Flotsam & Jetsam

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Aquaculture

What is Aquaculture and Why is it important?

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Aquaculture is the controlled cultivation and harvest of aquatic organisms. Most commonly grown are finfish and shellfish, but other aquatic organisms are also cultivated such as seaweed, microalgae, frogs, turtles, alligators, and endangered species. Not all aquaculture targets food production; live-bait, ornamental, research and education are important markets. There are many similarities between aquaculture and agriculture, but there are some important differences as well. Aquaculture, like agriculture, is necessary to meet the food demands of a growing global population with diminishing natural fisheries stocks. Unlike land under cultivation, the world's oceans, lakes, rivers and streams are usually public or common resources. Managing these common resources is often problematic.

The word "aquaculture" breaks down to "aqua" (water) and "culture" (to grow). Aquaculture is the art, science, and business of producing aquatic plants and animals useful to humans. Mariculture is the raising of such crops in the sea. Aquaculture and agriculture are both farming. However, aquaculture is farming in the water and therefore requires a different set of knowledge, skill, and technology.

Aquaculture takes place in four general aquatic environments:

1. **Warmwater aquaculture** is the culture of plants and animals, such as catfish, tilapia, and most ornamental fish, that thrive in warm (>30^{o} C), fresh water.
2. **Coldwater aquaculture** is the culture of plants and animals, such as trout, salmon, char, that thrive in cold (<20^{o} C), fresh water.
3. **Coolwater aquaculture** is the culture of plants and animals, such as yellow perch. Walleye, black bass, that thrive in cool (between 20-30^{o} C), freshwater.
4. **Mariculture** is the culture of plants and animals, such as seaweed, bivalve mollusks, salmon, that are acclimated to marine or brackish waters.

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Inside This Issue

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Calendar 2011

Monday, January 31, 2011
Deadline for MME Board Member Nominations
Sent to Bill Andrake, Nominations Comm. billandrake@hotmail.com

Wednesday, March 16. 2011
High School Marine Science Symposium — UMass Dartmouth
Contact: Margaret Brumsted — mbrumsted@dartmouthps.org

Saturday, April 30, 2011
35th Annual Meeting and Conference — Woods Hole Oceanographic Institution
Contact: Bill Andrake — billandrake@hotmail.com

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President's Message

In early November 2010, our colleagues in NEOSEC (New England Ocean Sciences Education Collaborative) hosted an Ocean Literacy Summit at the University of New Hampshire. This summit's focus was the fifth Essential Principle of Ocean Literacy: The ocean supports a diversity of life and ecosystems. To that end, the sessions, keynote presentation and panel discussion focused on the monumental but necessary undertaking known as the Census of Marine Life (CoML). To borrow from their Facebook page: *The Census of Marine Life is a global network of researchers in more than 80 nations engaged in a scientific initiative to assess and explain the diversity, distribution, and abundance of life in the oceans – past, present and future.*

Before saying more about this huge collaborative effort, I would like to applaud the NEOSEC team for putting together an excellent event. NEOSEC is a partnership of 43 institutions from across the five coastal New England states. MME is a member institution, as are our colleagues in SENEME (Southeastern New England Marine Educators) and GOMMEA (Gulf of Maine Marine Educators Association. The event organizers seized on an opportunity to bring together significant participants of the CoML, and educators within NEOSEC to provide us with an entertaining and informative overview of the CoML, and ways to use the information in our institutions. Better yet, Dr. Sylvia Earle topped off the evening with an inspiring presentation.

This treasure trove of data should prove useful for years to come. There are vivid photos, posters and videos for use by those looking to generate a sense of excitement about what lives in the ocean. For those who need to focus on a specific region of our world ocean, there are projects that narrowed in on those locales. For those who want to connect coastal citizens to their past, there is the History of Marine Animal Populations. All of this and more can be found at www.coml.org. I strongly encourage you to visit this site.

Most importantly, there is a strong education component to this endeavor. For those looking for lesson plans and other classroom resources, there are several places to look. The CoML site has a Census Resource tab which will then connect you to an Education page. Once on this page, the Education and Outreach link has some useful suggestions (and a couple of dead links). The best ones here are Mar-ECO and Tagging of Pacific Pelagics. The Smithsonian link sends you to Ocean Portal, which should prove to be both fun and useful. Pressing on the Marine Life Database square will send you to www.iobis.org which has its own education page.

Another educational resource exists within the Encyclopedia of Life. The EoL goes beyond the marine aspect of CoML to try to incorporate all organisms on the planet in its cataloging. Within their educational efforts http://education.eol.org/ they are adding marine themed resources and are encouraging students to add to this database. Some of the affiliated projects have their own web-based educational resources.

I'd like to end this column by recognizing the work of David Simser. Dave passed away in mid-November after a long battle with cancer. Simser (most people called him by his last name) was my Entomology professor in graduate school. He was also a great friend and colleague to marine researchers at Stellwagen Bank National Marine Sanctuary, Whale and Dolphin Conservation Society, and International Fund for Animal Welfare. His focus may have been insects, but he understood the importance of ecosystemic approaches to solving problems and understood the connection between land and sea. In true Simser fashion, his life was celebrated with good food, beer and conversation at the home of David Wiley (SBNMS) and family in Wareham on November 28. His spirit and diligence will be missed.

Bob Rocha
President, Massachusetts Marine Educators

OBIS OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM

eOL

CENSUS OF MARINE LIFE Encyclopedia of Life

From the Editors Desk

The fall months have been very busy for your editor. I have completed work on a Problem Based Learning Module for NASA dealing with climate change. Its title is **Ocean Warming – Smaller Plankton Bloom**. The module in pilot form may be viewed at http://esseacourses.strategies.org/module.php?module_id=135. This is one of a series of modules being for NASA using NASA Materials. It is being pilot tested with middle and high school students. I have two more modules, which are in the development stage and will be posted for pilot testing later this winter.

In November, I was invited to New Orleans for the unveiling of the Hurricanes: Science website and in concert with the opening of the Louisiana State Museum exhibition, Living with Hurricanes: Katrina and Beyond. The unveiling took place during the Hurricane Science and Education Symposium at the Tulane/University Xavier Center for Bioenvironmental Research. The website is a project of the University of Rhode Island Graduate School of Oceanography. It is a work in progress, and will be the featured in our summer F&J with a topic of Hurricane Preparedness. As a work in progress, many features are still being added to the site as materials are completed.

Later that same week I was in Kansas City at the first of the NSTA Area conferences. Here I had an opportunity to meet with a large group of Earth Science Teachers for a discussion of the new National Science Frameworks that are in a draft form. These frameworks move the Earth Sciences from a little sister science to a level nearing that of Biology, Chemistry and Physics.

In November, I was in Boston for the MME Board meeting at the Aquarium, where discussions centered on the High School Marine Science Symposium, the spring WHOI conference, and the NMEA National conference in Boston at the end of June. I was fortunate that the meeting was the same week as the 2010 Ocean Literacy Summit at the Univ. of NH in Durham. This was a very worthwhile meeting with reports on a decade of Ocean Research and the **Census of Marine Life**, presenting the results of this study and a census of marine organisms across the world's oceans. Although the decade is over, research continues worldwide and is being entered into the database. It was astounding to hear that **4-5 NEW marine species are being discovered EVERY DAY**. The next time you are home with your computer on a snow day, check the site out at http://www.coml.org/. Nearly 100 scientists and educators participated in the summit, and MME was well represented with 10 members participating. The keynote speaker at the summit was renowned marine scientist, Dr. Sylvia Earle. Dr Earle stated, "Only ten percent of the big fish still remain in the ocean. There are still some blue whales. There are still some krill in Antarctica. There are a few oysters in Chesapeake Bay. Half the coral reefs are still in pretty good shape, a jeweled belt around the middle of the planet. We are in trouble now, unless we deliberately take actions to take care of the sea, and make sure these systems continue to operate as they have for millions of years. There's still time, but not a lot, to turn things around." The fall meetings allowed many contacts to be made for this issue of F&J as well as initial contacts for the next two issues. Meetings of this type allow for a tremendous amount of networking.

In this issue of ***Flotsam and Jetsam*** our theme is aquaculture. In assembling materials for the issue, Your editor was taken aback when he found on the Australasia Marine Educators website, the video by our president and Sandman being featured for NMEA 2011.

Although many people think of this as a recent development, the cultivation of marine organisms dates back to very ancient times. Records in Chinese manuscripts of the 5th century B.C. indicate the practice of fish farming was occurring. Hieroglyphs indicate the Egyptians attempted intensive fish cultivation as early as 2050 B.C. Roman records indicate they cultivated oysters, These attempts at farming the oceans were the beginnings of a practice that has continued to the modern day.

Early attempts are far different that what is being done today. The modern form of aquaculture began in the mid 1700's when a German farmer successfully gathered fish eggs, fertilized them and then raised the fish that hatched. Initial aquaculture dealt with freshwater fish, but in the 20th century scientists developed new methods to successfully breed saltwater species. Large cage farm methods have been developed and can be found all over the world.

With the advent of large scale fish farming, have come new problems, as disease control and immunology of species as well as dealing with the mixing of farm raised species with wild populations have

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Shellfish Aquaculture is Alive and Well

Robert Rheault

Bob Rheault was president of Moonstone Oysters in Narragansett, Rhode Island for 26 years. He has a Ph.D. in Biological Oceanography and is an adjunct faculty member in the University of Rhode Island's Department of Fisheries & Aquaculture. He served as ECSGA President for five years before taking the Executive Director's seat.

The shellfish aquaculture industry in the United States is alive and well. The industry has been heralded by environmental groups as a sustainable form of production with tangible benefits to the marine environment. A growing recognition of the ecological services provided by cultured shellfish is bringing new interest from both industry and coastal managers. The industry has been expanding rapidly in many areas, and as we develop novel ways to address our many challenges that strong growth is likely to continue.

Aquaculture production worldwide has grown to eclipse the harvest of wild fish, but our national growth rate lags the rest of the world and the United States produces only about $1 Billion in cultured aquatic species. Of that 80% is freshwater species such as catfish and trout, and only 20% is marine species such as salmon and shellfish. Clams, oysters, and mussels account for two thirds of our production of marine species and shellfish farming is one of the few sectors of our economy that is experiencing robust growth in many states.

Shellfish aquaculture by dollar value is split almost equally among the East, West and Gulf Coasts, with each producing about $100 Million annually. The industry is dominated by small farms that collectively employ thousands in rural coastal areas, and for every job directly created in aquaculture production economists project that four more jobs are created in supporting industries such as processing and boat building.

Oysters Growing out to Market Size
Picture by Robert Rheault

Rudimentary forms of shellfish farming have been practiced around the world for hundreds of years. Whenever wild shellfish resources started to suffer from overexploitation fishermen have developed a variety of novel ways to enhance natural sets and protect stocks from predators. The perfection of hatchery techniques over the past 50 years has ensured a reliable source of seed and permitted growers to selectively breed strong performing lines.

Wild and farmed shellfish populations have always been susceptible to a variety of parasitic and bacterial diseases. Since shellfish have primitive immune systems and are grown in open waters, growers cannot use drugs, immunization or antibiotics. Efforts to improve shellfish survival rely primarily on selective breeding of resistant strains. These efforts have been ongoing since the development of hatchery techniques, and excellent improvements in survival have been made. However, in comparison to other crops, the genetic improvement of shellfish is still in its infancy.

