Flotsam & Jetsam

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MARINE ALGAE

THE SEAWEEDS OF MASSACHUSETTS

By Gil Newton

The word *seaweed* refers to a group of marine organisms called macroalgae. Though they often resemble plants, technically these organisms belong to a different kingdom called the Protista. True plants have vascular tissue (xylem and phloem) for the transport of water, sugars, and minerals. Algae lack these specialized tissues though they do photosynthesize, making their own food using sun energy and chlorophyll. Algae do not have true leaves, stems, roots, flowers, fruits, or seeds. They have structures which resemble these familiar plant parts and even carry out similar functions. Thus, we describe an alga's leaf-like blade, its stem-like stipe, and its root-like holdfast.

Reproduction in algae can be by asexual methods—such as fragmentation (a new alga growing from a piece of the parent), or spore production—or sexual methods in which male and female gametes are released into the water for fertilization.

The seaweeds are divided into three main phyla, or divisions, based on the different color pigments in their cells. The first phylum is the green algae (*Chlorophyta*), and one of the most recognizable seaweeds along the upper region of the shoreline is sea lettuce (*Ulva lactuca*). This green alga consists of large sheets that fold along the edges, much like salad lettuce. *Ulva* grows in a variety of habitats that include bays, estuaries, salt marshes, and the intertidal zone. This species has blades that are two cell layers thick and can grow up to three feet in length. There is a small, inconspicuous holdfast, though many specimens are found floating. Sections of sea lettuce sometimes break apart from the main alga and can continue to grow by fragmentation. The life cycle is an example of an alternation of generations between a diploid and haploid stage. An interesting feature is that these two stages are morphologically identical.

This is sea lettuce (*Ulva lactuca*), the green alga.

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If you have difficulty accessing this journal, contact the editor at dimmick@esteacher.org . The next issue of *F&J* will be posted on the website on March 5.

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2017 MME Winter Calendar

Check the website and F&J for details

JANUARY 11, 2017
MME Board Meeting
National Marine Life Center
Kathy Zagbebski host
kzagzebski@nmlc.org

MARCH 1, 2017
MME Board Meeting
New England Aquarium
Kara Mahoney Robinson, host
kmrobinson@neaq.org

MARCH 9, 2017
High School Marine Science Symposium
Northeastern University
Information in this issue

MARCH 15, 2017
High School Marine Science Symposium
Salem State University
Information in this issue

APRIL 8, 2017
Woods Hole Conference and Annual Meeting

All MME Members are invited to Board Meetings.
Let the host know if you are coming.

The Hidden Life of Seaweed

By Annie Evankow, Collections Associate at Ocean Genome Legacy,
Northeastern University Marine Science Center http://www.northeastern.edu/ogl/

This is the story of one seaweed scientist who unknowingly saved the nori industry and made it possible for sushi to become a global food.

Sheets of seaweed, known as nori, are today used by chefs around the world to wrap rice, vegetables, and fish in sushi rolls. Nori, however, was not always so cosmopolitan. Before the 1950s, farmers struggled to grow the seaweed reliably and thus called it *gambler's weed*. No one knew how to plant nori, because seaweeds do not produce seeds like land plants. It would have been impossible to grow enough nori to meet the world's current demand before Kathleen Drew-Baker, a seaweed researcher, discovered its complex life cycle and the secret to producing nori anytime of year.

Nori sheets are made from a species of red seaweed, known to biologists as *Porphyra*. The lettuce-like blades are harvested, cleaned in fresh water, cut up, and set out to dry on racks, producing a paper-like dry sheet. There are several species around the world. Drew-Baker focused her research on a species native to England, known as laver. Although seaweed was not eaten as often in England as in Japan at the time, laver was used to make bread and soup. Nori and laver are valued for their rich content of protein, iron, fiber, and vitamins A, B, and K. Both species also have the same complex life cycle, as they switch life forms from a visible red blade to a hidden pink crust, only found in shells. It is the alteration of life stages that confounded farmers and made cultivation unpredictable, until Drew-Baker's discovery.

Although it appears dark green after processing, nori is a species of red seaweed. The red color comes from an abundance of the pigment, phycoerythrin. Unlike plants, seaweeds do not reproduce using seeds. They also lack roots. Instead, they have a bundle of root-like structures, called holdfasts, that secure them to surfaces. In Japan, farmers today grow seaweed by setting out nets that the nori can cling to and grow. The nets are simply lowered into the places in the ocean with enough nutrients and sunlight for the seaweed to flourish. The biggest threat to the annual nori harvest are epiphytes, other marine organisms that grow on seaweed. These epiphytes block sunlight and compete for resources. The nets are raised and lowered, following tidal patterns to reduce growth of bacteria and other seaweeds on the nori blades.

