In this issue....

3
Microbes and Mud Give Scientist Clues about Life on Mars... and Earth

Peg Van Patten

5
Rapid Evolution Rampant at Sea

Hans G. Dam

6
Marine Protected Areas: an Ecosystem-Based Fisheries Management Tool

Bob Pomeroy

8
Lobster Resource Showing No Signs of Recovery as Research Progresses

Nancy C. Balcom

16
Gifted and Talented Youth Join Marine Scientists for a Day of Fun and Science

Nancy C. Balcom

The Year of the Shad

Tessa S. Getchis
NASA’s Mars Rover is expected to provide geologic samples from the surface of the Red Planet in 2004. Meanwhile scientists are already studying rocks and sediment from Space for microfossils and other clues that may tell us whether life is, or was, present.

Astrobiologists hope to determine whether other planets in the universe have supported life or may be evolving the precursors to life as we know it.

Photo: National Aeronautics and Space Administration (NASA)
Pieter Visscher’s work is out of this world—sometimes literally, as he works with the NASA Astrobiology Institute as part of the Pale Blue Dot project team. Astrobiologists study the origin, evolution, distribution, and future of life on Earth and in the Universe, so part of their mission is to seek life beyond Earth. Extraterrestrial life is a very real possibility from Visscher’s perspective (which due to the nature of his research, is a bit broader than most).

Besides seeking the true answer to the old question, “Are we alone?”, astrobiologists want to identify planets that may have the potential to support life, should humanity ever feel the need to migrate on a grand scale.

The “Pale Blue Dot” is how author Carl Sagan described Earth as viewed in a photo taken by U.S. astronauts from deep space, and the name underscores the importance of scale and perspective in scientific pursuits. Ironically, this planet that defines our very existence is barely visible in the grand scheme of things. Visscher, both a biogeochemist and an astrobiologist, looks at life from our biggest lenses—information provided by instruments aboard NASA spacecraft, such as the Hubble telescope, to our tiniest—

Microbes and Mud give Scientist Clues about Life on Mars ...and Earth

by Peg Van Patten

The specialized electron microscopes in the university laboratory, and tries to put the observations together.

“I truly believe that there is life on Mars,” Visscher says, “and that, when we find it, it will be aquatic and subterranean.” No, he doesn’t wear a tin foil hat or talk to tiny green men. What he does do, as an Associate Professor of Marine Sciences at the University of Connecticut, is use high-tech tools such as a scanning laser confocal microscope and microautoradiography to examine the activities of tiny green-blue cyanobacteria and other primitive life forms that were present during our planet’s early days, as well as organic cycles that determine how sediments form and persist.

It’s not as strange as it sounds. Recent photos of Mars taken during the NASA Odyssey mission show channels thought to be the remains of early rivers that once cut patterns through the surface of the Red Planet, and dirty ice was found below the Martian surface in 2002.

continued on page 4

A founding member of NASA’s Astrobiology Institute, UCONN marine scientist Pieter Visscher is also an astrobiologist with the NASA Pale Blue Dot EMERG team. They want to learn more about early and emerging life, both on Earth and distant planets. A native of the Netherlands, Visscher came to UCONN in 1994.

Photo is a whimsical composite of a portrait by Peter Morenus, UCONN, and NASA Images.
A debate still rages on as to whether crystals found in a meteorite that broke off of Mars are fossilized remains of life or not. And clouds have been observed in the atmosphere of some distant planets. “The problem is, we don’t yet know what’s under the clouds—could there be a Sea Grant office on the surface obscured by the clouds?”

Joking aside, Visscher explains that before we can identify, confirm, or understand emerging or evolving life in space, we need to understand what early life and the environment of Earth was like long before humans came into the scene. In other words, we need to know where we’re coming from before we can predict where we’re headed.

“Biogeochemistry combines three disciplines—biology, geology, and chemistry,” Visscher explains. “That’s important because it’s the combination of processes in nature, rather than the individual ones, that allow us to better understand our environment and predict what may happen when it is perturbed.” His pursuits focus on what happens to simple organic compounds—the stuff of which life is made—in the coastal sea.

