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A few words from the Director of the NRS

The detection of trends in ecosystems depends upon (1) a good description of the foundation or benchmark against which changes are measured and (2) a distinction between natural and anthropogenic changes.
— P. K. Dayton et al., in "Sliding Baselines, Ghosts, and Reduced Expectations in Kelp Forest Communities," *Ecological Applications* 8(2), pp. 309-322 (1998).

Superficially, it appears the two requirements named above should be readily achievable for marine ecosystems. In reality, the task is difficult and long. Yet the information is critically important, as is evident from the recent Pew Oceans Commission report (<http://www.pewoceans.org/>), which describes the severe degradation of ma-

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In This Issue

A scientist takes the measure of a mollusk and finds it wanting. Giving greater protection to California's intertidal zone could give the individuals of this and other species a chance to mature and perpetuate themselves. Photo by Jerry Booth

Man meets mollusk and learns: size *does* matter — even in the intertidal zone

The best scientific questions, by definition, lead researchers down unexpected paths. The investigations of UC San Diego professor and NRS faculty reserve manager Kaustuv Roy are a case in point: though Roy's research initially focused on how certain marine fauna are responding to global warming, his line of inquiry expanded to reveal surprising new information about the health of California's intertidal zone. Now, it turns out, his findings have implications for conservation practices as well as for basic science.

Roy's research began with his realization that temperature increases, if accurately projected for the next few decades, would far exceed anything that had been observed in historic times or even estimated in recent geologic times.

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Man meets mollusk

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Graduate student Phil Fenberg surveys contemporary mollusk populations in the high tidal zone at Cabrillo National Monument. Above him and the beach, preserved in the area's striated bluffs, are fossil records of many of the same species. Photo by Jerry Booth

To discover what effect these changes were having on living creatures, Roy and his graduate students turned to the intertidal zone just down the hill from their San Diego campus. Not only was this local intertidal zone convenient, it also provided a geologic context. Researchers working with specific species at low tide had only to climb the bluffs above the beach to compare their contemporary species with the community as it existed during the Pleistocene Epoch, 11,000 to 125,000 years ago. "The fossil deposits from the Pleistocene intertidal community are surprisingly similar to what's found along the coast today," Roy notes. "Eighty percent of the modern species are represented in the fossil records in sufficient quantities to estimate relative abundances and sizes."

The geologic record provides an important context for interpreting present-day changes along the coast. Species' ranges, for example, have changed continually to adapt to a changing environment. Fossil evidence clearly indicates that, during the late Pleistocene, many species ranged a full degree further south than they do today. And, during the last interglacial period, many southern species ranged at least a degree further north.

Home, home on the range

The fossil record proved especially valuable when Roy began looking at *Acanthinucella spirata*. Today this common snail is found from mid-Baja California up to Tomales Bay, 40 miles north of San Francisco — and much of this geographic range is covered by the fossil record. However, further investigations by Roy revealed, within this range, important differences between the species as it existed in prehistoric times and as it now exists contemporary times.

For one thing, genetic variation in the northern population is now much less than that found south of Point Conception. After studying both the genetic data and the fossil record, Roy and his colleagues theorized that northern populations of the snail became extinct at some point, and then the area had been recolonized by a small number of individuals from the south during the last 12,000 to 30,000 years.

The lack of genetic diversity in the present-day northern population would seem to indicate that it is not as healthy as the southern population. Yet, when morphological diversity is also measured, the finding is that species form and structure are much more varied in the north than in the south. Apparently, after the snail recolonized its former territory, a new form evolved with much thicker, shorter, and broader shells.

This discovery has implications for resource managers who usually focus on conserving the most genetically diverse populations of threatened species in the belief that genetic diversity will help a species withstand future environmental changes. Roy's study suggests that conservation criteria should be expanded to include morphologic as well as genetic diversity.

That was then, this is now

Roy's research, with its paleontological focus, naturally drew him toward extensive use of museum collections. In addition to fossils, many museums also hold collections of contemporary specimens collected 50, 80, or 100 years ago. What Roy discovered from working with these collections was that contemporary specimens collected in the mid-twentieth century and earlier differ in two distinct ways from what today's researchers see in their field surveys: (1) many species no longer range as widely as they once did, and (2) individual representatives of these same species now tend to be smaller than individuals in past times.