The shellfish culture industry in the US is almost as diverse as the range of species that we culture. Oysters make up the majority of our nation’s farmed shellfish production and there are a wide range of approaches that are employed. The bulk of oyster farming relies on extensive techniques that are little changed over the past 100 years. Clean shell (known as “cultch”) is placed in shallow coastal waters when oyster larvae are known to be abundant. Once the larvae settle on the shell, they are collected and moved to growout beds where they can be monitored and protected from predators. In a few years the oysters are harvested and the cycle is repeated.

(Shellfish - cont on page 6)

(Shellfish - cont from page 5)

The development of hatchery techniques and the invention of plastic netting has ushered in the development of a variety of novel gear types that are used to grow oysters and other shellfish intensively. The challenges of intensive shellfish production consist (in essence) of designing containers that protect shellfish from predators such as crabs and starfish while at the same time allowing an adequate flow of seawater to ensure the shellfish are amply supplied with food.

Shellfish are filter-feeders that capture microscopic algal cells from the waters on delicate gills. Each animal clears a prodigious volume of water and to ensure decent growth, farmers need to ensure that each individual shellfish has access to tens of gallons of food-rich water each day. This would be a simple matter were it not for the plethora of fouling organisms that grow on any surface, wire, line, net or structure placed in the waters. Fouled nets block the flow of water and food, and the fouling organisms themselves usually compete directly for the same microscopic algal cells that the shellfish feed upon.

Intensive shellfish farmers spend the majority of their time controlling fouling on the various types of culture gear and spreading out the crop as it grows in size and volume. These containers consist of a variety of plastic-mesh bags and cages, lantern-nets, and trays that are either placed on the bottom, floated on the surface or suspended in the water column. These apparatus are deployed variously in both the subtidal and intertidal zones. Fouling control techniques include periodic air-drying, brine dipping or blasting the fouling organisms off with high-pressure water jets.

Container of market size oysters. Picture by Robert Rheault

Over the past 30 years there has been a radical transformation in the oyster market. Historically, most oysters were shucked for the meat market, but recently there has been a renaissance of raw bars. This market demands a more uniform, smaller product and growers have evolved to meet that demand. Producers are beginning to worry, however, that ever-increasing production levels may drive down prices. We saw it with salmon, catfish, tilapia and most recently with clams.

When clam farmers learned how to protect their crops from predators using nets similar to blueberry netting, production increased dramatically, but prices collapsed. The number of growers dropped and prices have stabilized, but one has to wonder if this could have been avoided with a proactive marketing campaign.

While shellfish farming seems poised for growth, there are still many challenges for the industry to overcome. Many of our best growing areas are periodically ravaged by parasitic diseases. Water quality issues still continue to force the closure of many good harvest areas and natural toxins associated with harmful algae or natural bacteria scare off consumers who are increasingly intolerant of food-borne risks. Expanding our production to new areas is usually opposed by waterfront homeowners who value their view or their desire to sail freely everywhere more than they value food production. Affluent opponents increasingly resort to lawsuits to block new lease applications. We have been able to disprove their claims of environmental menace, but farmers can seldom afford to battle in the legal arena.

Perhaps the best thing about shellfish farming is that it is still a relatively new industry. We are still writing the book and much trial and error lies ahead. No single method works everywhere and we can be reasonably sure that we have not invented the best way to do it yet. There is ample room for innovation and that keeps it interesting. If you like working on the water and don't mind getting muddy, shellfish farming might just be for you too.

Bob Rheault
Former owner of Moonstone Oysters
Executive Director ECSGA.org

Gone Home

MME lost another very active member of the association with the passing of Joseph Balsama. He has been a fixture for years at our conferences, and many of the items that ended up at the raffle at WHOI were gifts from him. He was a life member of the Massachusetts Marine Educators association.

Joseph Balsama, born in Waltham, Massachusetts on July 18, 1933, died suddenly on the morning of October 3, 2010. Joe was raised in Belmont, attended Belmont High School, and completed his bachelors and masters degrees at Boston University. He served in the U.S.Army during the Korean War. Joe worked for the United States Weather Service until 1958 when he was hired to teach science at the Swampscott Junior High School. He was married to his wife Barbara for 41 years.

Joe was an institution at Swampscott High School. He taught biology, physics, marine science, and climatology. He was science department chairman for over 20 years. Joe was a founding father of Massachusetts Marine Educators as well as a member of the American Meteorological Society, The Blue Hills Weather Observatory The Lynn Mineral Club, The Swampscott Historical Society, and the Boston Street Railway Association. Joe was a mentor to Bill Andrake and me in the Swampscott public schools. The headline in the Swampscott Reporter was “A Loss for the Town”. In truth Joe’s death is a loss for us all.

His wife’s address is: Barbara Balsama, 23 Sherwood Road, Swampscott, MA. 01907.

Thanks to our member Chris Ratley for this article.

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moved to the forefront of the industry. Biologists have spent many years studying life cycles of fish, spawning habits and growth stimulation. Today aquaculture includes fish hatcheries in many states where sport fish are raised in hatcheries and then released into local rivers and streams after they reach a sustainable size. This allows more young fingerlings to be introduced into the natural environment than would survive if they were to hatch in the wild.

For many years, only luxury species such as salmon, shrimp, oysters and scallops were the chief products of aquaculture attempts. Today, nearly a hundred species of fish, crustaceans and mollusks are produced through the aquaculture process. To this end, we have asked several people working in the field to provide an insight into the aquaculture process in this journal.

On page 16 in this issue is an article I have asked two friends from MA to write on their experiences this summer on a research cruise across the Atlantic from the Azores to Woods Hole. I hope you enjoy their article.

We look forward to seeing you at one of the MME – NMEA meetings coming up this year.

Howard Dimmick
Editor

(Aquaculture - cont from page 1)

Students working in Weymouth with their large fish net. Picture by Dr. Joe Buttner

Aquaculture can be separated into two broad categories: public sector/restoration aquaculture and private sector aquaculture. Public sector/restoration aquaculture is generally aimed at replenishing depleted fishery stocks. It tends to be conducted by non-profit organizations, or by the state and federal government. Motivations for public sector aquaculture vary. Sometimes officials are attempting to protect a potentially threatened or endangered species such as the Atlantic salmon (*Salmo salar*) in some watersheds. When fish or shellfish are raised to restock depleted waters, it is restoration or enhancement aquaculture, such as on-going efforts to replenish softshell clams (*Mya arenaria*) in Boston Harbor. Another motivation for public sector aquaculture initiatives is to replenish depleted commercial fishery stock to enhance the local fishing economy, such as efforts targeting the American lobster (*Homarus americanus*). Private sector aquaculture has profit as its main motive. The goal is to sell products for a profit. The product may be seaweed, finfish or shellfish for a local, regional, or national market. Locally important species include livebait (e.g., crayfish, Orconectes spp.) for angling, gamefish (e.g., largemouth bass, *Micropterus salmoides*) for stocking, and a variety of bivalve mollusks (e.g., hard clams, *Mercenaria mercenaria*) for dinner!

Aquaculture has been around for thousands of years. It has become increasingly important the last two decades as capture fisheries globally have stagnated at approximately 90 million tons annually. According to the United Nations (2009), over 80% of all monitored fisheries are now fully exploited, over-exploited, depleted or recovering. To provide the animal protein that 6.8 billion people (and growing) require, aquaculture, has become a necessity. Aquaculture, currently provides over half of the fish products consumed globally by humankind (up from merely 4% in 1970). Aquatic organisms are grown in a variety of systems from minimally managed ponds and tidal flats to intensively managed net pens and recirculating aquaculture systems (RASs).

Students from Northeastern University's 2010 Summer Coastal Ocean Science Academy visit the Cat Cove lab to learn about aquaculture resources. Picture by NUMSC

Culture of finfish and shellfish in coastal waters can be pursued sustainably with benign impacts if sites are carefully located and wisely managed. Finfish culture utilizes prepared feeds that are formulated to provide all nutritional requirements in an economical pellet. Bivalve mollusks feed on microscopic organisms and organic material suspended in the water; their culture is frequently viewed as a "green" pursuit that can improve water quality. Mollusks remove excessive nutrients (such as N, P) from our coastal and estuarine waters. They sequester carbon dioxide from the atmosphere by incorporating carbonates dissolved in ocean waters into their shells. Sustainable aquaculture promotes jobs, perpetuates a working water front and fishing traditions, serves as source of safe, high quality seafood, and can reduce the ecological footprint of humankind.

Since 1999 when the Cat Cove Marine Laboratory at Salem State University officially opened, thousands of taxpayers and their children, scores of teachers, and representatives from dozens of communities from Cape Ann to Cape Cod and the Islands have visited the Lab and learned about aquaculture. Courses offered by SSU have introduced high school youth to pensioners and displaced fishermen to aquaculture. Dozens of teachers have participated in Topics in Aquaculture (BIO 705), gaining the competence and confidence to integrate aquaculture as a teaching tool in their classrooms. Public and private sector aquaculture operations in both fresh and marine waters have been facilitated and realized.

Aquaponics

Dr. Joel Rubin, Science Department,
Stoughton Public schools, and MME Board Member

All right, so this isn't about a marine system – maybe you can take the lead to investigate growing algae for biodiesel or sushi nori. My personal introduction to aquaponics started in the 1990s when the New England Aquarium, in collaboration with the National Museum of Kenya hosted "Nyanja", an exhibit on the culture and science around the mass extinction of Lake Victoria's endemic cichlids. I had the opportunity to host the ELF ("Endangered Lake Fish") project, a group of teachers, mainly from Colorado, engaged in a school-based effort to aquaculture (captive-rear) some endangered Victorian cichlid species. This was a "Noah's Ark"-type operation for kids, similar to what is taking place at universities, zoos and aquariums around the world to help save endangered species. Among the teachers who took an interest in the ELF project were a group from Greater New Bedford Voc Tech HS. The GNBVT aquaculture program was large scale – 500 gallon tanks — and provided fish (tilapia) for the school cafeteria. One of the teachers, the late Rick Reinecker, had a relative teaching at the K-5 level who wanted a system scaled to her classroom constraints. The result, which, with a few small modifications, I have used successfully for many years, took a 20 gallon tank, and a brand of box filter called the Penguin Emperor (a dual biowheel product sized for much larger set-ups) to grow leafy greens in trays above the tank. This particular model has 2 spray bars, one to spin each biowheel. For this set-up, one spraybar/biowheel set is removed and replaced by a clear plastic hose ~1/2" diameter that lifts water above the tank and into the plant trays with the growing medium. Gravity returns the water to the tank, minus some of its solid and nitrogenous wastes (I mean plant nutrients) — it's a win-win for both the fish and the plants.