To find out about early life on Earth, Visscher works with a team on a project fondly called RIBS (Research Initiative on Bahamian Stromatolites). It has nothing to do with Baby Backs or barbecue sauce—rather, it has to do with the study of stromatolites, a type of microbial reef found in shallow seas. Stromatolites consist of layered rock composed of tiny crystals produced by microbial organisms. Some say they cannot correctly be called either living or nonliving, since it is an interactive combination of both. These strange mounds found in coastal waters represent the intertwining of simple life forms such as blue-green bacteria with layers of sediment formed from their secretions, to form large multi-layered structures. Stromatolites were quite common in the Precambrian period of Earth’s history, but are rare now. Until 35 years ago, existing examples were unknown, then stromatolites were discovered at Shark Bay, off Australia. Seventeen years ago, more formations were found off the Bahamas, and these are now considered to be the only known living examples. The earliest fossilized stromatolites are more than three and a half billion years old, and thus are evidence of the very earliest life on our planet. Some grew to the size of today’s typical house. If life is emerging on other worlds with similar conditions, Visscher thinks it will likely be similar.

The RIBS team includes experts in many fields, in order to get the big picture of how life forms, geological sediments, and chemical cycles are interacting. Visscher’s primary role is to examine geochemical processes such as the sulfur cycle. Why sulfur? Most of us who poke around wrack lines, if we think of sulfur at all, connect it with the pungent odor of low tides or the stink of rotten eggs (hydrogen sulfide). Others recall that highly flammable yellow stuff in chemistry class—those of a certain age might come up with the term “brimstone”. Sulfur originates in the Earth’s crust and enters the atmosphere and oceans as a gas, then, once oxidized, may fall back to earth as weak sulfuric acid, better known as “acid rain”. When taken up by plant roots, sulfates, the soluble forms of sulfur, are incorporated into some amino acids and become, as it travels through the food web as part of animal proteins. As organisms decompose, the sulfur is released again as gas.

In the case of stromatolites, those strange “living rocks”, layers of green or purple bacteria colonies called “microbial mats” cycle sulfur, and as a product secrete calcium carbonate (limestone to us—the same stuff
By Hans G. Dam

By some accounts almost half of all Americans believe that evolution is just a theory, not a fact. This is perhaps the most pervasive and dangerous misconception about the wondrous process that has shaped life as we know it. Another misconception, one that even Charles Darwin held to some extent, is that because evolution proceeds at a snail pace we cannot witness it in action. As author Steven R. Palumbi points out in his readable *The Evolution Explosion*, both of these misconceptions are dismissed by examples of “antibiotic resistance, the triumph of HIV over antiviral drugs,… and resistance of insects to nerve gas pesticides” all of which have happened in a few decades. Similarly, in his book the *Beak of the Finch*, Pulitzer Prize-winner Jonathan Weiner describes how evolutionary biologists are documenting evolution as it occurs among the celebrated Galápagos finches that inspired Darwin to formulate his famous theory of natural selection.

Most examples of rapid evolution are from land studies. But aquatic scientists are quickly realizing that rapid evolution is also rampant at sea. For instance, selective removal of large fish in commercial fisheries has led to dramatic changes in the size of some species. A delicious example (bad pun intended) is the 30% decrease in the mean size of pink salmon caught off British Columbia, Canada, since the 1950’s, a fact documented by fisheries biologist W.E. Ricker.

Pink salmon are born in freshwater streams, spend their youth at sea and return after two years, when they mature, to their native streams to spawn. The return to the spawning grounds is such a Herculean effort that after spawning, the wasted salmon die. In this life-history pattern, salmon put all their eggs in one basket and the stakes for leaving offspring are immense. Fishermen have figured out this life cycle and understand that it is better to catch the salmon before they are physically wasted; hence, they set their gill nets on the path of salmon trying to return to their spawning grounds.

Because pink salmon returning to a spawning ground are all two years old, larger individuals are those that have grown faster. Unfortunately for these fast growers, they are disproportionately retained in the gill nets. Relatively few of these fast-growing salmon ever get the chance to reach their spawning grounds to reproduce. In contrast, the slow-growing and smaller salmon pass through the nets to reach their spawning grounds, where they can produce offspring. Over the years, the proportion of slow-growing individuals has increased in the population, leading to a decrease in mean size of the fish caught in the gill nets.

In this salmon story, we can reason that the reduction in fish size with time has resulted from selection against fast-growing individuals, a case of natural selection. Natural selection is one of the main mechanisms of evolution.

