grade. Approx. 200 pages.
Only One Ocean: Marine Science Activities for Grades 5-8 *($24.00)*, and ***Ocean Currents*** *($24.50) are available from GEMS, Lawrence Hall of Science #5200, University of California, Berkeley, CA 94720-5200. Call 510-642-7771, fax 510-643-0309, online at* http://www.lhsgems.org.

Under the Sea Poster Book, with text by Andy Case, Mark Faulkner, and Edward Seidel, is a fantastic resource for young children. There are 30 full-color, 9½" x 12" posters, each with an informational paragraph about the species on the back. See fish, insects, mammals and others in crisp, clear color.
***Under the Sea Poster Book** ($9.95) is available from Storey Publishing, 210 MASS MoCA Way, North Adams, MA 01247. Call 800-441-5700, fax 413-346-2199, online at* http://www.storey.com.



Videos and DVDs of Jacques and Jean-Michel Cousteau's undersea adventures (from 1966-2000 and later) offer a captivating view of the oceans. Many complete series are available from Netflix (http://www.netflix.com), a mail rental service. Consider a membership for your classroom or to share with another teacher or team; for a monthly fee you can rent unlimited DVDs. Snippets of documentaries or fictional works (like *20,000 Leagues Under the Sea*) could serve as great attention grabbers in the classroom as supplemental material. Netflix offers a large collection and inexpensive rates.

Picture Atlases are marvelous tools in the elementary classroom because of the combination of captivating illustrations or photos and blurbs of information. The way these elements are arranged on the page invite the reader to browse and linger over images while considering compact bits of information. These resources offer up-close portraits of individual animals or habitats as well as a global picture of large systems at work. Dorling Kindersley has the best collection of picture-book type atlases (many now come with CD ROMs) that will engage kindergarten through eighth graders. Topics include fish, shipwrecks, and coral reefs.



*To contact the publisher, **Dorling Kindersley**, call 800-788-6262, fax 800-227-9604, online at* http://us.dk.com.

Sea Shanties are wonderful resources for integrating music, social studies and science. Many of the lyrics are not intended for children; adaptations may be called for in certain cases! Men working (usually hauling rigging) on sailing ships sang rollicking choruses to help organize their efforts and distract sailors from the physical hardship of their work.
Good collections can be found at http://www.shanty.rendance.org *and* http://www.contemplator.com/sea/index.html.

Bring your class to visit your local ***Fish Market*** to personally view species that usually reside in the deep. There you can buy a specimen for dissection or for *Gyotaku*, Japanese fish printing.
For plastic models of fish to print (and many other resources and supplies), visit http://www.acornnaturalists.com.

Web Sites of Aquariums and oceanic studies offer lots of information, often times on a special "Kids" page. Here are a few that have great graphics, video clips, and useful information for student research projects:
Monterey Bay Aquarium: http://www.mbayaq.org/lc/;
New England Aquarium: http://www.neaq.org/scilearn/kids/index.html;
FORSEA Institute of Marine Science (WA), http://www.forsea.org.

The “AnREADomous” Challenge

A Thematic Approach to Learning

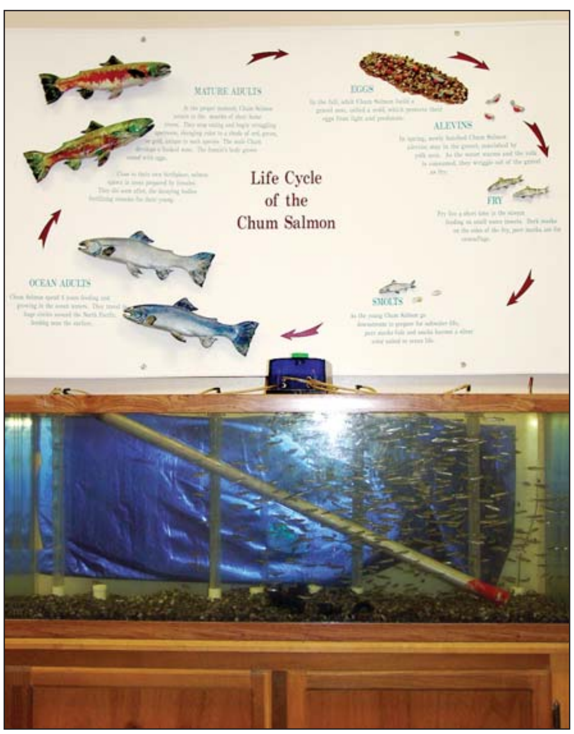
by Christine Daniel

Although the premise of the program is to encourage reading, it has become a catalyst to align science, math and other related topics.