The original design called for plants to be set in rockwool. An aquaponics program (now defunct) run by Bob Green at the Boston Museum of Science and designed by the New Alchemy Institute of Falmouth, MA also grew a type of tilapia (a commercially extinct Victorian species, *Oreochromis esculentus*, brought back to the US by Les Kaufman of Boston University) with plantings in holes in Styrofoam floats on the surface of the tanks and in trays filled with vermiculite. After experimenting with various materials over the years (and having to scoop out vermiculite floating in my tank after trays accidentally fell in) I eventually settled on polyester quilt batting as the simplest solution to my need for an inert growing medium. This system has enabled me to successfully grow basil and watercress for many years. I have found various ways to suspend "grow light" fluorescent fixtures over the tanks – the key being to keep in mind the dominant safety issue: electricity and water don't mix. I put the pollyfill batting in plastic plant trays with a bit of plastic screening to block a drain hole at one end that returns the water to the fish tank. As with other aquarium systems, I aim to make 10% water changes weekly. The system has a high evaporation rate owing to the greatly expanded wetted surface area of the polyfill batting plus transpiration from the plants. As a consequence, in practice I need to add about 25% (10 gallons to the 40 gallon breeder tank I currently use – breeders have a larger footprint & less height than display tanks, a tradeoff to gain surface area for better gas exchange).

That's my aquaponics story but there are a great many more. I encourage you to try this out for yourself. Feel free to email me <j_rubin@stoughtonschools.org> and here are a few links for those interested in pursuing matters further on the web:

http://www.umass.edu/aquaculture/projects/vocational_ed.htm
http://www.ciese.org/curriculum/aquaponics/
http://springvilletilapia.weebly.com/inspiration.html

Large scale (HS):
http://www1.teachertube.com/viewVideo.php?video_id=42364&title=MS_and_HS_Hydroponics_Aquaculture_and_Aquaponics

Small scale:
http://www1.teachertube.com/viewVideo.php?video_id=50570&title=Aquaponics_Hydroponics_Aquaculture_

The Role of U.S. Aquaculture in Global Seafood Supply

Chris Botnick

Chris Botnick is the Outreach Specialist with the NOAA's Aquaculture Program in Silver Spring, MD He holds a Master of Public Policy and a Master of Science in Natural Resources from the University of Michigan. He earned a Bachelor of Science in Natural Resource Economics from Cornell University.

Advancing marine education is a worthy goal. The marine environment – the oceans, habitat, and species – is so vast, so intertwined, so *impressive* – that one can't help to be enamored with its beauty and complexity. As we use technology to open up the marine frontier to science and exploration, we learn more and generate more questions. Just recently, scientists discovered new species along ocean trenches in the Southeast Pacific Ocean and there clearly is much more to explore. But what do we know about the seafood that we eat? Sure, we know what oysters, catfish, and salmon are... but where exactly do they come from? The world's oceans are a big place. Would you be surprised to know that roughly half of all the seafood consumed globally and in the United States comes from a *farm*?

Oyster Trays
Picture by Chris Botnick

Marine aquaculture, often known as "fish farming," refers to the cultivation of aquatic organisms such as fish, shellfish, and algae in controlled aquatic environments. Aquaculture serves many purposes including contributing to commercial and recreational fisheries, wild stock replenishment, rebuilding populations of threatened or endangered species, and restoration of oyster reefs. Aquaculture also is the fastest growing form of food production in the world. Achieving marine literacy and awareness of ocean issues necessarily involves education on the topic of aquaculture.

The reality of today's global seafood market is that demand greatly exceeds the supply from wild fisheries. The fact that global landings of wild-caught fish have stagnated in the last 25 years has necessitated a rapid increase in global aquaculture production. According to the Food and Agriculture Organization, aquaculture has grown since the 1970s from supplying about seven percent of the fish available for human consumption to over 50 percent today, meaning that aquaculture has overtaken capture fisheries as a source of food fish.

Most of this growth in aquaculture takes place outside of the United States and is heavily dominated by the Asia-Pacific region, which accounts for 89 percent of production (by volume). While world aquaculture production is valued at about $70 billion, U.S. production only is about $1.2 billion. Marine species only account for about $200 million of that. Together, U.S. freshwater and marine aquaculture combine to provide only about 5 percent of the seafood consumed in the Unites States.

U.S. seafood consumption continues to outpace domestic production. In fact, the United States imports 84 percent of its seafood, about half of which is farmed abroad. In economic terms, this results in a seafood trade deficit of over $9 billion. Of the ten most consumed species in the United States, five are farmed. These include shrimp, salmon, catfish, tilapia, and clams. Experts agree that the United States needs both a strong commercial fishing industry and a robust aquaculture industry in order to meet projected seafood demand. It appears as though we have a choice: we can continue to import increasing amounts of seafood or we can begin to produce more of it here.

There are many reasons to produce more seafood through domestic aquaculture. It supplies a source of safe, healthy, and local seafood. It's good to be familiar with the state, town, or even the specific harbor where your seafood came from. Eating locally means lower transportation costs, fewer CO2 emissions, and less time from ocean to plate. Aquaculture also supports domestic jobs. This is exemplified by the fact that most marine seafood farmers are from fishing and seafood families. There are many synergies with traditional capture fisheries. Aquaculture supports the same infrastructure as commercial fishing, so the economic impact of the industry extends well beyond benefits to aquaculture companies. "Upstream"

(Botnick - cont on page 11)

(Botnick - cont from page 10)

industries that supply aquaculture production include agriculture, hatcheries, feed manufacturers, equipment manufacturers, and veterinary services. "Downstream" industries supplied by aquaculture include processors, wholesalers, retailers, transportation, and food services. In many coastal communities, new aquaculture operations could provide additional fish and shellfish to local processing plants and fishermen may be able to use existing vessels to support aquaculture operations. In a time when employment is hard to come by, aquaculture is an excellent opportunity to expand a “home grown” industry.

The health benefits of eating seafood abound and are broadly supported in scientific literature. Typically rich in omega-3 fatty acids, seafood’s long-established health benefits include increasing cognitive function, improving cardiac health, and decreasing the risk of stroke. Newer research indicates that omega-3 fatty acids have some ability to protect against dementia, and fight diabetes, menopause, depression, and obesity, among others. In recognizing that a diet rich in seafood is necessary to good health, nutritionists are encouraging Americans to double their consumption of seafood to two seafood meals per week, up from one.

Aquaculture in the United States

The largest single sector of the U.S. marine aquaculture industry is molluscan shellfish culture (oysters, clams, mussels), which accounts for about two-thirds of total U.S. marine aquaculture production, followed by salmon (about 25 percent) and shrimp (about 10 percent). Current production takes place mainly on land, in ponds, and in coastal waters under state jurisdiction.

From a national perspective, a compelling case can be made for growing more seafood in the United States. Aquaculture, as a complement to wild harvest fisheries, can help meet this growing demand for seafood and help rebuild wild fish stocks. Domestic aquaculture is also critical to maintaining infrastructure in coastal communities to support both commercial fisheries and aquaculture and all of the jobs associated with the seafood industry. Finally, aquaculture in the United States operates under some of the most stringent health and environmental standards in the world.

Mussel Operation
Picture by Chris Botnick

In the future, the United States will need all forms of aquaculture – freshwater and saltwater, finfish and shellfish, existing and new technologies – to meet growing demand for seafood. The National Oceanic and Atmospheric Administration’s (NOAA) Aquaculture Program is working to address all forms of marine aquaculture including coastal shellfish, algae and finfish culture, and marine stock enhancement (hatcheries) for species important to commercial and recreational fishing, as well as the production of pharmaceutical and other by-products from aquaculture.

Based on the current level of U.S. aquaculture production, the challenge is to integrate aquaculture into domestic seafood production so that boat owners, fishermen, and processors can benefit directly from aquaculture. In some cases, U.S. fishermen already have incorporated aquaculture as part of their overall operation. For example, fishermen in New England who are interested in adding aquaculture as part of their business and researchers at the University of New Hampshire are working in tandem to design equipment, site operations, and share knowledge while operating cod and mussel farms in open ocean locations. On the opposite end of the East Coast, fishermen in Florida, displaced by closures of wild fisheries or declining catches, have successfully turned to clam aquaculture.

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Right in Massachusetts, fishermen are farming blue mussels in offshore locations using technology developed by the University of New Hampshire. The first commercial harvests from Martha's Vineyard in the fall of 2010 were featured in the Boston Globe. In Duxbury, oyster aquaculture has flourished since the town adopted an Aquaculture Management Plan in 2009, which is providing local jobs and supporting local businesses. As of 2008, there were 30 licensed aquaculture lease holders in Duxbury and 70 acres of leased area.

Addressing the Technical and Scientific Barriers

NOAA, in partnership with other federal agencies, research institutions, and the private sector are working to address several existing barriers. Those barriers include

* developing innovative technologies and management practices to ensure protection of marine ecosystems;
* clarifying the regulatory and environmental requirements for existing as well as new marine aquaculture operations, including uses of federal waters; and
* reducing costs and improving the efficiency and sustainability of different systems, including production in land-based and marine locations.

As an agency, NOAA is working to address the technical and scientific barriers to marine aquaculture production in a number of ways. Since 1998, NOAA has funded a total of about $100 million through the National Marine Aquaculture Initiative, Sea Grant, and congressionally-directed projects. Past projects have responded to key scientific, engineering, environmental, and economic questions for aquaculture. For example, NMAI has funded studies of candidate species, health and nutrition, best management practices, ecosystems monitoring and management, new production systems for closed recirculating and offshore systems, and legal and operational frameworks.

Trends in U.S. Aquaculture Point to New Technologies

The United States continues to be an active player in global aquaculture through the development of advanced technologies, feed formulations that reduce stress on other fisheries, aquaculture services, and investment; we're just not producing much aquaculture here. New and still-emerging aquaculture technologies — an area where the United States continues to be a world leader — are reflecting the potential that marine aquaculture has in playing an important role in domestic seafood supply. Advanced technologies include off-bottom shellfish culture, land-based closed recirculating systems, integrated multi-trophic aquaculture, and offshore aquaculture. What are those? In short, they are very exciting opportunities that build on the trials of past experience and reflect a true commitment to maintaining the environmental integrity of our ocean and coastal ecosystems. This is a true opportunity for learning. How has aquaculture progressed? What are the promises and constraints in modern aquaculture? There are many exciting stories to tell and as many entrepreneurs willing to tell them.

Oyster Spat
Picture by Chris Botnick

Two Choices, Really

Growing consumer demand for safe, local, and sustainably produced seafood, increasing energy costs, and the decline of fishing-related industries and working waterfronts are emerging drivers that support sustainable domestic aquaculture production. Aquaculture production is ever-evolving toward sustainable practices through regulations at the federal and state levels, scientific advancements, technological innovation, industry best management practices, and protocols for responsible stock replenishment and hatchery practices. Marine aquaculture has the potential to contribute greatly to domestic seafood supply and to support our nation's economy. In a sense, the United States is at a crossroads – which way will it go?

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In one direction, we can continue to export technology, investment, and jobs and re-import the seafood produced by aquaculture elsewhere. This has positive and negative implications. Some argue that consumers have benefited from cheap imported seafood. However, adverse impacts include the decline of working waterfronts without new sources of seafood to keep processing plants and other seafood businesses going. It also turns out that importing seafood becomes more and more expensive. Regional food supply and security will become increasingly important as other countries consume more of their seafood at home. This may drive up seafood prices. Most importantly, consumers may refrain from eating imported seafood, resulting people missing out on the health benefits that seafood provides.