The salmon story illustrates the essential ingredients for natural selection to occur: 1) variation in traits among individuals in a population (in this case size at
Coastal marine and freshwater living resources are under stress. Many populations, along with the ecosystems upon which they depend, are showing signs of collapse as a result of increasing overexploitation and habitat degradation by fishing activities. At present, the United Nations Food and Agriculture Organization reports that roughly 70 per cent of fish stocks for which data are available are fully exploited or overfished. The potential impact of the degradation of coastal and marine ecosystems on human health, food security, conservation of biodiversity, and local and national economies will be multiplied as coastal populations continue to increase. The pressure on these systems will be multiplied as well.

Approximately one billion people rely on fish as a major source of their food, income and/or livelihood. Assuming that this is accurate, at least 85 per cent of these people rely on fish as their major source of protein. For 60 per cent of populations in developing countries, 40 to 100 per cent of their animal protein comes from fish. For example, fish contribute more than 50% of total proteins in Bangladesh, Congo, Ghana, Guinea, Indonesia, Japan, and Senegal, as compared to less than 20 per cent in the United States.

The sea was long thought to be an inexhaustible supply of animal protein for human use. Recently, however, as the impacts of human use have become more apparent, our understanding of the limits of the seas’ wealth has become clearer. In the U.S., of 905 fish stocks monitored within the 200-nautical mile Exclusive Economic Zone, 164 stocks are in an overfished condition. Closer to home, commercial fisheries in Connecticut and Long Island Sound are in transition as well, with a number of fish stocks overfished and one commercially important stock (lobster) suffering from a severe die-off due to yet unknown causes.
Obviously, the seas’ resources are not inexhaustible and they must be used sustainably. There has been a call for sustainable fishing, that is, fishing activities that do not cause or lead to undesirable changes in biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next.

In recent years, the collapse of some populations and social impoverishment of some of the world’s best known and most productive fishing grounds (e.g., George’s Banks) has fueled a widespread and growing belief that the conventional fisheries management approaches, such as using various harvest control regulations, is more part of the problem rather than of the solution of fisheries overexploitation.

In the last decade, following concerns about conventional management as well as fishery overexploitation and environmental degradation, the objectives, approaches and policies of fishery management systems have begun to change. The objectives have shifted from maximizing annual catches and employment to sustaining stocks and ecosystems, and from maximizing short-term interests to addressing both short- and long-term interests. There is a shift from using only conventional production and stock- and species-based approaches to include conservation and ecosystem-based management.

Ecosystem-based management is an approach to maintaining ecosystem health and sustainability through emphasis on protecting the productive potential and biological diversity of the system that produces goods and services from the ecosystem, as opposed to protecting an individual species or stock as a resource. Ecosystem management pays attention to species interactions such as competition and predation, conservation of habitat, and protecting critical life history stages of species. Ecosystem-based measures, such as marine protected areas, provide alternatives for protecting fish populations and the habitats upon which they depend.

Because of their integral role in marine biodiversity conservation and sustainable development policies, marine protected areas (MPAs) have recently emerged as a solution to intractable fisheries management problems.

continued on page 13
FRUSTRATION AND LOBSTERS go hand in hand these days. Frustration at the lack of lobsters, frustration and despair at the loss of a livelihood, frustration at the amount of time it takes to find answers. Frustration at watching those answers being sought in universities and a federal civil court simultaneously. Today, the problems generated by the massive Long Island Sound lobster mortality event in the fall of 1999 are still with us.

Scientists feel the answer is coming into focus, but conclusive results are not yet available, as research projects will not be completed for another six months to a year. Yet, from this massive research effort, scientists are learning a lot about lobsters, information that will prove beneficial to resource managers, policy makers, and lobster biologists in the long run. And yes, hopefully it will lead to the long-term recovery of the lobster resource in Long Island Sound. This information may help those in Rhode Island and Massachusetts, faced with their own plummeting lobster landings. It may even help those in Maine enjoying record high landings of lobsters.

Good, rigorous, reproducible research takes time. Lobster stocks may recover over time. But for lobstermen, time is the enemy.