Kathleen Drew-Baker discovered that the red lettuce-like appearance of nori is only one stage of a complex life cycle. Similar to metamorphosis, the nori changes shape and appearance during half of the year. Its other life stage was first classified as a separate species, known as *Conchocelis*. Drew-Baker observed the blade-like nori under her microscope and determined that it produces gametes, that when fertilized, grow into a tiny pink crust hidden inside mussel shells. Nori takes on its pink crust life stage in the warm summer months, when the leaf-like stage would be eaten by herbivores and there are few nutrients in the environment. Through this process, it produces new individuals

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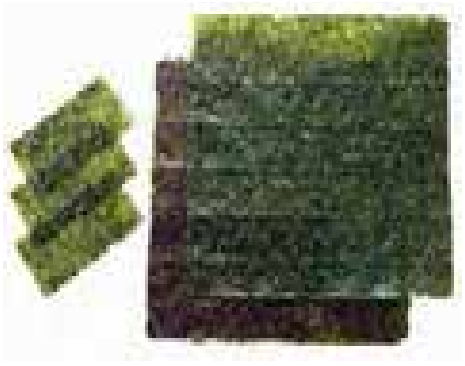
Sushi rolls wrapped in nori.
Photo: Wikimedia commons/Susan https://commons.wikimedia.org/wiki/File:Homemade_sushi_rolls,_2009_(2).jpg

Blade life stage of *Porphyra*, commonly known as nori or laver.
Photo: Wikimedia commons/Laurent Breillat https://sco.wikipedia.org/wiki/File:Porphyra_umbilicalis.jpg



Nori sheets
Photo: Wikimedia commons/Alice Wiegand https://commons.wikimedia.org/wiki/File:Nori.jpg

Crust life stage of *Porphyra,* grown inside shells in greenhouse.
Photo: The Seaweed Site http://www.seaweed.ie/aquaculture/nori-cultivation.php

President's Message

Dear Members,

This issue of *Flotsam and Jetsam* focuses on seaweeds with an article on the anatomy and life cycle of seaweeds by Gil Newton, as well as an activity for your students. Gil's book, *Seaweeds of Cape Cod Shores: A Field Guide* is a useful tool for identifying local seaweeds both in the field and classroom. The article by Annie Evankow from Northeastern University Marine Science Center spotlights Katherine Drew-Baker, a British Phycologist who discovered the complex life cycle of Nori. Nori is the red lettuce-like seaweed used by chefs around the world to wrap sushi rolls. Drew-Baker conducted her research in the early 1900s. She founded the British Phycological Society in 1952 and became its first president. From 1922 into the 1950s, Drew-Baker conducted research on seaweeds, publishing 24 professional papers. Sharing this article with your students and discussing Drew-Baker's work highlights a successful role model for girls interested in STEM careers.

Massachusetts Marine Educators continues to provide opportunities to enhance your science curriculum with marine science content and classroom activities that meet the revised Massachusetts Science and Technology/Engineering Standards. On October 1, over 60 educators attended the Boston Harbor Educators Conference for an exciting day of speakers, workshops, and field trips. Thanks to Peg Collins and her dedicated committee for putting together another great conference.

We hope you are planning to join us this Spring for one of the 2017 High School Science Symposia. This year's symposia are scheduled for Thursday, March 9 at Northeastern University and Wednesday, March 15 at Salem State University. Both symposia feature an engaging line-up of speakers and will enable your high school students to interact with professionals in the fields of marine science and oceanography. Details and registration information for the symposia are included in this issue of *F&J* and can also be accessed on the MME website (http://ma-marine-ed.org/mmeevents/high-school-marine-science-symposium/). The MME Annual Meeting is scheduled for Saturday, April 8 at the Woods Hole Oceanographic Institution, so mark your calendar for this event as well. We are looking for volunteers to help with the Annual Meeting; this is a great opportunity to become more involved with your association and work with other dedicated members. If you would like to volunteer, please get in touch with conference chair Anne Smrcina at president-elect@ma-marine-ed.org.

We look forward to greeting you at the MME events this Spring.

Sandi

Fish Vulnerability in an Era of Climate Change

Stressors and impacts

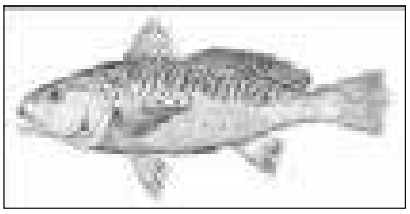
As the Atlantic Ocean warms, many marine species—including commercially important fish stocks—are moving further north along the Northeast United States. As a consequence, fishing boats based in traditional ports need to travel further to catch the same fish, or change their strategy to pursue different species of fish. In turn, businesses that serve fishing communities may need to purchase new equipment, develop new practices, or encourage workers to gain new skills. In order for fisheries and the businesses that depend on them to prepare for such changes, fisheries managers need tools to identify which fishery resources may be most vulnerable to our changing climate.

NOAA Fisheries scientist Jon Hare carries baskets of fish during the 2006 winter trawl survey on the Northeast US continental shelf. This annual survey started in the 1960s and has been instrumental in documenting changes in fish distributions over the last four decades.

Making meaning of data

Dr. Jon Hare, a scientist at NOAA Fisheries, has spent 25 years researching the impacts of the environment on fish species. From his home base in Narragansett, Rhode Island, he spends several days per year on research cruises, trawling for fish and documenting the details of the catch. He records the species, number, size, and age of fishes as well as information such as the location, depth, and water temperature in which the fish were caught. For every day spent on a research cruise, Hare spends many more days in front of a computer, analyzing the data.

Hare's careful research on the Atlantic croaker—a silver fish popular with recreational anglers offshore of the mid-Atlantic states—indicated that warming waters would decrease mortality among young croakers over time, leading to an increase in their numbers. A team of fisheries experts performed similar research to predict how climate change will affect cusk, a bottom fish that is caught incidentally in several New England fisheries. As cusk habitat is projected to decrease in response to warming ocean temperatures, the team determined that their numbers should decline over time in the study region.