In the other direction, constituencies work together to make room for more domestic marine aquaculture generating positive benefits to consumers and coastal communities. In this case, the United States continues as a technology and environmental sustainability leader and a vibrant aquaculture industry sustains communities' economies and enhances environmental quality. Aquaculture serves as a tool to complement wild catch, maintain working waterfronts, create jobs, and provide new sources of seafood to keep processing plants and other seafood businesses going.

The choices we make about the food we eat are entirely up to us. As seafood become more of a mainstay in the diets of populations worldwide, we must effectively harness all sources and all technologies with an eye to satisfying demand without compromising marine ecological health. This is the challenge to which we must rise. Education and ingenuity will help us meet it.

For more information, please go the NOAA Aquaculture Program website at http://aquaculture.noaa.gov.

Introduction to Mariculture

Aquaculture is the farming of freshwater and saltwater organisms such as fish, molluscs, crustaceans and aquatic plants. This article discusses forms of Sea Cage Farming section on Marine aquaculture also known as Mariculture. Marine Aquaculture involves growing then harvesting marine organisms under controlled conditions usually in sheltered coastal waters.

Types of mariculture

A very brief summary of the main types of mariculture is provided here. More information on these is available in the case studies of individual species.

* **Seawater ponds** (Prawns; Fish; Eels; Crayfish)
  In seawater ponds, marine species are grown in ponds which get water from the sea. This has the benefit that plankton present in the seawater can be used as a food source.
* **Tank farming** (Prawn brood stock tanks; Prawn culture tanks)
  Some species grow well in tanks which are aerated and have a continuous exchange of water to keep the dissolved oxygen levels high and remove wastes.
* **Sea Cage farming** (Salmon; Tuna; Snapper; Mulloway)
  At the age of one, young salmon are transferred to cages in the sea. The salmon are fed an artificial diet, specially prepared to maximise growth. Adults are harvested after two years weighing approximately 3 to 4 kg.
* **Long Line farming** (Pearl oysters, Mussels)
  This method is used for offshore culture. It uses a series of styrofoam floats arranged in a row. The long-line is secured at each end with two anchors. One long-line is 100 m long and consists of about 51 floats connected by a polyurethane rope 15 mm in diameter. A series of strings of oysters called "rens", each about 5m long is attached to each rope.
* **Raceway farming** (Abalone; Oysters; Algae)
  Raceways are usually large concrete tanks, generally 30 m long, 3 to 10 m wide and 1 m deep and usually have higher flow rates than ponds.
* **Fish hatcheries**
  Fish hatcheries are used to breed a large number of fish in an enclosed protected environment. Such an environment greatly increases the chances of survival of the fish fry. Many hatcheries then sell the juvenile fish for release into the ocean (e.g. into sea cages).

This article is reprinted with permission from the website of the Marine Education Society of Australasia. To find a unit on Mariculture in Australasia, go to their website http://www.mesa.edu.au/ In addition, their site has several other marine science units of interest.

28th Annual High School Marine Science Symposium

Wednesday, March 16, 201 8:00 am – 1:00 pm
UMass-Dartmouth

Join us for an exciting glimpse into the marine world from a diversity of speakers from throughout Massachusetts, including researchers from the University of Massachusetts' Marine Science Research Center (SMAST) and its Biology, Chemistry, Physics and Engineering Departments. Students will have the opportunity to investigate current and on-going projects in marine science and related disciplines.

The Symposium will feature two keynote speakers and 20 workshops all geared towards high school students and their courageous teachers.

Check the website later in January or email Margaret Brumsted for more information: mbrumsted@dartmouthps.org

Election Time

At our annual meeting at Woods Hole in April, there will be openings for the MME Board. If you are interested in becoming a board member, send an e-mail to Bill Andrake at billandrake@hotmail.com NOT LATER than January 31. *You can nominate yourself for a board opening send us information about yourself and your activities.*

facebook

Social networking, Here we come!!!!

You can now find your favorite marine educator group on Facebook. In an effort to keep MME members and future members informed on upcoming events and happenings, MME has joined the social media frenzy. Find us on Facebook and get reminders about all the great opportunities this organization offers. Also, this page is a great place to post useful resources for educators.
Use this link to reach us:
http://www.facebook.com/group.php?gid=147127885303150

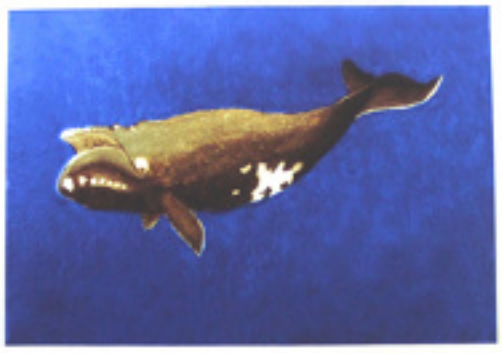
MME Showcases Student Art in New Product Line

MME offers a series of matted prints and card sets showcasing winning entries from our annual Marine Art Contest. The prints come in two standard matte sizes -- 8"x10" and 11"x14" (for larger sizes, contact Anne Smrcina at 781-738-2242 for more information). Cards come in sets of three (same image) with envelopes. All proceeds from this project will be used to expand the art contest and fund student awards.

The first series of winning artwork depicts:
Crab, Goosefish, North Atlantic Right Whale, and American Lobster.

Card Sets (3 cards and envelopes): $10 + $3 s&h
8"x10": $20 + $6 s&h
11"x14": $30 + $8 s&h

When ordering, specify mailing address and send check or money order to:
MME, c/o Gail Brookings, Treasurer, 184 Highland Street, Taunton, MA 02780



High Seas Adventure… for teachers!

By Heather Pacheco, Frank Scofield and Bob White

There are myriad terrific adventure-style teacher professional development opportunities for teachers of science who have the time, availability and inclination to participate. They range from day-long to year-long, and cover topics across the sciences: AMS's Maury Project, Colorado School of Mines Teacher Enhancement Program courses, NOAA's Teacher at Sea, NSF's Research Experience for Teachers, Department of Energy's ACTS Program, National Estuarine Research Reserve System Programs, Albert Einstein Distinguished Science Educators Fellowship. These fantastic opportunities and many more can be found on websites like NESTA, NSTA, MAST and MME. But not all teacher opportunities are organized through large agencies and organizations. Sometimes they come to you through your colleagues . . . good reason to build a broad network of colleagues!

Here's something that all teachers need to know: every scientist who applies for federal funding through agencies like the National Science Foundation is required to include a plan for "Broader Impacts" and this plan can involve you!

These scientists have 5 major categories of Broader Impacts to choose from that advance the NSF Mission of the NSF Act of 1950, "To promote the progress of science; to advance the national health, prosperity and welfare; to secure the national defense; and for other purposes". The main types of Broader Impacts activities are:

* Advance Discovery and Understanding While Promoting Teaching, Training and Learning
* Broaden Participation of Underrepresented Groups
* Enhance Infrastructure for Research and Education
* Broad Dissemination to Enhance Scientific and Technological Understanding
* Benefits to Society

There is a misconception that most scientists choose to engage in K-12 educational activities (under "Advancing Discovery and Understanding While Promoting Teaching, Training and Learning"). As an Einstein Fellow, I served at the National Science Foundation for a year and was amazed at how few scientists choose this route.

Researchers cite all kinds of reasons for why K-12 isn't at the top of their Broader Impacts list. One common issue I heard often was that researchers

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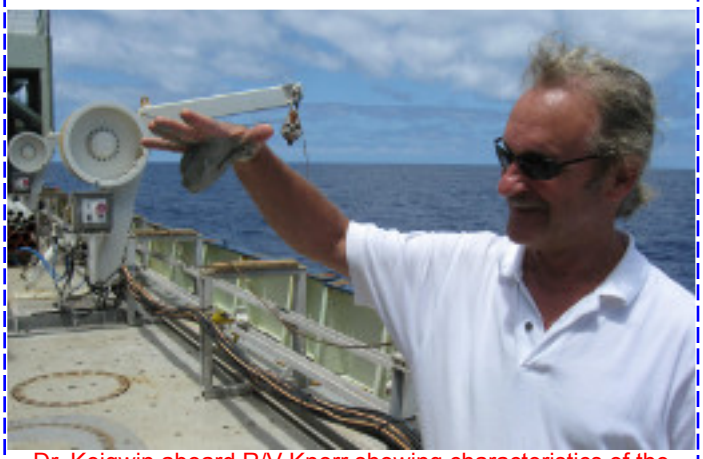
Frank Scofield, Heather Pacheco and Bob White on the deck of WHOI's R/V Knorr July 2010

don't really know teachers. They're in their world, we're in ours. The nugget I hope you walk away with from this article is the seed of an idea about reaching out to researchers at the institutions in/near your community. We have researchers all over New England! If you're interested but don't know how to begin, don't hesitate to email me, Heather Pacheco. Contact information for each of us is at the bottom of this article.

There are, of course, brave and insightful researchers who do opt to engage in K-12 education for the Broader Impacts component of their projects. This article shares the experiences of three Massachusetts teachers, Frank Scofield, Bob White and me, Heather Pacheco, who were part of just such a project with Dr. Lloyd Keigwin and his amazing oceanographic team during July 2010.



Dr. Keigwin aboard R/V Knorr showing characteristics of the ocean floor mud

Dr. Lloyd Keigwin is a senior scientist in Geology and Geophysics at our very own Woods Hole Oceanographic Institute (WHOI). He studies the chemistry of microfossils pulled from the layers of sediment covering the seafloor to learn about the history of ocean circulation and Earth's climate. He and his talented team of research assistants,

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coring and technical oceanography experts and scientists sail the oceans for weeks and months at a time aboard WHOI's research vessels. On these "cruises", they work tirelessly gathering layers of sediments kilometers below the ocean surface to bring back for study in the labs. It's hard, dirty work but, man, they've got a great view! And we got to go along - Heather and Bob blogged on the cruise.

You can access the blogs at:

* http://studying-climate-ocean.blogspot.com/
  Educational blog designed for student investigation (along with Sunday funnies), career pathways and cruise mapping
* http://www.chemwhite.net/main/random.php
  Ongoing blog with entries from the cruise (see July entries) – great way to get ideas about integrating blogging into your classroom!

Frank

Keep your network of bridges intact as you go through life. It's much easier to do so now than it was in the last century, when I spent the bulk of my career as an earth science teacher. Just out of college I made the decision to teach about earth science rather than pursue research. My motivation stemmed from deciding to marry and have kids, and realizing that I'd miss a lot of my kids' childhood if I was off exploring the corners of the planet or traveling to conferences. Retired now, I'm still healthy enough to do moderate grunt work without having to run for an Advil.

Frank is hard at work on the deck of the R/V Knorr. Gloves, life vests, hard hats and steel-toed boots were needed for working with the heavy duty equipment.

I've reconnected with Lloyd Keigwin, a Woods Hole Oceanographic Institution scientist and one of my fellow geology major classmates who enabled me to experience, first hand, the world of climate research and data collection. Until I participated in my first coring cruise in 2004, I had little understanding of the actual nuts and bolts of the process of oceanographic climate research. I've never met anyone who wasn't actually involved

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in climate research who had any real understanding of how much work, time and expense climate study entails. My experiences, first as a volunteer in 2004, then as a staff member this past summer were life experiences for me, for whom the sea has held a lifelong fascination.