“The lobsters are depleted and the fishermen are suffering,” says Nick Crismale, president of the Connecticut Lobstermen’s Association. Three years after the LIS lobster resource was declared a fishery disaster, those that have not already left the fishery are still struggling financially, waiting and wondering whether they should continue to hang on, or give up and find something else to do. Weighing and balancing the odds of a turn-around this year or next. Loving their traditional livelihood. Hating the idea of shore-based, water-less employment. Waiting for the research community to provide final results. Wondering what fisheries managers will do with the information to facilitate the recovery of the resource. Waiting for the civil lawsuit filed in 2000 against the manufacturers of mosquito control pesticides to progress.

Today, there are about half the number of licensed commercial lobstermen fishing the Sound than there were nine years ago. The number of market-sized Long Island Sound lobsters landed went from a high of 11 million pounds in 1997 to 2.5 million pounds in 2002.

While the harvest data show that recent landing of market-sized lobsters are similar to those of 1985–1986, the difference is in the amount of effort it took to catch the lobsters, which was much greater in 2001-2002. The average number of pounds of lobsters caught per trap dropped from 23 pounds in 1986 to about 7 pounds in 2001. Nearly three times the number of traps used in the mid-1980s are used now. It takes more effort to catch fewer lobsters, and costs more, too.

A tagging study conducted by the Connecticut Department of Environmental Protection (DEP), in cooperation with some lobstermen, is in its second year. The tags, colored orange or white, have a monetary incentive associated with them, to encourage lobstermen to report any tagged lobsters they catch, before re-releasing them.

“The tag return data so far show that lobsters are not inclined to move far from their original release points after they are tagged,” said Penny Howell, a DEP marine fisheries biologist. “Most move less than 5 km, although some have been found more than 20 km away from where they were tagged and released.” Overall, the net movement of the lobsters is slightly to the east.

This information becomes more interesting when it is coupled with the results of a genetic study of the Long Island Sound lobster population, conducted by
Joseph Crivello at the University of Connecticut for the CT DEP. Crivello’s study shows that overall the lobster population in the Sound functions as a distinct population from, for example, those found offshore in the Atlantic. This study further found that the lobsters in the western part of the Sound, from Bridgeport south and west, are about as genetically different from lobsters in the eastern and central sections of the Sound as they are from lobsters caught offshore.

**What progress has the research community made?**

In March 2003, 225 researchers, state and federal resource managers, lobstermen, and other concerned individuals convened in Bridgeport, Connecticut for the Third Long Island Sound Lobster Health Symposium. Co-sponsored by the LIS Lobster Mortality Research Initiative and the CT DEP LIS Research Fund, the meeting was organized and hosted locally by Connecticut Sea Grant. “While the purpose of this symposium was to present preliminary results from the on-going research projects, some, in particular the lobstermen, were looking to participate in policy discussions,” said Edward Monahan, Director of Connecticut Sea Grant. “They’ve been waiting for answers since the fall of 1999. Time has run out for many of them, and they’ve had to leave the fishery. But good answers will only come from good research, which takes time. It’s a very unfortunate mis-match of time scales.”

The current status of the lobster resource and preliminary results from 19 research efforts, funded by the Lobster Mortality Research Initiative were summarized. The research projects were loosely grouped into four topics, environmental stressors, physiological response to stress, pesticides, and parasites and disease.

“The environmental conditions (higher water temperatures, seasonal low dissolved oxygen levels, and the presence of ammonia and sulfides in the bottom waters) present in western Long Island Sound in the fall of 1999 were capable alone of causing lobster mortality, or at least to have stressed infected lobsters to the point that resulted in mass mortality,” said Carmela Cuomo, a research associate at Yale University.

How do lobsters react to stressful conditions? Investigators are now gaining a better understanding of how a lobster’s immune system reacts to the presence of foreign cells (e.g. disease organisms) by studying the formation of antimicrobial agents in lobster hemocytes or blood cells, said Richard Robohm, a fishery biologist with the National Marine Fisheries Service, at the symposium. They are also looking at how levels of stress proteins in a lobster change in response to unsuitable environmental conditions. Six research teams are developing these tools to better evaluate the ability of lobsters to protect themselves against disease, when exposed to environmental stresses like abnormally warm water temperatures, low dissolved oxygen levels, or sulfides.

In 1999, lobstermen reported finding egg-bearing females that were molting. Female lobsters normally carry their eggs for nine months and do not molt (shed their shells in order to grow) during this period. These “eggers” also seem to be more susceptible to the shell disease pitting the shells of lobsters living in the eastern portions of the Sound, as well as Rhode Island waters and Buzzards Bay, Massachusetts.