Anadromous describes the behavior of salmon to run upstream from salt water (in this case, the Pacific Ocean) to fresh water to spawn. The AnREADomous Challenge is an Integrated Thematic Unit reading program that I introduced to an elementary school with the help of other teachers. It replaced a previously existing reading program, “The Reading Olympics.” My underlying objective in introducing the program was to engage students in a local subject of interest while meeting the state’s curriculum Standards through an exciting and motivating learning approach.

The AnREADomous Challenge purposely coincides with *Salmon in the Classroom,* a state-wide school program instituted by the Washington Department of Fish and Wildlife, in which approximately 600 participating schools annually raise 500 salmon from eggs they received from hatcheries to fry stage. As students care for “their” salmon, they learn about salmon life histories and habitat requirements. By becoming salmon stewards, students also become more aware of wild salmon ecosystems and issues surrounding them. Both programs conclude with students releasing their fry after studying the streams and creeks into which the fish will be released (to learn more, visit the Washington State Department of Fish and Wildlife, http://www.wdfw.net/).

Chum salmon, from egg to fry, raised in the classroom



Salmon are an icon of the Pacific Northwest. Learning about salmon and their ecological connection is also a focus in Washington State science curriculum Standards. Since salmon are already part of the science curriculum, integrating other related activities generates much excitement about this reading program.

Integrating reading across the subjects

Although the premise of the program is to encourage reading, it has become a catalyst to align science, math and other related topics. Throughout the Pacific Northwest, salmon are a cornerstone for environmental awareness. The wild salmon population and its decline may well be an indicator of ecosystem health. Salmon play an important role in maintaining an ecosystem’s productivity by transporting nutrients and energy from the marine environment to the fresh water aquatic and terrestrial ecosystems. Additionally, salmon have strong economic and cultural significance in the region for both the Native and non-Native communities.

The ultimate goal of the AnREADomous Reading Challenge is to increase children’s reading for enjoyment. Throughout the challenge, students can use both at-home reading minutes and school SSR minutes (Sustained Silent Reading), in their tally. The reading can be in any genre.

In the AnREADomous Challenge, the entire student body (approximately 550 students) decorate and use a cardstock cutout of a salmon to represent their reading progress. On a 3-D, topographic map of the Pacific Coast from Washington to

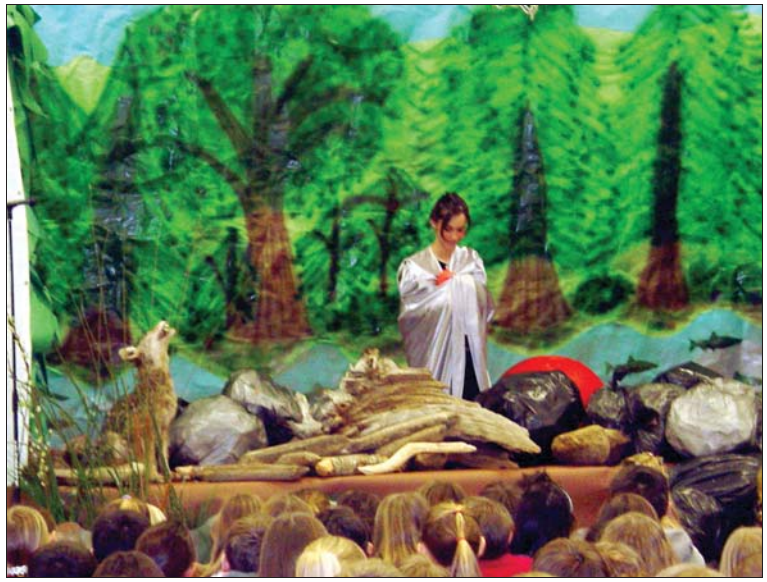
Alaska that stretches along the gym wall, students physically move their salmon along the mural, "migrating" with every minute they read. Once they leave their freshwater environment, each minute read is equal to two miles in the salmon's migration. The distance traveled is correlated to a large, scaled ruler at the bottom of the mural. This represents 1500 miles of coastline from the Hood Canal to the Bering Sea, or 3000 miles total for the round-trip journey.