Participating in the assembly, deployment and retrieval of the coring devices and interacting with the people who designed and work with this equipment, the research assistants, graduate students and scientists, as well as the ship's crew, this past summer was an unforgettable experience. Some of the equipment weighs many tons and it's essential that everyone involved in the process understand the safety concerns, their role in the team and how to handle themselves and the machinery with confidence and skill. Inattentiveness or lack of ability to operate the equipment can result in injury and/or costly damage.

I made a career of helping kids learn about the Earth, and this summer I was given the opportunity to help two younger teachers take part in a month long WHOI sea floor coring cruise. It was a pleasure to get to know and work with my recruits, Heather and Bob. Prior to our flying to the Azores to meet the R/V Knorr, I had only spent a few minutes meeting each of them, so I wasn't at all certain how things would play out, and it was great to see how they both found different but valuable ways to participate in their roles as crew members. Heather, an earth science teacher from Framingham, spent a major portion of her time working with the research staff, operating the core logger and helping to disassemble and section the cores and working late into the night on an outstanding blog (be sure to check it out!) which enables you to get a real feel for the daily activity of a coring operation, the people who perform the variety of tasks, and see photos of the people and equipment. There is even a fast motion video which condenses the myriad of shipboard activities that comprise the coring operation, thanks to crewmember Tom Lanagan. Heather was able to quickly master the software, came up with some very creative ideas, and equally important, she was able to stay up way past the point where I had to crash into my bunk for the night. Bob teaches chemistry in Braintree, and he spent the majority of his time working with the ship's crew and science staff assembling, deploying and retrieving the coring devices, and discussing with the scientists the logistics and decision making about where to take the cores and how they would

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be used to further climate research. His Navy experience on a nuclear sub was obvious in the way he seemed to intuitively understand the construction and operation of so many of the electrical and mechanical devices we utilized.

As I prepare to hand off the care of our planet to younger generations, I'd like to feel that I did my part to improve public awareness about the importance of understanding climate change. It is my hope that I can guide and encourage other teachers to consider opportunities similar to our recent experience.

Bob

The email, on first glance, appeared to belong in the DBR category, and I was about to do so, when the words "Woods Hole summer cruise opportunity" in the subject line made me think twice. I clicked it open and read the following:

Seeking one science teacher to participate in a project involving a Woods Hole Oceanographic Institute coring cruise this summer from July 10-Aug 1. The cruise will run from the Azores to Nova Scotia, and return to Woods Hole. Subsequent to the cruise this project will include working with two other teachers to develop classroom activities that will enhance the communication among WHOI scientists, teachers and students. A $1000 honorarium will be paid in addition to covering shipboard costs and transportation to the Azores. Contact Frank Scofield if interested

I'm a water guy. I spend the bulk of my summers sailing and fishing. I grew up around the water, live on the water, and cannot imagine life away from it. This looked very cool to me. I equally liked the pithy nature of the request. After consulting with my wife, I cobbled together a resume of sorts, combining my professional educator self with my mariner self, and sent it off to Frank, via email. I figured this was akin to buying a lottery ticket and promptly put it out of my mind.

Bob on the busy deck of the R/V Knorr with the CTD tool used to measure essential physics properties of sea water.

The winter weeks alternately dragged on and flew by, as typical in any school year. It was during

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the really rainy period we had in early spring that I received a call from Frank, asking to meet me, interview me I guess. We made arrangements for him to come to my classroom, had a nice chat, and I was on the team.

The island of Sao Miguel is absolutely beautiful. Frank, and I arrived a few days before we were to sail, and we tried to use every minute well. Downtown Ponta Delgada was rich with history and architecture. The surrounding hills were green and lush, a testament to their volcanic origins. The various calderas and fumaroles were powerful reminders of what a sleeping giant the earth generally is. As a chemistry teacher amidst so many earth scientists, I was learning at every turn. The Azores are definitely on my ever growing list of places in need of a return visit.

Our ship, R/V Knorr, awaited us, tied to the pier in Ponta Delgada. Knorr is a veteran ship, in service since 1970. She has been well maintained and is equipped to support a wide variety of oceanographic activities, including coring. She was specifically tasked (and extensively overhauled a few years ago) to support WHOI's long coring system. She has an experienced, professional crew who understand that their job is not just to operate a complex ship and its systems safely, but to also support the mission of the scientific party. They do this difficult job with both grace and skill.

We sailed on Saturday morning, July 11th, and by three in the afternoon we were at work deploying the long core for a test. We kept working and coring for the next three weeks. At times the pace was exhausting, but the professionalism and good spirits of the WHOI team kept it interesting and fun. Jeff Hood, Kathryn Rose, Marti Jeglinski and Al Gagnon are all WHOI employees with various, full time land jobs at the institute. But when the call goes out to core, they pack their bags and board the ship, bringing a most impressive set of talents to bear on a unique task: neatly and gently bringing stratified samples of mud from ocean floor to surface, in depths measured in miles. On this cruise, they were joined by two of the west coast's best, Chris Moser and Paul Walczak, both of Oregon State University.

Over the course of three weeks, R/V Knorr traversed the Atlantic. We sampled spots along the Mid-Atlantic Ridge, north to an area known as the Tail of the (Grand) Banks, east to the Laurentian Fan, and south to the New England Sea Mounts. We had a lot of successes, a few misses, some gear failures, a couple of gales, and lots of beautiful

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summer weather. I quickly fell back into the routine of life at sea, recognizing the rhythms and routines from my Navy days.

This was a great experience for me. I learned about not only the science but also the engineering involved in doing the science. I would like to thank Frank Scofield and Lloyd Keigwin for giving me this opportunity. Also big thanks to the coring crew for being so patient with me, teaching me, allowing me to participate so fully, and otherwise being the wonderful, welcoming people they are. Lastly, thanks to the crew of the Knorr- having been crew on a ship years ago, I know what a hard job it is. To do it so well, and also meet and support the demands of a scientific party, is quite an impressive feat. They make it look easy.

Heather

I will add a few logistical points to wrap up our story. My own high school Earth Science teacher and mentor Tom Vaughn knew Frank and introduced us. We can't say enough about the importance of fostering networks.

The technical team at WHOI was phenomenal,

Heather learns from WHOI Research Specialist Dr. Steve Swift about the process of studying the ocean floor for viable sample sites.

giving me an over-the-phone crash course in blogging and providing ongoing support while we were aboard. Lloyd took the time to discuss his vision for our role as educators – this is a key piece to maximizing the "investment" of engaging teachers. Work aboard the ship was tough at times but we always had the option of stepping back. Communication with the scientists, researcher assistants and technicians is important. Think about how this kind of experience could add to both your

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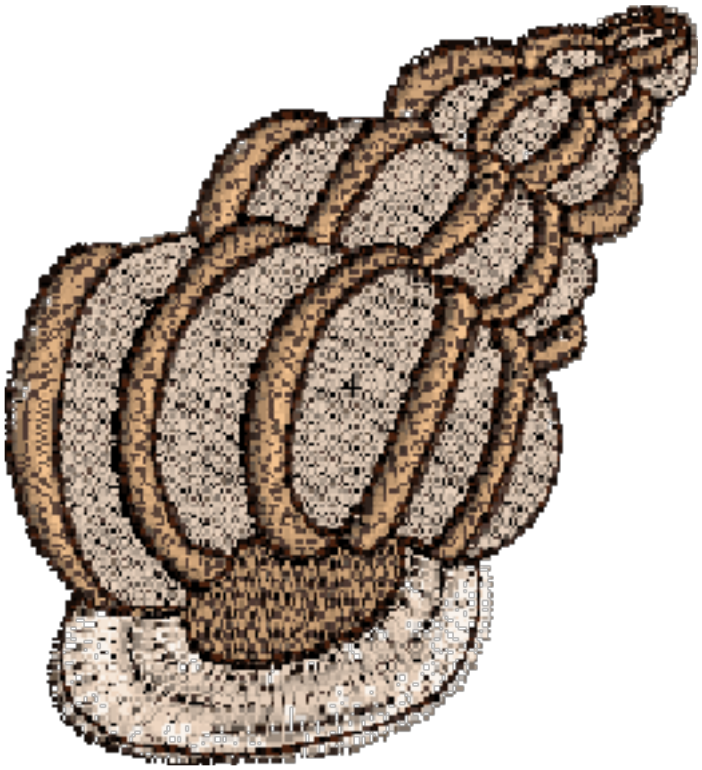
classroom and your own professional development. This experience significantly increased my awareness of career options, my understanding of the process of science and really emphasized to me that science is a collaborative endeavor, something we should be encouraging more in the classroom. We want more teachers to have impactful opportunities like this - think about it!

Frank Scofield holds a B.S. in Geology and M.Ed in Earth Science Teaching. He is currently retired from teaching Earth Science in Waltham and spending as much time as possible sailing and a good deal of the rest chasing his four grandkids around and traveling with his lovely wife Nancy.
Email: fscofield@verizon.net

Bob White holds a B.S. in Chemistry and M.A.T. in Secondary Chemistry. He is currently a teacher of Chemistry in Braintree, MA and a Coast Guard licensed captain.
Email: RWhite@braintreema.gov

Heather Pacheco holds a B.S. in Geology and Geological Oceanography and M.Ed in Education. She taught for 8 years in Framingham, MA and is currently in a PhD Program in Science Education at Arizona State University.
Email: pacheco.heather@gmail.com



NMEA 2011

You may remember from the last F&J that we started telling you about the upcoming NMEA 2011 annual conference in Boston. It's time to follow up with some more details about important dates, the conference schedule and our committees.

By the time you read this, we will have announced the Call for Proposals. These presentations are the foundation of these conferences, as they provide three days worth of sharing lesson plans, curriculum ideas, resources, contacts and new information. Proposals will be accepted until Feb 18, 2011 and we will notify all submitters by March 15 as to the status of their proposal. Past President, Pat Harcourt is Chair of this subcommittee.

We will open Advanced Registration online on January 13, 2011 and keep it open at this reduced rate until April 15. After this date, the rate will increase and registration will stay open until June 24. (Check web site for costs.) Walkup registration will be available in the Curry Student Center on campus.

There are several means of securing assistance in paying for attendance. NMEA offers general scholarships to NMEA members, and an Expanding Audiences scholarship to participants from underrepresented groups. For practitioners of Traditional Ecological Knowledge, there is a $1000 stipend available for the best applicant. Check the Scholarships page on the NMEA web site http://www.marine-ed.org/scholarships-stipends.html for application start and end dates. In addition, MME members looking to attend for the first time can apply for a Sandman Scholarship.

As mentioned in the previous F&J, the meat of the conference takes place between Wednesday, June 29 and Saturday, July 2. Wednesday, June 29 is the Field Trip day. Our field trip subcommittee, chaired by Lydia Breen, Howard Dimmick and Anne Smrcina is coordinating ten trips for our visitors that will take them around coastal MA and southern NH. There are multi-stop field trips to New Bedford, Salem and Nahant, Woods Hole, Gloucester and the village of Buzzards Bay. There are boat based trips that include a whale watch, a dive trip to Rockport, a ride up the Essex River, and a Boston Harbor Islands tour. For those who like aquaria, there is a behind-the-scenes visit to the New England Aquarium that will finish with a ferry ride to the USS Constitution. We look forward to showing off our natural resources to our visitors.