“We found that the level of a certain lobster hormone called ecdysone, that normally increases right before molting, is elevated at other times in shell diseased lobsters. This may be the reason why molting may be occurring while eggs are still being carried,” says research team leader Hans Laufer, emeritus professor at the University of Connecticut.

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**continued on page 14**
forms the shells of clams, crabs, and the like). Some of the reactions that occur in nature involving sulfur are those that either make life possible in new environments or, conversely, make the environment uninhabitable to some organisms. It is bacteria using sulfur for energy that facilitate life in the fiery hydrothermal vents at the sea bottom, for example. Sulfur reactions in the atmosphere are very important in the context of climate change, and indeed in determining which organisms can survive on a planet. In the sediments it is found mostly as gypsum (calcium sulfate) and iron pyrite; in the ocean it is found in many forms.

Peering at mud and microbes in the laboratory, Visscher can see a world in miniature—evidence of the complex layering involved in stromatolite formation.

First, a “pioneer” colony of blue-green microbes moves in, forming the first layer by clustering together and secreting a gooey substance which traps falling grains of sand. As they become buried in sand and goo, the bacteria then migrate upward. Next, another species of sulfate-cycling bacteria group above the first layer. These tiny but very active organisms produce a different goo, containing calcium carbonate. This forms a new, thin layer of hard white crust.

Finally, a third type of cyanobacteria colonize the surface of the crust. They bore through the sand grains by dissolving them, then calcium carbonate “glue” fills the holes, cementing the whole tiered structure together into a whole. Thus the primitive structures are formed by the complex interaction of three distinct communities with sand.

Using microelectrodes, Visscher measures sediment characteristics, such as oxygen and sulfide levels, pH, redox potential, and temperature, to find out and compare what conditions were conducive to early life and what makes a good “home” today. He also determines which tiny organisms are present, and finally assembles the information into “profiles” used to devise laboratory experiments with sediments and cultured microbes. Visscher uses the same techniques to study other critical habitats, such as seagrass beds in Long Island Sound and the functioning of marine ecosystems.

These investigations will gain momentum as the NASA Mars mission progresses rapidly, with two unmanned missions underway, and a Martian Rover surface sampling mission planned by 2004. In the meantime, the interactions of microbes and minerals may have a more immediately practical application for Earthlings, if new ways to produce energy can be found.

Peg Van Patten is Communications Director for Connecticut Sea Grant at UCONN and Wrack Lines editor. She has never visited Mars!
maturity, which is driven by growth rate), 2) differential reproduction (here, slow-growing smaller individuals leave more offspring than fast-growing ones-larger ones), 3) Inheritance of traits (size at maturity is passed between generations).}

Furthermore, the salmon story also illustrates a common feature to many historical sciences; that is, the phenomena of interest are inferred after the fact. It is possible, however, to predict the outcome of evolution and to carry out experiments to test these predictions. For instance, one prediction that has been confirmed experimentally by microbiologists is the evolution of bacterial strains resistant to antibiotics.

Can we experimentally study the evolution of resistance in natural populations at sea? In my own laboratory we are interested in finding out whether grazers evolve resistance to toxic dinoflagellates, a group of microalgae. Along the coasts of New England and eastern Canada, dinoflagellates of the genus *Alexandrium* produce a group of neurotoxins, called saxitoxins, which interfere with nerve-transmission signals, resulting in paralysis of those that ingest the toxins. Depending on how much toxin is ingested, effects range from slight stupor to death from asphyxiation, as breathing muscles fail to work. (Saxitoxin effects were first documented in people that had ingested shellfish that in turn had ingested *Alexandrium*; hence, saxitoxin poisoning is commonly known as paralytic shellfish poisoning, PSP.) Our interest in this topic is more than academic since New England fishermen lose millions of dollars annually when fishing grounds are closed due to dangerously high PSP toxic content in fish and shellfish. In addition to economic losses, PSP also represents a threat to public health.

In our own work on grazer resistance to PSP toxins, we use copepods (a group of planktonic micro-crustaceans) as the grazers that face toxic *Alexandrium*. Because they are the most numerous animals on the planet and have short generation times (a couple of weeks to months, depending on temperature), copepods are an important and convenient subject for studies of evolution.