The coastline mural where students and teachers record their reading progress

High school students lead the way

A school wide kick-off ceremony gets the students excited about the reading and education journey they are about to begin. The ceremony changes annually to maintain student interest. Last year, high school students participated in the kick-off ceremony and helped to initialize the program. They created and laminated the mural for year-after-year use, and created 3-D components for visual interest. High school students also performed a salmon life-cycle skit for the entire elementary school as part of the opening ceremony. They created props, costumes, and the stage backdrops for the skit.

Through the process I mentored the high school students to convey my vision of the program. This included helping with the mural design and specifications, their play script, costume designs, and other play and Reading Challenge components. The rest of the details were then in the hands of the students, bringing the vision to life. The large (28'W x 10'H) mural they created accurately portrayed the mountain ranges, glaciers, rivers, tributaries, near shore, ocean environment, townships, Native villages, commerce, etc. Students who created the mural researched the features associated with this region to create a realistic representation. Pictures, labels, etc. identified these points of interest.



A high school student enacts the alevin emerging from egg.

As they became involved, they took ownership and pride in their work, far surpassing my expectations. The lead high school teacher arranged for the appropriate class time needed to execute the project. Since the project was thematic, she was able to work this into her high school Curriculum Standards as well. In the end, both the elementary and high school students benefited from this thematic-based curriculum approach.

The Port Gamble S'Klallam Tribe's Canoe Club kicked-off this year's ceremony by opening the program with traditional songs, stories, and dancing. The Coastal Tribes of the Pacific Northwest have a long cultural history with salmon. Annually, almost all Tribes from Alaska to Oregon celebrate the return of the *First Salmon*. Their canoes are fashioned like salmon and are traditionally built, modeling the salmon's streamline formed body. Salmon are also a valuable subsistence and trade commodity among their people, and have influenced songs, dance, stories, totemic art, and clan identity. Even the vertebrae of the salmon are used in their traditional regalia. Having the Tribe come to bless and open the ceremony for the reading program inspired both Native and non-Native youth to have a better understanding of the Coastal Tribes. The S'Klallam Tribe's relationship to salmon has existed for thousands of years. The Tribe's presence at the opening ceremonies presence prompted students to learn more about the Native culture.

Growing through the stages

As the students in the reading challenge "migrate" from the local creek where they will be releasing their own salmon, they travel past the geographic features illustrated on the mural map. They pass through various biomes, from the forest to the estuarine, and to the ocean. They learn about the food chain and the interconnectedness of all the biotic and abiotic components associated with wild salmon ecosystems. They learn about the life stages, physiology and biology of salmon and about the migration challenges they face on their journey. Additionally students learn about the associated economic, social and historic value of salmon and about geography and culture of the region as they journey pass the coastal terrain and Tribal Nations.

During their mural migration, students also advance in their developmental life stages (egg, alevin, fry, parr, smolt, 1-, 2-, and 3-year adult, and 4-year spawning adult). At the end of the program, all of the students are winners at different levels and stages of development. In a school-wide assembly, each student receives a certificate of achievement and a medal for the level earned based on their individual reading progress. In general, about half of the students make the full journey and achieve their gold medal, averaging approximately 34 minutes read daily.

Students use math on a daily basis to calculate their reading minutes and the distance their paper salmon can swim. In their classrooms, students move their own salmon, graphing their individual progress. Additionally, each grade level competes to see which species will reach their migration/reading goals first. These levels are designated as a particular species of salmon. Each grade has a large wooden salmon representing their entire grade level class. These representations of different species of fish are constructed from 8' sheets of plywood, and were also created by high school students who researched salmon and their life stages to accurately portray specific species as mature, spawning adults.