That evening, we will officially welcome everyone to Boston with an icebreaker activity, a cocktail reception and opening remarks from Northeastern University representatives, local geology expert Dr. Allen Gontz, and author Trevor Corson. We hope you are able to be with us that night and all through the conference. I've been to 12 NMEA conferences and have enjoyed every one of them. The resources and networking are invaluable.

NMEA 2011
Cape to Cape: In the Hub of Marine Education

June 29 - July 3, 2011

Northeastern University, Boston, Massachusetts

Get all of you information here

Call For Papers:
National Marine Educators Association
Annual Conference
June 29 – July 3, 2011 Boston, MA
Cape to Cape in the Hub of Marine Education
Hosted by Massachusetts Marine Educators

Calling all educators, scientists, swimmers, and all who love to learn and teach about the world of water! Come share your experiences, information, and ideas for lessons at the 2011 National Marine Educators Association Annual conference in Boston, MA. Please see strand topics listed below and note that each session must relate to one of the Ocean literacy principles. Email the completed form to: patharcourt@charter.net .
Contact Pat Harcourt for more information (508) 215-9641 or patharcourt@charter.net

See you in the Hub!

Deadline for submissions is Friday, February 18, 2011.

Strand themes for NMEA 2011

Audiences - Focus is on cultivating a global community of water conservationists. Presenters are invited to share strategies and programs that focus on connecting to underrepresented audiences.

Breakthroughs - Focus is on scientific research and new technologies that enable us to better understand the ocean, including the role of freshwater as it applies to inland waterways and its impact on the ocean.

Partnerships - Focus is on successful partnerships and collaborations among educators, researchers, diverse audiences and communities as well as opportunities for teacher training, grants, awards and classroom funding.

Research - Focus is on behavioral patterns of students and educators in schools, and other organizations as they relate to ocean literacy. Presenters are invited to share their specific projects.

STEM - Focus is on combining science, technology, engineering, and mathematics in order to provide inquiry opportunities to enhance students' understandings of aquatic ecosystems.

Sustainability - Focus is on conservation issues as they pertain to the well-being of the natural world and the responsible use of natural resources. Specific topics may include global climate change, policy initiatives and local success stories.

Teaching – Focus is on successful classroom experiences using aquatic and marine themes. Presenters are invited to share their best practices.

Traditional Knowledge – Focus is on the long standing traditions, practices and cultures of regional, indigenous and local communities as they relate to freshwater and marine environments. Traditional ecological knowledge is cultural practice based on generations of place-based observations and empirical, experiential information. Presenters are invited to share perspectives, programs and strategies that embrace, support and celebration traditional knowledge.

CLASSROOM ACTIVITY

Aquaculture in the Middle School Classroom

Bill Andrake, Swampscott Middle School

In my twenty plus years of classroom aquarium keeping I have found that many of the learning standards we need to address can be made relevant and meaningful by integrating some form of aquaculture in the classroom. Whether its a simple aquarium or large aquaculture system, I have found that most students are fascinated by aquatic life and welcome the opportunity to observe and raise these creatures.

The science of the aquarium is the science of ecology. Lessons in biology, physical science, and chemistry can be incorporated into the maintenance and operation of an aquarium. The challenge to aquarium keeping is to mimic those conditions found in nature using mechanical devices, chemicals, and cooperative creatures. To make sure the simulated environment is safe for the residents of the aquarium involves measurement, data collection, and analysis.

In addition to good science, the aquaculture projects promote lessons in responsibiltiy, teamwork, and stewardship. Most importantly, aquarium keeping is an excercise in creative and practical problem solving, as there are inevitable problems (teaching opportunities) that arise in even simple systems. It is rewarding to see students identify a problem in a system from their water quality data and then take the steps needed to solve it. As is often the case, I don't have a solution for many of these problems, thus we need to work together to solve it and we all learn.

I certainly do not consider myself to be an expert in this area as I am always learning new methods for aquaculture and still making mistakes. However, with each mistake I find that I am better equipped to anticipate a potential problem and take the necessary precautions to prevent it. Its nice to see this ability develop in my students as we carry out our projects.

It would be nearly impossible for me to share all that I have learned in this contribution to "F & J." However, I thought that I would summarize in this issue the project that I do with my seventh graders and I would like to offer some basics I have learned on aquarium filtration to which apply to any system. I would also like to thank those who have helped me to implement aquaculture in my classroom especially Brandy Wilbur and Sarah Hammond with MIT Sea Grant's Aquaculture Education Programs.

The Aquaculture of Winter Flounder in a Recirculating Aquaculture System

The seventh-graders at Swampscott Middle School have been working with M.I.T. Sea Grant's education outreach program since 2003 in the aquaculture of Winter Flounder.

Like many of our commercially valuable saltwater finfish, Winter Flounder populations are in decline due to pollution and overfishing. The aquaculture of these fish is one way to help restore their populations.

Our students have conducted several projects involving aquaculture of Winter Flounder, Pleuronectes americanus in a recirculating aquaculture system. It has been a great opportunity for our students to learn experimental design and experience the scientific process in a real and "hands-on" manner.

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The Winter Flounder are raised in a chilled recirculating aquaculture system or “R.A.S.” designed by aquaculture specialists at M.I.T. seagrant. See an animation of the system at the link below.
http://seagrant.mit.edu/education/resources/recirc.html

The following are photos of our R.A.S.

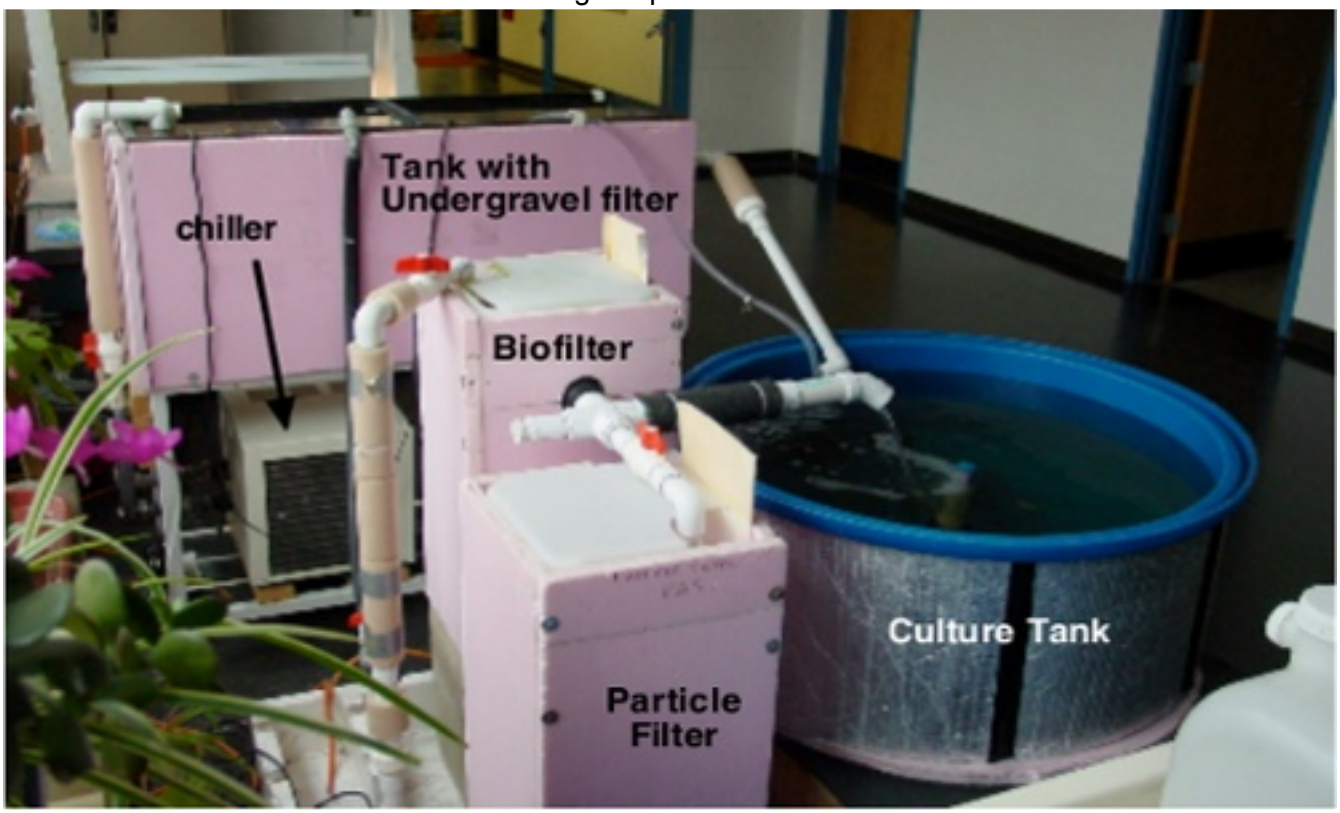

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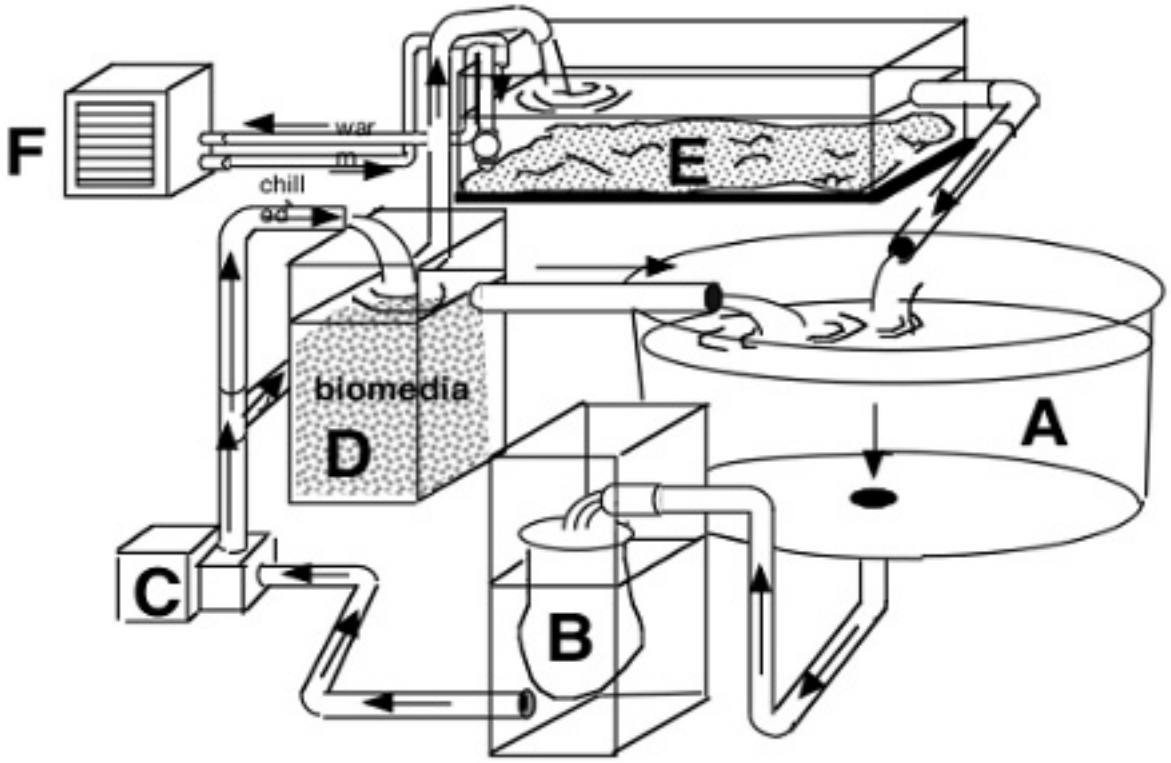
Illustration of the R.A.S.