Regular encounters with beach visitors backed up this observation. Older people who approached the field crews almost invariably spoke about how much California's coast had changed since they were young — species they

were used to seeing had disappeared, and the size of those that remained was much smaller. Such encounters were so frequent, Roy began to worry he was working in a system so out of balance it might invalidate his scientific work. He explained: "If we're losing species at particular sites, or if sizes and population numbers are changing, then ecological relationships are changing as well. How much of the change is natural? This is where we run our experiments and do our empirical work. If the system is so far from equilibrium, even on a scale of 150 years, then we really need to keep that in mind. If everything is half the size of what those individuals were 150 years ago, then we've got a problem, both from a conservation and a scientific perspective."

Measuring a mirage

Roy began to worry that what he'd thought was his ideal laboratory had already become a victim of the "shifting baseline syndrome" identified by fisheries biologist Daniel Pauly in 1995. Pauly used the term *shifting baseline syndrome* to refer to a disturbing trend in resource management where each generation of scientists "accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this baseline to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stock at that time that serves as the new baseline. The result obviously is a gradual accommodation of the creeping disappearance of resource species…" (D. Pauly, "Anecdotes and the shifting baseline syndrome of fisheries," *Trends in Ecology and Evolution* 10(10), p. 430 (1995).)

It was at about this point that Roy decided to try to quantify the health of the intertidal and the changes occurring there. Working with Paul Dayton, of UC San Diego's Scripps Institution of Oceanography, and David Lindberg and James Valentine, of UC Berkeley, he began to collect and organize an online database that would provide a baseline for detecting local extinctions, diminished body sizes, and morphological changes. They named their group Conservation and Biodiversity of the Rocky Intertidal of Southern California (CBRISC); supported by a grant from the UC Marine Council, they began to compile their data. Nowadays the database includes more than 4,100 historical records, drawn from a wide variety of sources and dating back to 1869. These records cover intertidal mollusk species found at 301 localities throughout southern California.

Fossil records and museum collections provide the geologic perspective for the database. Records of archaeological explorations of Native American middens provide the early human record. The personal observations of early European explorers, nineteenth- and twentieth-century naturalists, and amateur collectors offer first glimpses of the impact of modern civilization. And these observations are amplified by data drawn from a wide range of scientific publications, from the Edward "Doc" Ricketts classic, *Between Pacific Tides*, to recent doctoral dissertations.

The database has grown sufficiently inclusive to help guide current CBRISC field research, as teams return to locations previously surveyed to identify local extinctions, changes in community composition, and size shifts in individual species.

The prodigal snail returns

The database is shedding new light on the health of the intertidal. It has shown, for example, that southern California has an abundance of extralimital species, invasives that have moved into the area from beyond their historic ranges. *Mexacanthina lugubris*, for example, has become the most common intertidal snail in San Diego. Its historic northern limit was Ensenada in northern Baja California, but, in 1976, it started showing up at Point Loma National Seashore in San Diego. Earlier this year, La Jolla was thought to be the snail's new northern limit, but now Roy has begun finding it in Orange County. Though the speed of the invasion seems rapid, in a sense *M. lugubris* is simply returning home: the fossil record indicates it was found throughout southern California during the Pleistocene.

Kaustuv Roy (center) and several graduate students collect data in the intertidal zone at Cabrillo National Monument. Photo by Jerry Booth

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Man meets mollusk

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For Kaustuv Roy, one scientific question has simply led him to the next — and the process has become so interesting, he has no intention of ever stopping. Photo by Jerry Booth

Roy is intrigued at what prompted this recolonization. Is *M. lugubris* simply moving up the coast in response to warmer water and air temperatures? Or did something happen to the California species that is being replaced by this species? Has the southern California intertidal become a "sink habitat," where mortality exceeds reproduction? If so, how much of the destruction is natural and how much has been caused by humans?

Losing at hide-and-seek

Roy's curiosity led him to investigate the impact human collecting has on body sizes of the intertidal mollusks. Body size is an important indicator of a community's well-being, because many animals, especially mollusks, are long-lived (20 to 30 years), and body size correlates directly with reproductive capacity.

Previous studies in Chile, Australia, and South Africa have shown that human collecting can dramatically impact the size frequency distribution of exploited species (those that people eat). These studies were conducted by comparing protected intertidal zones with public areas. All showed that, in human exclusion zones, exploited species had significantly larger body sizes, while control species (those that humans didn't eat) were not significantly larger even where they were protected.

Roy decided to conduct a similar study that would also include a historic perspective from the database. For exploited species, he chose *Lottia gigantea* (owl limpet) and *Tegula aureotincta* (gilded turban snail), while, for nonexploited species, he chose *Acanthinucella spirata* (a small predatory snail) and *Fissurella volcano* (a small limpet). CBRISC crews surveyed sites from southern Los Angeles County to the U.S.-Mexican border, including the NRS's Scripps Marine Reserve in San Diego County. At almost every location, they found significant size declines in all species, exploited and nonexploited, over three time periods: pre-1960, 1960 to 1980, and current (1981 to present).