Atlantic croaker

Cusk

Both of these studies provided solid scientific information about the future of a single species. However, to manage an entire ecosystem, fisheries communities need similar analyses for all the managed species. As the study of a single species takes multiple years, and the region contains more than 50 managed species, it was unrealistic to think scientists could characterize the potential effect of climate change on all fisheries and protected species in the region. With so many species to study, the answers would come too late to inform management decisions that could boost the resilience of the most vulnerable species.

Expanding studies to develop a methodology

In order to provide the information fishery-dependent communities need, NOAA Fisheries organized a group of experts to consider more efficient ways to characterize the vulnerability of many species at the same time. Their goal was to come up with a method that would enable them to predict which species in an ecosystem would be most to least vulnerable to climate change.

Based in part on lessons learned from the studies of individual species, and drawing upon expert opinions to look across multiple fish and invertebrate species, the group came up with a vulnerability assessment methodology for understanding how populations across the ecosystem might change in response to warming trends. To check its effectiveness, Hare implemented the methodology in his own research area.

Two years into the study, scientific results now offer estimates of the relative vulnerability of 82 species of fish and invertebrate species in the Northeast U.S. continental shelf ecosystem. Fisheries scientists can access the information to help them identify species that might benefit from more

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From the Editor's Desk

The holiday season is past and we are into the cold days of winter. Members of MME do not let winter slow them down. We are busy preparing for our upcoming spring events. In this issue, you will find the announcement for the Annual Art contest. The theme this year is "Exploring the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary."

Our two High School Marine Science Symposium programs are coming in March. The high school events fill up quickly and if you are planning to attend, please check the MME website later this month when the registration materials are posted: http://ma-marine-ed.org/mmeevents/high-school-marine-science-symposium/.

It is not too early to plan for our 2017 Woods Hole Conference and Annual Meeting on Saturday, April 8. The committee is hard at work planning for this event and will post information on the website very soon.

The Annual Meeting also reminds us that annual elections will be held at the meeting. There are Board positions open this year. If you would like to join the Board please contact our President Elect and Elections Chair, Anne Smircina at president-elect@ma-marine-ed.org

This issue is dedicated to seaweeds and marine algae. Gil Newton, director of the Sandwich STEM Academy and an MME Board member has given us an article and a classroom activity dealing with the subject. Gil is the author of *Seaweeds of Cape Cod Shores – A Field Guide,* now in its third printing. This 35-page illustrated guide is available at the Cape Cod Museum of Natural History, www.ccnhm.org. Too often we forget about the role that these organisms play in the marine food chain. A second article about the life cycle of seaweed by Annie Evankow at the Northeastern University Marine Science Center is also in this issue.

Carleton College has recently produced a six-unit module about the importance of oceans, basic ocean processes, and their impact on human activity. Although it is designed as an undergraduate course, much of the material can be adapted for environmental science and marine biology courses in high schools. Take time to check out the module on the website.

Marine Science in the News and a climate change article from other sources have also been added to our winter issue. I hope you enjoy this edition of *Flotsam and Jetsam*.

Howard Dimmick
Editor

Massachusetts Marine Educators' Boston Harbor Educators Conference Changed the Tide for 21st Century Learners

On October 1, 2016, Massachusetts Marine Educators' (MME) annual Boston Harbor Educators Conference, *Celebrating Boston Harbor: Changing the Tide for 21st Century Learners,* was attended by teachers from across the state as well as the Museum Institute for Teaching Science (MITS). Participants were able to build professional connections while gaining insight into uses of Boston Harbor as an educational resource.

Keynote Speakers

The day began with keynote speaker Giles Parker, Superintendent of Boston Harbor Islands National Recreation Area, who discussed the history and expansion of National Parks and highlighted how the National Park Service (NPS) strives to keep protected lands in the forefront of American culture. For example, the *#FindYourPark* initiative (http://findyourpark.com/) celebrates 100 years of the National Park Service by prompting citizens to locate their local park and share their experiences as inspriational stories on social media.

Liza Stearns, Director of Education at NPS of Boston, began her keynote, *Engaging Youth and Community through Place-based Service Learning*, by briefing the audience on the use of field locations to enhance learning outcomes. Stearns described how National Parks of Boston is working with Boston Public School teachers and community partners to develop experiential, place-based programming celebrating Boston's Harbor Islands. She encouraged participants to identify and share ways the NPS might better implement local and collaborative K-12 place-based programming. More information about this presentation is available on the MME website (http://ma-marine-ed.org/mmeevents/boston-harbor-educators-conference/).

Workshops

Workshops highlighted marine science topics—oceanography, climatology, coastal development, and resource management. Educational Passages, a project based in Maine that educates youth about ocean sciences, inspired teachers to engage students by designing miniature sailboat drifters with oceanographic monitoring tools. Teachers learned to tell the story of climate change using comic tiles, and then they got their feet wet with ocean engineering activities in a workshop led by the New England Aquarium. Sea Education Association, leader in undergraduate ocean education, compared environmental impacts of long-term versus short-term shoreline development and reviewed methods to mitigate effects of erosion and pollution. Middle school teacher, Kathryn Buckley, taught us how to use cod population data estimates to calculate expected economic outcomes of cod fishing, and the Massachusetts Water Resources Authority presented "Dwayne the Storm Drain" activities that teach children about stormwater management systems.