(A) Culture or Habitat Tank (B) Particle Bag Filter (C) Circulation Pump
(D) Biofilter (E) Undergravel Filter Tank (F) Chiller

Water leaves the biofilter and returns to the culture tank after passing through the undergravel filter tank, which serves as an extra culture tank as well as another biofilter in the system.

CLASSROOM ACTIVITY

The Nitrogen Cycle in Action: Biofiltration in Aquaculture Systems

by Bill Andrake Swampscott Middle School

Organisms kept in aquaria are living in a closed environment and are in effect living in their wastes, namely carbon dioxide, the by-product of respiration and ammonia (NH3) from the breakdown of nitrogen, containing organic molecules such as proteins.

Ammonia is excreted from animals as they deal with metabolic and digestive wastes and is also released from the decay of uneaten food or any death in the aquarium. Ammonia is fatal for most aquarium animals (especially fish) in concentrations of only 1-2 ppm, so if these wastes are not dealt with they can lead to death in a short period of time.... more ammonia. One solution is to change the water everyday, but this isn't realistic. The solution is biological filtration (filtration by living things).

Biofiltration in the aquarium

Biological filtration takes advantage of nature's way of dealing with these wastes through the Nitrogen Cycle. In this process certain forms of beneficial *Nitrosomonas* bacteria feed on ammonia and convert it into a less toxic compound of nitrite. The nitrite is then consumed by *Nitrobacter* bacteria and converted to non-toxic nitrate compounds. See the diagram below.

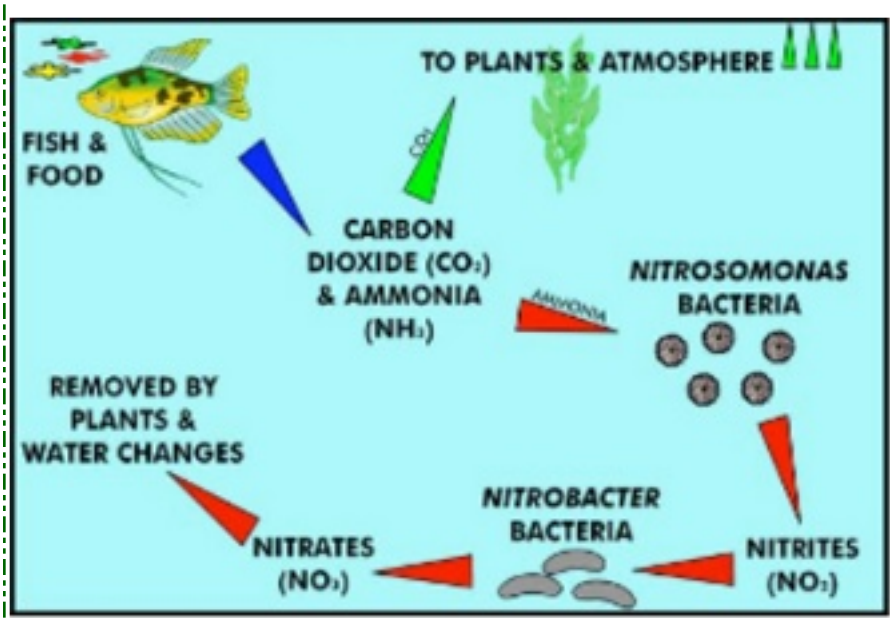


Diagram by Les Pearse from Filtration and the Nitrogen Cycle. aquarticles.com

Nitrate compounds are safe in high concentrations for most aquarium animals. However, high concentrations of any material dissolved in water means less space between the water molecules for oxygen. Additionally, nitrates serve as fertilizer for algae, which can become a nuisance. Therefore, partial water changes are recommended to keep the nitrate levels down.

Setting up a biofilter in aquaria

A good aquaculture system is set up to take advantage of the nitrogen cycle by maximizing the growth of the beneficial bacteria which convert ammonia to safer nitrogen compounds. These bacteria are everywhere and will readily multiply in the presence of ammonia and a surface for them to grow upon.

The bacteria grow on every surface in an aquarium from the tank surface to rocks, pipes, and tubes. However, this is not enough surface area to get the population density of bacteria needed to effectively neutralize ammonia. The best way to maximize the growth of these bacteria is to come up with a way to to have a lot ... that's A LOT OF SURFACE AREA FOR BACTERIA TO GROW ... and that's what biofilters are set up to do.

There are many filters on the market which foster biological filtration all with advantages and disadvantages. All biofilters have water passing through beds of gravel, sponges, or thousands of plastic pellets called "Biomedia". All of these materials provide a lot of surface area in a small space for bacteria to grow.

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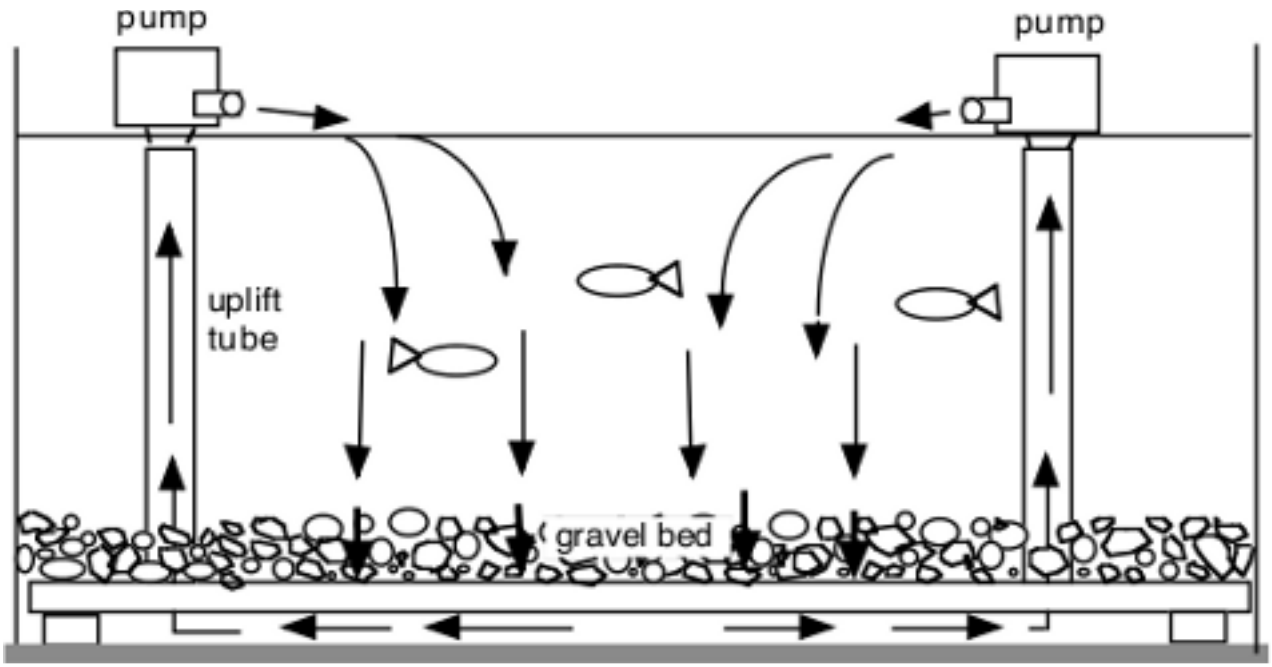
Bed Filter Media from Water Management Technologies Inc.

Look at all of the surfaces for bacteria to grow on just one pellet!

The Undergravel Filter



The gravel bed is the “biofilter” for this system. It rests on a raised porous plastic platform. As water falls through the gravel bed bacteria change ammonia to nitrites, and nitrates and particles that make the water cloudy are also filtered. Cleaned water now lies under the gravel bed. Powerhead pumps pull filtered water up from below the gravel through the uplift tubes and into the aquarium’s living space.

Some designs use air stones connected to an air pump to bubble up water through uplift tubes. This design may be less expensive at first, air stones wear out and clog up quickly and need frequent replacement . In addition, they don’t supply the lift needed to draw water through a substantial layer of gravel effectively. I recommend using powerhead pumps on these filters. They are a little more money at first but they last a long time.

The advantage to this set-up is that everything is in the tank with two pumps. With power filters, which are also very good filters, a canister or tank sits outside of the aquarium. Water must be drawn from the tank and pass through the filter and return to the system. If there are any air locks in the system, pump failure, or pipe leaks, you can have a real mess.

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The disadvantage to the undergravel system is that it does require vacuuming from time to time to keep the gravel from getting too clogged. This is a lot more maintenance than is required for most power filters.

Getting the Nitrogen Cycle established... "Cycling"

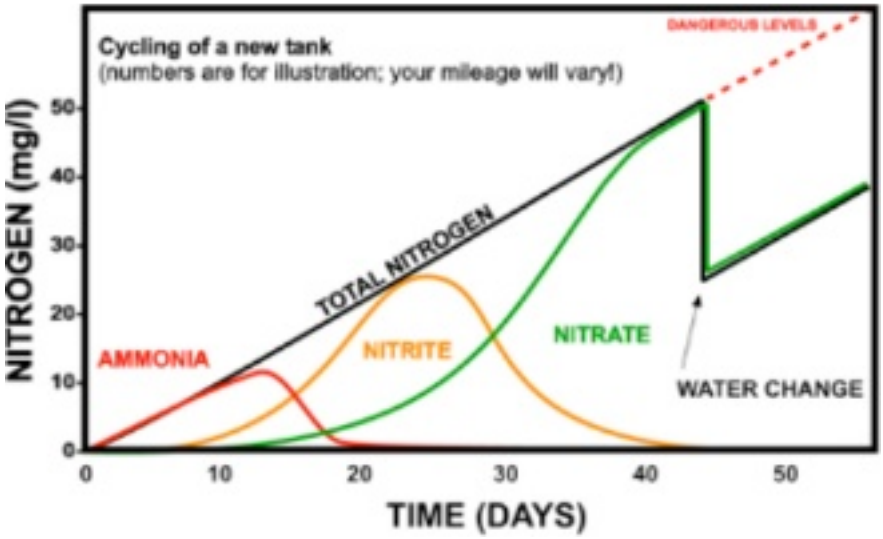
First of all you need a good aquarium water test kit to measure ammonia, nitrite, nitrate levels and pH.

Once the tank and filter have been set up you need a source of ammonia and the *Nitrosomonas* bacteria will show up to the feast. Not right away, but in a week or two or three... be patient. I have gotten things started by adding a few drops of clear household ammonia to a tank every few days or so. You can also jump start the system by taking materials, ie. gravel or pieces of sponges from established biofilters and innoculating your new filter with bacteria.