We chose to work on the copepod *Acartia hudsonica*, a ubiquitous species found along the eastern coast of the U.S. and Canada. Populations of *Acartia hudsonica* from Massachusetts to Nova Scotia are frequently exposed to blooms of toxic *Alexandrium*. South of Massachusetts, toxic *Alexandrium* blooms are rare or nonexistent. Sean Colin, a former doctoral student in my lab, and I reasoned that if resistance had evolved in the northern New England copepod populations, they would have higher reproductive rates when faced with toxic *Alexandrium* than copepod populations south of Massachusetts, which had not previously faced *Alexandrium*. This prediction was indeed borne out by laboratory experiments. When we repeated the experiments using a nontoxic food, there was no difference in reproductive rates between copepod populations that live north or south of Massachusetts. Clearly, then, any differences between copepod populations had to do with their responses to the toxic dinoflagellate. Moreover, in these experiments we kept the several copepod populations under the same environmental conditions for several generations before running the experiments. Therefore, we were able to rule out the potential effect of the environment, or the effect of the interaction of the environment and genes, on the performance of the different populations.

Put another way, our results are more readily explained by genetic differences between the copepod populations. Thus, the lower reproductive rate in the copepod populations that are not typically exposed to blooms of the toxic dinoflagellate is consistent with the hypothesis that these
populations have not evolved resistance.

A skeptical observer would argue that our experiments have yet to show evolution of resistance to toxic algae. Put another way, one can ask whether there is more compelling evidence of the evolution of resistance. The answer is yes, and is in the form of genetic selection experiments. In this case, we took a copepod population that had never faced *Alexandrium* and split it in two groups. One group was reared from eggs to adults on a diet free of *Alexandrium*. In the other group, 20% of the diet consisted of *Alexandrium*. We then measured, during five successive generations, the reproductive rates in both copepod groups when they were fed only *Alexandrium*.

After only three generations, the group reared on the diet containing *Alexandrium* had higher egg production than the group reared in the *Alexandrium*-free diet. The most logical explanation for this observation is natural selection of resistant individuals in the group exposed to *Alexandrium*.

Clearly, our experiments show not only the existence of wild copepod populations resistant to PSP toxins, but also that such resistant can potentially evolve in a matter of a few generations. For a scientist, this is exciting news from a purely intellectual point of view. However, our findings also raise many interesting practical issues. For instance, if toxin-resistant grazer populations evolve, can they eventually act as biological pest controls? One can envision a future in which toxic algae are kept from blooming by toxin-resistant grazers. This potential outcome is encouraging news.

On the other hand, the evolution of toxin-resistant grazers also means that fish that feed on these grazers will in turn have higher toxin content. Will we observe in the future more human health problems related to consumption of fish loaded with toxins? The same concern applies if instead of toxins we consider the evolution of resistance of organisms to pollutants such as heavy metals. The possible scenarios due to resistance outlined here show that evolution can have both positive and negative consequences for the quality of our environment.

A practical lesson for us all is that without understanding the evolutionary history of populations, we will be hard-pressed to come up with effective management plans for living marine resources.

The author thanks Dr. David Avery for comments and suggestions that improved this article.

For further reading:


Government scientists and fisheries managers in the United States, for example, proposed that 20 per cent of the continental waters in the southeastern United States be governed as MPAs. Another influential report, funded in part by the World Bank, argued for the development of a globally representative system of MPAs that encompasses at least 10 per cent of the marine environment. A global group of marine scientists has prepared a petition calling upon governments to protect 20 per cent of the world’s oceans within a globally representative system of MPAs by the year 2020.

A marine reserve, one type of MPA, is a spatially-defined area in which all populations are free of exploitation. The primary purpose of MPAs is to protect target species from exploitation in order to allow their populations to recover. Perhaps more important, MPAs can protect entire ecosystems by conserving multiple species and critical habitats such as spawning areas and nursery beds. Stocks inside these areas can serve as a “bank account” or insurance against fluctuations in and the depletions of populations outside the protected area caused by mismanagement or natural variability. MPAs can also reduce conflicts between fishers and other users by providing areas where non-fishery users can pursue nonconsumptive uses of the resources. MPAs can also play a role in helping to diversify the coastal economy through tourism and conservation work. The size of the MPA relative to home range and habitat requirements of target species is important.