By the end of the day, conferees had acquired a greater appreciation of Boston Harbor, its rich history, and the many resources it provides to educators and the community. Educators who attended will bring the science and history of Boston Harbor back to their classrooms in creative, engaging ways. ⚓

Seaweeds of Massachusetts

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Sea lettuce is adapted to a wide range of salinity and nutrients. It is one of the algae species that grows abundantly in areas of excess nitrogen runoff. Consequently, its presence can be an environmental indicator of poor coastal water quality. Nitrogen acts as a fertilizer and can have a serious impact on the health of aquatic ecosystems. The affinity sea lettuce has for nitrogen can be put to good use; it could be employed to absorb excess nitrogen near sewer outfalls or fish farms and then applied to gardens to enrich the soil. This natural form of wastewater management will probably not be applied to wide areas, but could be used in smaller, localized situations.

Ulva is also an edible seaweed. Traditionally, it is cut up and used in soups and salads. Sea lettuce is high in iron, iodine, and vitamin C. It's about 15% protein and less than 1% fat. In many parts of the world including Scotland and China, sea lettuce is harvested directly from the sea. It should be washed thoroughly to remove any small marine animals. Also keep in mind that it does grow abundantly in areas of high concentration of nutrient runoff.

The second group is the brown algae (Phaeophyta) and there are several common local species represented here. One of the most visible is rockweed (*Fucus vesiculosus*), which grows in the muddy banks of salt marshes as well as on hard substrates such as jetties and pilings. The general characteristics of rockweed are easy to identify. The brown, forked branches have pairs of small air bladders along the midrib of the frond, which help the alga float in the water. The alga is attached to a hard surface by a strong holdfast. Sometimes the tips are swollen with small bumps containing the reproductive conceptacles. The male conceptacles release motile sperm cells in the water when the tide comes in. The female conceptacles release the egg cells that are carried by water currents. A single sperm cell fertilizes an egg cell and the resulting zygote settles down on a solid surface. It then grows into a new adult rockweed.

Picture is rockweed (*Fucus*).

Ecologically, rockweed has many functions. It forms a kind of canopy protecting ribbed mussels, barnacles, and other small animals during low tide. Some invertebrates and small fish graze on rockweed while other species—such as periwinkles—scrape microscopic diatoms and bacteria from the fronds. When the rockweed dies, it decomposes and breaks up into small organic bits of food, becoming detritus. This gets swept up by the tides and currents and transported to other areas as a source of nutrition.

Though rockweed is brown, due to the presence of the pigment fucoxanthin, it can photosynthesize and is a primary producer in the environment. Therefore, it also releases oxygen and absorbs carbon dioxide. Physically, rockweed helps prevent erosion along the banks by reducing the impact of wave energy. Examine a small piece of rockweed with a hand lens and you may see the young larval stages of many animals, as well as tiny tube worms and encrusting bryozoans.

Related to *Fucus* is another rockweed species called *Ascophyllum nodosum* or the knotted wrack. This robust species makes up what is commonly called the wrack line and is attached to a rock jetty or other hard surface. Knotted

This is the knotted wrack (*Ascophyllum nodosum*)

wrack is one of the largest rockweeds and can grow up to three feet long. The fronds are characterized by several large and single air bladders (pneumatocysts), but have no distinct midrib like in *Fucus*. The pneumatocysts give the alga buoyancy during high tide. This ability to float exposes a greater surface area for the fronds to increase photosynthesis.

Ascophyllum is an important seaweed for other forms of marine life. Many small organisms such as snails, sand hoppers, and crabs find shelter under its fronds. This provides them with protection from predators and desiccation at low tides on warm days. And like other brown algae, the knotted wrack produces a substance called algin, which is used in a variety of commercial products as an emulsifier or thickener. From puddings to ice cream, the alginates are an important additive to food products.

Traditionally this seaweed is an excellent one for clambakes. A pile of *Ascophyllum* contains enough moisture to provide the steam in cooking clams and vegetables. This ability to retain moisture also makes it a suitable packing material for lobsters and other seafood. Unfortunately, some areas have been stripped of *Ascophyllym* for this purpose. Care must be exercised to harvest this resource sustainably, so that it can replenish itself naturally.

There are many representatives of the third group, red algae (Rhodophyta) in

This picture is coral weed (*Corallina officialis*).

Massachusetts waters, and one of the most interesting examples is the coral weed *Corallina officinalis*. This red alga is found near jetties and tide pools where it is attached to shells and rocks. I have found it frequently growing on the shells of periwinkle snails. One unique feature about this alga is its ability to remove limestone (calcium carbonate) from the water and deposit it on their fronds. When alive, *Corallina* is pink to purple in color, but bleaches white when it dies. Examine it with a hand lens and you can see that the alga is jointed with flexible areas free from lime. This allows it to move back and forth in the waves without breaking. It can grow up to six inches in length and looks like tiny bones under a microscope. There is a small disc-shaped holdfast that attaches to solid objects.

Like other red algae, *Corallina*'s life cycle includes male and female reproductive structures which release their gametes for fertilization. Following this, specialized spores are released that form a structure called a tetrasporophyte. This results in a reduction division: haploid spores are released and female and male algae form.