Test the water every couple of days and it will happen; you will notice that the ammonia levels in the water have dropped to near 0 ppm and at the same time nitrite levels are climbing. This tells you that the *Nitrosomonas* bacteria are thriving but no Nitrobacter bacteria yet.

Keep the ammonia going as you have to keep feeding the *Nitrosomonas* bacteria. In a couple of weeks the nitrite levels will begin to drop and nitrate levels will rise indicating that *Nitrobacter* bacteria have multiplied in the system. At this point the biofilter is established and it is safe to begin to gradually add animals to the aquarium. Keep testing the water to make sure that the ammonia and nitrite levels stay at 0 ppm.

Aquarium cycling may take 6 to 8 weeks. If you can't wait that long, then be prepared to conduct frequent water changes.



An excellent class activity is to graph the progress of the Nitrogen Cycle in a new aquarium. Also, keep in mind that if you remove the aquarium animals from the tank for any length of time, you need to add a drop or two of ammonia to the water every couple of days to maintain healthy populations of bacteria in the biofilter.

Biofiltration is without question the single most important concept that one needs to understand and maintain to have a successful aquaculture system.

Marine Scientists Unveil the Mystery of Life on Undersea Mountains

From: Life Science News lifesciencenews@wiley.com

They challenge the mountain ranges of the Alps, the Andes and the Himalayas in size yet surprisingly little is known about seamounts, the vast mountains hidden under the world's oceans. Now in a special issue of Marine Ecology scientists uncover the mystery of life on these submerged mountain ranges and reveal why these under studied ecosystems are under threat.

The bathymetry of our oceans is now resolved at a scale and detail unimaginable by early pioneers and recent estimates suggest that, globally, there may be up to 100,000 seamounts, yet less than 300 have been well studied. Recognizing this scarcity of knowledge provided the motivation CenSeam, a seamount-focused field research project within the **Census of Marine Life** which commenced in 2005.

"The field of seamount ecology is rife with ecological paradigms, many of which have already become cemented in the scientific literature and in the minds of advocates for seamount protection," said Dr Ashley Rowden, one of the principal investigators of CenSeam. "Together, these paradigms have created a widely held view of seamounts as unique environments, hotspots of biodiversity with fragile ecosystems of exceptional ecological worth."

The special issue puts major paradigms in seamount ecology under the microscope to assess their status against the weight of existing evidence to date, and against the backdrop of the latest findings.

Researchers challenged the theory that seamounts act as hotspots of species richness, the weight of evidence now suggests that seamounts may have comparable levels of diversity and endemism to continental margins. However, it appears that their ecological communities are distinct in structure, and of higher biomass than neighbouring continental margins.

The geographical differences between seamount communities have suggested limited larval dispersal, local speciation, geographic isolation, or a combination of all these processes. New genetic research presented in the special issue addresses these themes, documenting complex patterns of connectivity among species populations that depend on spatial scale, physical barriers, and life history characteristics.

Much seamount research has been born out of the need to better manage these potentially vulnerable ecosystems. Globally, seamount ecosystems are under pressure from bottom-contact fishing and other human-related impacts. Researchers detail the footprint of trawling and a risk assessment confirms what has long been suspected: seamount communities are highly vulnerable to disturbance by bottom trawling and recovery from fishing impacts is a lengthy process, likely requiring decades at a minimum.

Its also predicted that a shallowing of the aragonite saturation horizon caused by ocean acidification is expected to place deepwater corals at risk, but researchers pose that the summits and upper flanks of seamounts may yet provide a spatial refuge from these impacts.

"It is hoped", says Thomas Schlacher, lead editor of the volume, "that the papers in this special issue will challenge some of the previously held concepts about seamount ecosystems, and hopefully stimulate and help guide future research endeavours both on seamounts, and across the wider deep-sea realm."

Research papers from the Census of Marine life have been published in two special issues of the Marine Ecology, published by Wiley-Blackwell. The Census of Marine Life's latest title Life in the World's Oceans: Diversity, Distribution and Abundance, also published by Wiley-Blackwell, and including the research of CenSeam, will be available in October.

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America's Colonial Hydrologic History Recreated

Human activities played important role in the evolution of watershed

Image of The Lake of the Dismal Swamp by John Gadsby Chapman, 1842.
Credit: Courtesy of the American Antiquarian Society

Image of The Lake of the Dismal Swamp by
John Gadsby Chapman, 1842.
Credit: Courtesy of the American Antiquarian Society

Once lost in the mists of time, the colonial hydrology of the northeastern U.S. has been reconstructed by a team of geoscientists, biological scientists and social scientists. The results, which extend as far back as the year 1600, appear in the current issue of the journal Environmental Science & Technology (ES&T).

The findings provide a new way of uncovering the hydrology of the past, and will lead to a better understanding of hydrologic systems now and in the future, the scientists say.

"We outline a methodology for synthesizing modern scientific data with historical records, including anecdotal sources," says Christopher Pastore of the University of New Hampshire, the paper's lead author. "It underscores the role of humans in an assessment of hydrologic change."

Throughout American history, water resources have played an integral role in shaping patterns of human settlement and networks of biological and economic exchange. "The research emphasizes the effect of human activities on the evolution of watersheds and on the dynamics of ecosystems important to water sustainability," says Thomas Torgersen, program director in NSF's Division of Earth Sciences, which funded the research.

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The scientists divided their study area into three geographic and socio-political subregions: New England; the Middle Colonies; and the Chesapeake. They then looked at the ways in which physical variables--such as soil, vegetation, and climate--combined with socio-political factors to influence each subregion's hydrologic environment.

In New England, for example, close-knit religious communities with strong central governments concentrated their economic efforts on fur-trading and timber extraction, according to the paper's co-authors, which include Charles Vorosmarty of the City University of New York, principal investigator on the NSF grant.

The Chesapeake region, on the other hand, was settled largely by young, unskilled men who cleared trees and planted tobacco fencerow to fencerow. "This caused extensive erosion, which dramatically altered rivers," says Pastore.

The Middle Colonies were characterized by diverse social, cultural, and religious traditions and feudal-style estate agriculture.

Integration of human decision-making into analyses of land-cover change, engineering and climate change is fundamental to understanding subregional hydrologic patterns and how they interact, the scientists say. They recommend two metrics for quantifying hydrologic change.

* The first, which they call a simple water balance, takes into account precipitation, evapotranspiration, and water storage, which can be used to track changes in annual river discharge.
* The second, termed mean water residence time, or the average time a water molecule spends in one place, can also be used to calculate the amount of water moving through a system.

The resulting information helps determine past water residence times, which in turn allow scientists to infer changes in the biogeochemistry of rivers and streams. Many pathogens, or disease-causing organisms, are linked to water flows. An understanding of historical water residence times, says Pastore, may lead to new insights into how diseases are transmitted today.

Other co-authors of the paper are: Mark Green of Plymouth State University; Daniel Bain of the University of Pittsburgh; Andrea Munoz-Hernandez of the City University of New York; Jennifer Arrigo of East Carolina University; Sara Brandt of the U.S. Geological Survey in Northborough, Mass.; Jonathan Duncan of the University of North Carolina at Chapel Hill; Francesca Greco of King's College, London; Hyojin Kim of the University of California at Berkeley; Sanjiv Kumar of Purdue University; Michael Lally of the University of Massachusetts at Amherst; Anthony Parolari of MIT; Brian Pellerin of the U.S. Geological Survey in Sacramento, Calif.; Nira Salant of Utah State University; Adam Schlosser of MIT; and Kate Zalzal of the University of Colorado at Boulder.

-NSF-

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The National Science Foundation (NSF) is an independent federal agency that supports fundamental research and education across all fields of science and engineering. In fiscal year (FY) 2010, its budget is about $6.9 billion. NSF funds reach all 50 states through grants to nearly 2,000 universities and institutions. Each year, NSF receives over 45,000 competitive requests for funding, and makes over 11,500 new funding awards. NSF also awards over $400 million in professional and service contracts yearly.

NOAA Launches Education Website With New Look and Content

New NOAA Education Website.

Site Link (http://www.education.noaa.gov/)(Credit: NOAA)

To better connect educators and students who are interested in NOAA's education and science resources, NOAA has just completed a major update of the agency's primary education resource portal, (http://www.education.noaa.gov/).

This website serves as a portal to lesson plans, educational multi-media, data sources, career profiles, and other education content from across the agency. The content is centered on five thematic areas that highlight NOAA science and stewardship, the themes are: Oceans and Coasts, Climate, Weather and Atmosphere, Marine Life, and Freshwater. Under each theme are topical resource collections that support common teaching topics and align with state and national science education standards.

"Educators look to NOAA as a trusted source for science based content they can use in their classrooms," said Louisa Koch, director of the NOAA Office of Education "This website has been completely redesigned and makes it easier for them to find the materials they need and want."

Teachers looking for information about hurricanes, tides, climate change, the water-cycle or other earth science topics will find scientifically accurate and evaluated content on this site. Materials will be added regularly and the list of collections will continue to grow to support the needs of the education community with current real-world science content. The site also provides information on professional development, academic scholarships, career exploration, and education grants.

The resources on (http://www.education.noaa.gov/)are easy to access and are easy to include into existing teaching activities. Whether an educator needs a video, educational game, data set, lesson, or activity the site provides some of the best materials NOAA and its educational partners have to offer.

The update to this website is based on research about what educators need for in their classrooms to teach science and stewardship. Input was gathered from educators on a national and local level to create a blueprint for this new format. NOAA's mission is to understand and predict changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and to conserve and manage our coastal and marine resources.

NOAA Arctic Report and Web links

The Arctic Report Card (http://www.arctic.noaa.gov/reportcard/) tracks recent environmental changes throughout the Arctic, and is updated annually. In 2010, it is clear that the Arctic is experiencing the impacts of a prolonged and amplified warming trend, highlighted with many record-setting events. Not surprisingly, the impact of this warming is most evident in the dramatic losses that have been observed in the ice covers that define the region. Since the loss of these ice covers serves to further feed the warming trend, the expectation is that warming will continue. This makes it increasingly unlikely (at least for the foreseeable future) that the Arctic will return to conditions that were considered normal in the later part of the 20th century. Instead, it is very likely that Arctic climate warming will continue and we will continue to see records set in years to come. The Arctic Report Card (http://www.arctic.noaa.gov/reportcard/) tracks recent environmental changes throughout the Arctic, and is updated annually. In 2010, it is clear that the Arctic is experiencing the impacts of a prolonged and amplified warming trend, highlighted with many record-setting events. Not surprisingly, the impact of this warming is most evident in the dramatic losses that have been observed in the ice covers that define the region. Since the loss of these ice covers serves to further feed the warming trend, the expectation is that warming will continue. This makes it increasingly unlikely (at least for the foreseeable future) that the Arctic will return to conditions that were considered normal in the later part of the 20th century. Instead, it is very likely that Arctic climate warming will continue and we will continue to see records set in years to come.

In addition to the Arctic report card website, NOAA also has an Arctic Theme Page with links to more than 20 different locations. To see this site go the theme page at (http://www.arctic.noaa.gov/)

For more information about the 2011 Marine Art Contest, please go to the MME website.

To get a membership application, please go to
http://www.massmarineeducators.org/membership.shtml