Clearly, MPAs can be effective in protecting species which are sedentary or have a limited range, as in many reef fish. For species that have a large range or highly mobile life history stages (such as planktonic larvae), MPAs can serve to protect the spawning ground, spawning aggregations or the nursery area. In other cases, protecting vulnerable life history stages of the adults, such as spawning migrations, may prove effective.

While it is evident that MPAs can be a powerful means of protecting critical marine areas, the extent to which MPAs can enhance fisheries is still unclear in many areas. MPAs should be considered a necessary but not sufficient component of fisheries management. One of the main concerns about relying too much on MPAs is that they simply displace fishing into adjacent areas, leading to greater local depletion there. This, in turn, increases the difference in abundance between...
protected and exploited areas, which may increase emigration of fish from the former to the latter, thus reducing abundance in the protected areas. In addition, MPAs do not always result in higher density for target species or in higher biodiversity. Well-planned studies of MPAs are still needed to understand how protected areas work.

Marine protected areas come in many types, shapes and sizes. Around the world, they encompass everything from small, locally managed marine areas established by coastal communities to help conserve dwindling marine resources or site of cultural interest to vast multiple-use areas that have a range of conservation, economic, and social objectives. In the United States, for example, 12 marine sanctuaries have been established in federal waters. No one approach has emerged as best in every situation; each can make a valuable contribution to maintaining biological diversity, depending on the ecological and socioeconomic factors in each area.

In some circles, MPAs have come to be advocated as the solution for all fisheries and ecosystem management problems. In reality, MPAs are not substitutes for fishery management, but are one of several tools in the toolbox. Keys to the success of MPAs include stakeholder participation, understanding and local acceptability, and monitoring and enforcement. Goals for the scope and purpose of MPAs must reflect a balance between scientific and social and economic needs and realities. W.L.

This shell disease is characterized by lesions more severe and extensive than are associated with the shell disease that has been around at fairly low levels for years. More information on how the lobsters become infected is needed, but it appears that there are at least three to seven strains of bacteria that may be associated with the disease.

In summarizing results of five lobster disease studies, Salvatore Frasca, a University of Connecticut veterinary pathologist, noted that lobsters were still dying during the summer of 2002, and that yet another disease had been described. Alistair Dove, a senior research associate at the Cornell College of Veterinary Medicine, determined that lobsters were suffering from calcinosis, a non-infectious but potentially fatal disease of lobsters, akin to the formation of kidney stones in humans. It was likely caused by the extremely warm bottom water temperatures that affected the lobsters’ normal metabolism of calcium, leading to the formation of calcium crystals in the gills, and ultimately, respiratory failure.

The new disease was affecting lobsters in addition to the earlier-described Paramoebiasis, a fatal, infectious disease caused by a parasitic paramoeba that engulfs lobster nervous tissues. It was discovered in the dead and dying lobsters in the fall of 1999 by pathologists at the University of Connecticut (see Wracklines Vol. 1:1, 2001.) Researchers are closer now to identifying the organism,
believed to be a Neoparamoeba species, and are developing tools to rapidly detect it in lobster tissues, as well as water and sediment samples.

The presentation on pesticides by Sylvain De Guise, a veterinary pathologist with the University of Connecticut, was the one most eagerly awaited, and debated, during the symposium. Lobstermen had recently learned that the lawsuit filed on their behalf against several manufacturers of mosquito control pesticides had been certified as a class action, and were looking forward to hearing the preliminary results of the three pesticide research projects. They contend that pesticides sprayed to control mosquitoes carrying the West Nile virus resulted in the massive die-off of lobsters in western Long Island Sound in 1999.

Laboratory tests on adult and larval lobsters show that lobsters are sensitive to the lethal effects of all three mosquito pesticides used—malathion and resmethrin (sprayed aerially for adults) and methoprene (larvicide).

“It really doesn’t take much to kill lobsters,” says De Guise, noting that his lab studies showed that 33 parts per billion of malathion killed off half the adult lobsters in the study within 96 hours.