The most obvious question is, how do these organisms stay alive when covered in limestone? After all, *Corallina* are photosynthetic; sunlight needs to reach their tissues. And what is the evolutionary advantage of this ability to calcify? Most scientists believe that enough light penetrates the armored layer to allow photosynthesis to take place. The limestone coating possibly discourages animals from grazing on their soft tissues, though sea urchins—which need the lime for their shells—may consume the coralline algae.

Other attractive red algae include some very useful species. The next time you eat ice cream, brush your teeth with toothpaste, or paint your living room, keep in mind that you might be using a product that has seaweed in it. That is, you might be using an extract from red algae called *carrageenan*. This could have come from a common seaweed that grows in many parts of the world, Irish moss (*Chondrus crispus*).

Irish moss grows in large populations and is attached to rocks and the substrate by a small disc-shaped holdfast. This alga is deeply red to purple, though it may be yellowish-green if exposed to direct sunlight for long periods of time. The blades are up to four inches long and dichotomously branched. It usually grows in the lower portions of the intertidal zone.

Irish moss is a red alga and not a moss. It was a staple of the Irish diet during the potato famine and Irish immigrants were the first to harvest it in Massachusetts. A large mossing industry developed in Scituate, Massachusetts in the mid-1800s and continued through World War II. The harvesting of Irish moss using long iron rakes was another way of earning a living by the sea. Even today, a seaweed pudding is made using Irish moss along with some milk, sugar, salt, and vanilla extract.

This is Irish moss (*Chondrus crispus*) which is red algae

This is also Irish moss mixed with knotted wrack (*Ascophyllum nodosum*) which is an example of brown algae.

The world of marine algae is endlessly fascinating for many scientific reasons, but we cannot overlook the fact that algae are also among the most aesthetically pleasing marine inhabitants when seen in their natural habitats. ⚓

About the Author Gil Newton is the Director of the Sandwich Stem Academy. He is a member of the MME Board and the author of several books dealing with the unique aspects of Cape Cod habitats and their ecological systems. He holds Bachelor and Master of Science degrees in biological science from Florida State University. He has taught in the Sandwich Public schools since 1981 and has served as an adjunct professor at Cape Cod Community College and Bridgewater State University.

Save the Seaweeds

(From *Seaweeds of Cape Cod Shores* by Gilbert Newton)

Many common types of seaweeds can be preserved for future reference and study. This method can also be used for various arts and crafts projects using seaweeds, and the materials needed are quite simple. The easiest ones to preserve are the stringy, flat, or filamentous forms. The large, thick seaweeds require more complex methods for preservation.

ACTIVITY:

1. Visit the beach and look for thin, filamentous seaweeds that have washed up, or are present at the water's edge.
2. Make sure that the algae still retain their color. Algae will bleach out their pigments if exposed to the sun for a long time after being stranded on the beach.
3. Collect several of the samples in a bucket, and fill the bucket half-way with sea water.
4. Back in the classroom, or at home, obtain a tray or pan large enough for the seaweed to spread out.
5. Fill the tray with sea water and float the specimen in it.
6. Use a thick sheet of paper, such as official herbarium stock, oak tag, or even a large index card.
7. Place the paper in the water and under the seaweed.
8. Slowly raise the paper so that the alga is picked up.
9. Carefully drain the excess water from the paper.
10. Using a medicine dropper, squirt water around the seaweed to arrange it the way you want to see and remove small pieces and debris that may remain.
11. Cover the specimen with cheesecloth or wax paper.
12. Place between several sheets of newspapers, and place several large books on it. (Note: Small plant presses can be purchased for this stage as well).
13. The newspapers should be changed the next day because they absorb the water.
14. In 2–3 days, carefully peel off the cheesecloth or wax paper, and the seaweed will remain stuck to the herbarium paper.
15. You should label your specimen with information that includes its name, habitat, and date of collection.

InTeGrate

InTeGrate is pleased to announce the publication of the complete ***Ocean Sustainability*** module on the InTeGrate site**:** http://serc.carleton.edu/integrate/teaching_materials/sustain_ocean/index.html

A 2 to 3 week module developed by Michelle Kinzel, Southwestern College; Cara Thompson, Santa Monica College; and Astrid Schnetzer, North Carolina State University, introduces the importance of oceans, basic ocean processes, and impacts of human activity on ocean health. It aims to increase awareness of our dependence on and responsibility for the largest habitat on Earth. Materials encourage systems thinking by addressing physical, chemical, geological, and biological aspects of the oceans. Students study the oceans from these multiple perspectives using scientific data and engaging activities designed to support higher- level thinking. One of the primary goals of this module is for students to understand the role that humans play in altering marine systems and their inhabitants and to recognize the power we have as individuals and a society to work toward practices that will sustain our ocean.

Ocean Sustainability is a great fit for courses in oceanography, environmental science, physical geography, marine biology, sustainability courses and marine science courses.

This module is part of a growing collection of classroom-tested modules and courses developed by InTeGrate. The materials engage students in understanding the Earth system as it intertwines with key societal issues. Prior to publication, this module was successfully used in three different courses at three different institutions. Full materials for faculty support, adoption, and individual notes/stories from pre- publication classroom practice are available to illustrate a full range of teaching environments.

The collection is freely available and ready to be adapted by undergraduate educators across a range of courses including: general education or majors courses in Earth-focused disciplines such as geoscience or environmental science, social science, engineering, and other sciences, as well as courses for interdisciplinary programs.