Classes graph their reading progress by dressing their "naked" fish with blank CDs representing fish scales. Scales are hot-glued onto the salmon when specific reading benchmarks are achieved. This idea creates a unified theme across grade levels and opens a friendly, school-wide competition. Additional math-related connections are limited only by the imagination of the teacher, as math is easily integrated with science.

The program creates opportunity for learning in multiple science areas. Topics include everything from water and water quality testing, to watershed awareness and understanding the forest, riparian and wetland habitats. Students can learn about taxonomy and scientific classification, or even create botanical keys as their migration journeys pass different biomes. Student- and teacher-inspired research may lead students to an understanding of animal and plant adaptations, species succession, or investigative discovery including: vegetation layers, fauna, and fungus. Other critters associated with wild salmon ecosystems include those in microbial matter, insects and stream bugs, amphib-

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Used CDs are scales marking progress on each class's salmon.

ians, fish, reptiles, birds and mammals. Studies can also include plant and animal dissections, observations through drawings, analyzing and other hands-on inquiry-based investigations.

Extensions into science

One science extension is benthic investigations through in-field stream kicks. Students get into the stream or estuary and literally kick at the substrate, sending it downstream towards the kick net held by other students, also in the water. The benthos, which is the aggregate community of organisms living on or at the bottom of a body of water, serves an important role as a food source for fish. Identifying what is living in the water not only shows students what salmon eat, it also indicates the quality of the water, as not all bugs are tolerant of poor water quality conditions.

An excellent children's book describing this food web connection is well articulated in the book *Salmon Forest,* by David Suzuki and Sarah Ellis. This benthic activity can be extended into other activities, such as water quality sampling, or through physical games like Macro-invertebrate Mayhem (a PROJECT WET activity). Acorn Naturalists is a valuable resource where I get almost all of my teaching supplies. I highly recommend this supplier to every K–12 educator.

Another extension is creating a model biome in the classroom. Suspend a long run of blue bulletin board paper from the ceiling and attach stuffed paper fish (to scale) dangling from a string, aquatic plants, drawings of aquatic, and other components in stream or estuarine, oceanic ecosystem that the students created. These ecosystem components can be researched on the Internet, or by actually getting out into the field and experiencing nature first hand.

Integrating local subjects of interest into your school's curriculum will not only inspire the students to learn more about something they are already familiar with, it will open the door to use outside resource professionals. Many of these folks have well-developed K–12 activities, and are willing to share their knowledge and expertise at little or no cost. While ITUs do not replace the need for texts and worksheets, teachers who embrace a more hands-on and inquiry-based teaching approach will engage and inspire students in standards-appropriate education. Some critics may argue that not all kids are going to grow up to be professionals in Natural Resources or related science fields; regardless, it is important that all students have a holistic understanding of ecosystem interconnectedness and the impact they individually have on the environment. As educators, we must remember that these children will grow up becoming the decision makers in a world of ever-dwindling natural resources. ✐

S'Klallam dancers honor salmon at the school-wide commencement of the reading challenge.

It is important that all students have a holistic understanding of ecosystem interconnectedness.

Studying macro-invertebrates in a freshwater stream

Fresh vs. Salt

An Experimental Meltdown

Which melts ice faster, fresh water or salt water?

To find out, we prepared two jars with 700 ml of water. One we filled with tap water, the other with tap water *and* ¼ cup of kosher salt. (We used about one cup of hot water to dissolve the salt first, then added the remaining cold water.) When the salt dissolved and the water in both jars was the same temperature, we added equal amounts of ice to each jar.

Within 3 minutes, most of the ice in one of the jars was melted. The other jar's cubes looked nearly the same as when we added them. Which one? Try it and see. We were surprised that the salt water melted the cubes *much* more slowly. After all, don't people use salt to melt icy sidewalks and roads?

As another trial, we put one dot of food coloring on the tops of three cubes of ice in each jar. They behaved very differently! The food coloring eventually dispersed throughout the fresh water. But even an hour later, the coloring sat on the surface of the salt water. What does this mean about the relationship of fresh to salt water? There are many opportunities to study salinity, buoyancy, and density. For more experiments with salt water, see the GEMS *Ocean Currents* guide (reviewed inside on page 20).

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