“One part per billion is equivalent to 1 drop of water in a billion drops of water, or one person in China,” De Guise said. However, what concentration of these pesticides, which degrade rapidly in the environment, lobsters may have been exposed to in the Sound is not known, and therefore a direct link from the lethal and sub-lethal effects seen in the lab to the Long Island Sound environment cannot be made at this time. The New York State Department of Health is required by law to maintain a database of all pesticide applications in New York. This database is only accessible to researchers, and no one has yet worked through the reams of data to determine the amount of pesticide that may have realistically entered the Sound’s waters during 1999. It is unclear if a similar database exists for pesticide applications in Connecticut.

In 1999, tests to measure the levels of any pesticides in the water came back negative. It is unknown if this was because no pesticides were present, or because the equipment and techniques available were not sensitive enough to record any measurable levels. Anne McElroy and Bruce Brownawell at SUNY Stony Brook have now developed methods for measuring levels of substances (like pesticides) in water in the range of parts per trillion, 1000 times more sensitive than the methods used in 1999.

As answers start coming into focus, more questions also arise. Key missing information is how to culture the paramoeba and the bacteria associated with the shell disease, so that infectivity studies of healthy lobsters can be conducted to learn how these diseases are transmitted. These efforts are underway, but so far, have been unsuccessful. Data on pesticide applications from New York and Connecticut await detailed analysis to calculate how much pesticide lobsters may have been exposed to in 1999.

Nevertheless, researchers are learning more every day about how the lobster fits into and is affected by its environment, both natural and anthropogenic. When the research is completed, the next logical step will be for resource managers to use the information to make some decisions regarding the recovery of the lobster resource and its associated commercial fishery—in time, hopefully, for at least some of the lobstermen. 

Nancy Balcom, Connecticut Sea Grant Extension Leader at UCONN, coordinates outreach efforts for the Long Island Sound Lobster Mortality Research Initiative. Balcom serves as a link between lobster fishermen and researchers.
Gifted and Talented Youth Join UCONN Marine Scientists for a Day of Fun and Science

Nancy Balcom, Program Leader
Connecticut Sea Grant Extension

One Saturday last November, the University of Connecticut marine science community put on its best face and welcomed 130 bright 8th and 9th graders and their parents to the Avery Point campus. Hosted in collaboration with the Johns Hopkins University Center for Talented Youth, the workshop introduced students from Vermont to Washington, D.C., to the diverse and fascinating world of ocean and marine science. “This was an ideal collaboration where everyone came together to showcase the many marvelous things going on here in the fields of ocean and marine sciences, the extremely talented people we have working here, and the phenomenal facilities we have to work in,” said Edward Monahan, Director of the Connecticut Sea Grant College Program at the University of Connecticut, one of the workshop’s sponsors.

As opening speaker, Professor Annelie Skoog set the stage by first describing the breadth of fields covered by the term “oceanography”, showing that it is far more than “just studying dolphins and whales”. She then took the students and parents on tours of the Arctic, Antarctica, and hydrothermal vents, showing how her research in chemistry has led her to study in these extreme environments.

Students then attended workshop sessions offered by more than 30 faculty and graduate students within the Marine Sciences Department, the Coastal Studies Program, the National Undersea Research Center, and the Connecticut Sea Grant College Program. Guided around campus by volunteer undergraduates currently enrolled in the coastal studies program, the visiting students also spent an hour aboard Project Oceanology’s vessel, Enviro-Lab. Meanwhile, the parents were free to choose among a series of science lectures, a workshop on Long Island Sound marine critters, or a tour of the campus and the Alexy von Schlippe Gallery of Art. At day’s end, the groups rejoined to hear the closing plenary offered by Professor James Kremer. They were treated to a problem-solving session which demonstrated how a problem that at first seemed to be solely a biological problem (loss of eelgrass beds in a Massachusetts Bay) was linked to community growth and development, economics, and societal changes as well.

From plankton to fish, microbiology to physical oceanography, computer databases and modeling to ROVs, bivalves and aquaculture to sonoluminescence, these gifted and talented youngsters learned that there are tremendously diverse and unlimited career paths available for someone interested in the oceans.

“OMG. It’s spinning!” Taking advantage of the Marine Sciences facility on the shores of Long Island Sound, gifted high school students enjoyed a day of mentoring with UCONN faculty like Professor George McManus (far left).

UCONN Marine Sciences faculty member Evan Ward helps a young student prepare marine organisms for examination during the fall workshop for gifted and talented youth.