Through the development of these modules InTeGrate (Interdisciplinary Teaching about Earth for a Sustainable Future), strives to infuse Earth literacy across disciplines, engage younger students in the geosciences, and develop a new vision for how geoscience is positioned in higher education. For more information on InTeGrate, please visit our website at: http://serc.carleton.edu/integrate/index.html

Contact: Krista Herbstrith, Science Education Resource Center • 507-222-5634 • kherbstr@carleton.edu

Fish Vulnerability in an Era of Climate Change

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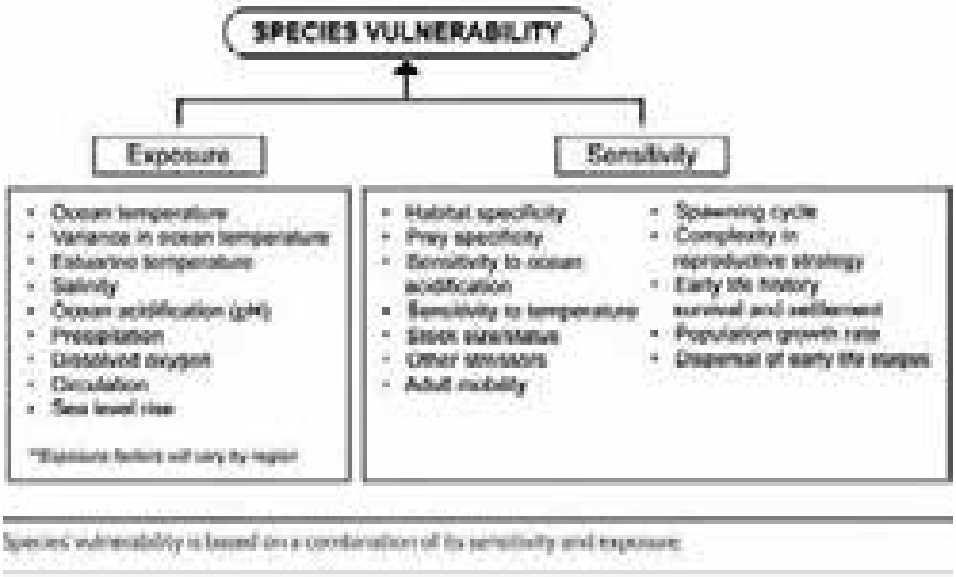

Species vulnerability is based on a combination of its sensitivity and exposure.

in-depth research. Fisheries managers can also use the information to help them decide if current management of vulnerable species should be adjusted. Finally, fishermen in the region, and the businesses they work with, can check which species have relatively high vulnerability to environmental changes, and use that information to prepare for the future.

Story Credit: Adapted from: Hane, JA, WE Morrison, MW Nelson, MM Stachura, EJ Teeters, RB Griffis, et al. 2016. A vulnerability assessment of fish and invertebrates to climate change on the northeast US continental shelf. PLoS ONE 11(2): e0146756. doi: 10.1371/journal.pone.0146756.

Hidden Life of Seaweed

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that hibernate, protected in shells over the summer months. When the weather cools down and the days grow shorter, the pink crust produces spores. The spores drift out on the currents, seeking a suitable place to cling to and grow into a new generation of red blades. These are the spores that nori farmers were trying to catch with their nets.

A few years after Drew-Baker's paper was published in *Nature*, a Japanese researcher, Fusao Ota, made the same discovery in Japan. The farmers were then able to use shells to "seed" their nori harvests, revolutionizing the industry. The lettuce-like nori release gametes when the days grow longer and the temperature increases. Farmers collect the nori by setting out shells. The gametes fuse, form zygotes and grow into the pink crust life stage. The shells can then be kept in controlled water tanks, and used to produce spores by artificially decreasing the light exposure and temperature, mimicking the climate in autumn. With this process, farmers are able to reliably cultivate and harvest nori multiple times each year.

Kathleen Drew-Baker did not set out to revolutionize sushi. Born in 1901 in England, she could have been my great-grandmother. Drew-Baker began her career as a researcher in 1922, with a degree in botany from the University of Manchester. She continued as a research assistant, and received a prestigious Commonwealth Fellowship to study at the University of California Berkeley for two years. Everywhere she lived and traveled, she collected specimens of seaweed for her personal herbarium. Drew-Baker also spent a lot of time looking into the microscope. Her largest contributions to phycology, the study of seaweed, focused on red seaweeds.

Kathleen Drew-Baker with her microscope.

Wikimedia commons https://upload.wikimedia.org/wikipedia/commons/3/35/Kathleen_Mary_Drew-Baker.jpg

Kathleen Drew married Professor H. Wright Baker in 1928. Due to regulations prohibiting married women from paid work at universities, Drew-Baker became a Research Fellow and continued her investigation of seaweed at home. Her husband set up saltwater tanks, where Drew-Baker could disentangle the systematics and life histories of red algae species. Drew-Baker received her PhD in 1939. During her career, she published 24 papers and became the first president of the British Phycological Society.

Of all of her research, Drew-Baker is best remembered for the paper published in *Nature* in October of 1949. The article, "*Conchocelis*-Phase in the Life-History of *Porphyra umbilicalis*" revealed her discovery that the red seaweed *Porphyra* is connected to what was believed to be a separate species, *Conchocelis*. Sadly, Drew-Baker passed away before she knew the true significance of this discovery for the nori farming industry.

She never traveled to Japan or tasted sushi, but for the last 50 years she is honored every year with a festival as "Mother of the Sea" in Osaka, Japan.

Further Reading

Calder, M. 1957. Obituries: Dr. Kathleen M. Drew. *Nature* 180: 889-890.

Drew K.M. 1949. *Conchocelis*-phase in the life-history of *Porphyra umbilicalis*. *Nature* 164: 748-749.

Harris, C., K. Matsuda, and D. Sattelle. 2013. Dr. Kathleen Drew-Baker, "Mother of the Sea", a Manchester scientist celebrated each year for half a century in Japan. *Bioessays* 35: 838-839.

Annie Evankow is the Collections Associate at Ocean Genome Legacy (OGL) at the Northeastern University Marine Science Center. Annie earned her bachelor's Degree in biology from Colorado College and her master's degree in ecology and evolution from the University of Oslo, Norway, where her research focused on population genetics of kelp forests. Annie is currently harnessing her expertise in marine algae to help the Ocean Genome Legacy expand the seaweed specimens in the marine biorepository. While not collecting and processing marine samples for OGL, Annie enjoys spending time outdoors, volunteering at science outreach events, and trying out new seaweed recipes.

The Massachusetts Marine Educators have been hosting a High School Marine Science Symposium since 1984. This event attracts hundreds of high school students and their teachers to come together and learn about research and practice around marine science topics and issues.

Both symposia feature keynote speakers in a plenary format as well as hands-on break-out workshops led by scientists, policymakers, graduate students, and others engaged in marine-related careers.

The event is co-sponsored by Northeastern University and Salem State University. The Northeastern University Marine Science Center is coordinating the two programs.

Registration will open mid-January 2017. Please see: http://ma-marine-ed.org/mmeevents/high-school-marine-science-symposium/

SAVE THE DATE for the 2017 High School Marine Science Symposium!

Thursday, March 9, 2017

Northeastern University in Boston

Keynote: Heather Goldstone, WGBH Science Reporter

Wednesday, March 15, 2017

Salem State University in Salem

Keynote speaker: David Wiley, Research Coordinator, Stellwagen Bank Marine Sanctuary

Both events will run from 8:30am to 1:00pm

Visit our website for more information, and to register to present a workshop or bring your students: www.ma-marine-ed.org

HIGH SCHOOL TEACHERS

Join us with your students to meet dozens of local experts as they share their knowledge, skills, and passion for marine science-related research and practice. Each symposium will feature two hands-on workshop sessions, lightning fast talks, and a keynote presentation. Registration materials will be available in January. This event is sponsored by Northeastern University's Marine Science Center and the Massachusetts Marine Educators (MME), with additional support from Salem State University and from many dedicated volunteer presenters. Registration will open Mid-January 2017. Please see: http://ma-marine-ed.org/mmeevents/high-school-marine-science-symposium/

CALL FOR PRESENTERS

Scientists, educators, resource managers, environmental planners, facilitators of citizen science, and others working in marine-related fields are invited to inspire the next generation by presenting hands-on workshops to high school students. Presenters can participate in one or both events, and will deliver two identical 50-minute back-to-back workshops. Some presenters may also be invited to introduce themselves and their journey to their career via a very brief lightning fast talk at the start of the day. Individuals and small teams are welcome, as are graduate students. **Submissions will be accepted through January 13.** Contact person for this year's HSMSS is Val Perini at v.perini@northeastern.edu

MARINE SCIENCE IN THE NEWS

Source: Gulf and Caribbean Fisheries Institute

Lionfish Invade Atlantic and Caribbean Reefs

The current high densities of invasive lionfish (*Pterois volitans* and *Pterois miles*) on Atlantic reefs pose a serious threat to the integrity of native ecosystems. While lionfish can be eaten by large predators such as groupers and sharks, such predators are rare throughout the Caribbean. Relatively healthy and well-protected Cuban reefs, however, still boast abundant populations of large native apex predators, while lionfish removal programs in Cuba are currently in their infancy. These conditions in Cuban waters present an unprecedented opportunity to test the biotic resistance hypothesis, whereby native predators in well-enforced MPAs are capable of curbing the lionfish invasion.

The Cuba Marine Research and Conservation Program (CMRC) tested the biotic resistance hypothesis to the Caribbean lionfish invasion in healthy, well protected Cuban reefs. Program staff teamed up with collaborators Dr. Mark Albins, a fishery biologist from Auburn University specializing in lionfish mitigation efforts, and Cuban partners and fishery experts Dr. Pedro Chevalier of the Acuario Nacional de Cuba, and Dr. Dorka Cobian, of the Parque Nacional Guanahacabibes, institutions under the Cuban Ministry of Science Technology and Environment (CITMA).

The invasive lionfish (*Pterois volitans* and *Pterois miles*) is now a hemispheric threat to the integrity of coral reefs and fisheries in the Western Atlantic. Scientists have suggested that the ongoing spread of the invasion may be controlled by native species (predators or competitors), providing biotic resistance to the invasion. Whether native predators are capable of competing with or consuming lionfish sufficiently or quickly enough to mitigate their negative effects is actively debated in scientific circles. Cuban coral reefs, particularly Cuba's well-enforced marine protected areas, provide a unique case study. Most Caribbean reefs are not viable locations to test the biotic resistance hypothesis because abundant apex predators are no longer present (i.e., they have been systematically overfished). If they exist in sufficient numbers in well-enforced MPAs, those are often the same areas in which lionfish removal programs have been active for some time, and the confounding effect of human removal cannot be controlled for. In selected Cuban MPAs, large apex predators are abundant, and the removal of lionfish has either not yet started, or is in its infancy. The Jardines de la Reina MPA boasts the highest biomass of native predators in the Caribbean. The lionfish removal program here has only recently begun, and every lionfish removed has been recorded by reserve managers, and removal locations carefully documented. ⚓

— The Waitt Foundation

OCEAN LITERACY PRINCIPLE 3:

The ocean is a major influence on weather and climate.

Heat exchange between the ocean and atmosphere can result in dramatic global and regional weather phenomena, impacting patterns of rain and drought. Significant examples include the El Niño Southern Oscillation and La Niña, which cause important changes in global weather patterns because they alter the sea surface temperature patterns in the Pacific.

Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones. Most rain that falls on land originally evaporated from the tropical ocean.

MASSACHUSETTS MARINE EDUCATORS

2017 MARINE ART CONTEST

Theme: Exploring the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary

DEADLINE: April 28, 2017

Massachusetts Marine Educators and co-sponsors invite students in grades K-12 to participate in the 2017 Marine Art Contest. The theme is "Exploring the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary."

REQUIREMENTS

- Make sure that all artwork depicts species that are found in Stellwagen Bank National Marine Sanctuary, located in the Gulf of Maine just off the Massachusetts coast.
- Entries should be no smaller than 8"x10" and no larger than 18"x 24".
- White, non-glossy paper is recommended—please do NOT laminate and try to keep artwork flat. Do not fold, if possible.
- Label each entry on the back with student's name, age, grade, school, school address, school phone number, teacher's name, and teacher's email address, or use the official entry form. On a separate line write the name(s) of the animal(s) in the artwork.
- For individual entries (not associated with a school program) include home address, email of parent or guardian, and phone number for correspondence purposes.

DIVISIONS

- Elementary School — Grades K-4
- Middle School — Grades 5-8
- High School — Grades 9-12
- Scientific Illustration — All Grades
- Computer Graphics & Photography — All Grades

PRIZES

1st Place: $50 cash award, 4 NE Aquarium passes, certificate.

2nd Place: $30 cash award, 2 NE Aquarium passes, certificate.

3rd Place: $15 cash award, 2 NE Aquarium passes, certificate.

4th-6th Places: certificate.

SPECIAL AWARDS ($20 each)

- MME/Joseph McQuade Memorial Award for seabird art
- Whale and Dolphin Conservation Award for Marine mammal art
- New England Aquarium Award for fish art
- Center for Coastal Studies Award for sea turtle, invertebrate or plankton art
- Stellwagen Bank National Marine Sanctuary Award for invertebrate art
- Ocean Genome Project Award for invertebrate or plankton art

Additional admission passes for winning artists have been donated by the Harvard Museum of Natural History, the South Shore Natural Science Center, and other local institutions.

Contest sponsors retain the right to use artwork submitted to this contest for educational, outreach, and promotional non-commercial use. Original artwork will be returned to the artists.

DEADLINE — Friday, April 28, 2017

Deliver in person or via delivery service or postal service (1st class mail) with postmark by deadline date to: MME Marine Art Contest, c/o Stellwagen Bank National Marine Sanctuary, 175 Edward Foster Road, Scituate, MA 02066

ALTERNATE THEME FOR COMPUTER GRAPHICS

In recognition of the 25th anniversary of Stellwagen Bank National Marine Sanctuary in 2017, artwork commemorating this anniversary is offered as an alternate theme and will be used by the sanctuary in publications and at events. In addition to a printout of the artwork, please send a digital file via disk, thumbdrive, or email (stellwagen@noaa.gov).

For more information: http://ma-marine-ed.org/mmeevents/marine-art-contest/ or http://stellwagen.noaa.gov

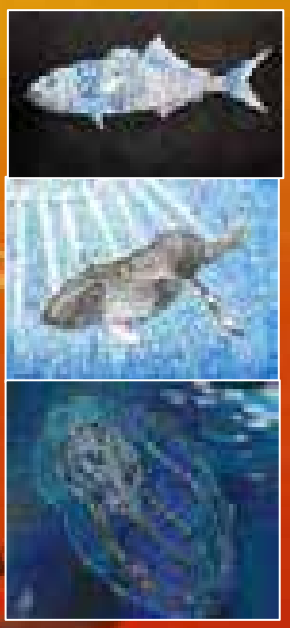
anne.smrcina@noaa.gov 781-545-8026 ext. 204

SEND ENTRIES TO:
MME Marine Art Contest
c/o Stellwagen Bank National Marine Sanctuary
175 Edward Foster Road
Scituate, MA 02066

2017 Marine Art Contest

Grades K-12

Deadline: April 28, 2017



Art Contest Sponsors:
Massachusetts Marine Educators
New England Aquarium
Ocean Genome Legacy Center
Provincetown Center for Coastal Studies
Whale and Dolphin Conservation
Stellwagen Bank National Marine Sanctuary

Theme: *Exploring the Marine Biodiversity of Stellwagen Bank National Marine Sanctuary*

Join MME Today!

To get an MME membership application, please go to **http://ma-marine-ed.org/about/membership**