Their next challenge was to identify the cause of these declines in size. Possibilities included human disturbance, warmer water temperatures, and poor field survey techniques. To eliminate the latter two possibilities, the CBRISC field crews surveyed the one site in southern California with an enforced human exclusion zone, the rocky intertidal at Cabrillo National Monument at Point Loma. By using the same crews and techniques, in an area with similar habitats, they would be able to isolate human disturbance as the cause of the size changes.

The findings were dramatic. All four species, even those not known to be exploited, were significantly larger at protected Point Loma than anywhere else along the coast. In fact, specimens for two of Roy's four species were even larger than the specimens found in museum collections.

It seems humans *are* impacting the sizes of intertidal mollusks in southern California – and in a major way. What's more, the effect is pervasive and can be seen not only in species that are directly exploited by humans, but also in those that are not. "If you enforce existing laws," Roy notes, "you can minimize the loss somewhat. The bad news is that most laws are not being enforced anywhere in southern California."

But Roy is still a bit puzzled over why inconspicuous, nonexploited species have declined. He suspects that either they are being affected by human trampling (see page 5 sidebar, "Is California's intertidal zone being loved to death?"), eaten by an unknown group, or being taken by indiscriminate poachers. Anecdotal discussions with Fish and Game wardens seem to indicate that poachers often prefer to wipe an area clean quickly rather than spend a lot of time focusing on particular species, all the while exposing themselves to greater risk of being caught at their illegal activities.

What it all means

What does Roy's work reveal about the health of the intertidal? He fears the entire system may be in a slow-motion collapse that will be difficult to reverse. What he discovered about the exploited *Lottia gigantea* provides insight: "This species lives at least 30 years, and individuals change sex as they grow. A 50-mm specimen can be 18 to 20 years old. At about 40 mm, they change from male to female. At many sites, we no longer find large *Lottia gigantea*, and we don't know what impact this is having on sex change. Are they changing earlier in response to human impact? Looking down the road, is the species going to be in trouble when the individuals who are 20 years old now start crashing?"

The CBRISC database continues to open new lines of inquiry. And Roy is looking to increase his survey range, expanding northward to the Channel Islands and central California. In addition, he's considering including more species in upcoming size surveys to find out if his current four choices are exceptions. Then there's the possibility of conducting more studies that integrate both historical data and quadrat-scale comparisons.

"CBRISC takes up a lot of our time because it's so darn interesting," Roy notes with a smile. "But given the results we have already, it's important that we continue. If we don't, we'll never know what the system is going to look like 10, 15, or 20 years from now. And without knowing this, we'll never be able to manage it." — *JB*

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Some well-meaning intertidal zone tramplers at Scripps Coastal Reserve near UC San Diego. Photo by Allen Collins

Is California's intertidal zone being loved to death?

Educational programs in schools and aquariums have significantly raised the level of people's awareness of the ocean and their concern for its health. These programs have also increased the public's desire to visit the seashore. Unfortunately, like Jonathan Swift's Gulliver cast ashore in Lilliput, even well-intentioned visitors can do harm.

"Trampling is a serious issue," explains Kaustuv Roy, a UCSD professor whose research into the effects of global warming on marine invertebrates is typically conducted in California's intertidal zone. "Everyone wants to go to the intertidal because it's accessible. We want to enjoy it and turn over every rock and poke at everything we see. But, in doing that, each one of us is contributing to the decline of the whole system. Multiply [one person's actions] by thousands and you have a serious issue."

A number of programs have been developed to reduce damage caused by intertidal trampling. Major focus has been given to helping teachers lighten the impact of class visits on the intertidal zone. The Crystal Cove Conservancy in Orange County, for example, has created a video for teachers and students that outlines proper intertidal etiquette. Their recommendations include:

- Never remove animals, shells, or rocks from tidepools.
- Never pick up animals off the rocks, or poke them with sticks.
- Walk gently, taking care not to step on plants or animals.
- Never turn over rocks.

If you're interested in getting a copy of this video or other educational materials, contact the Crystal Cove Conservancy at: 949-240-3957.
— *JB*

NRS coastal reserves help marine researchers from multiple institutions working together to support a new era of Ocean Literacy

In the late nineties, marine biologists Peter Raimondi and Mark Carr at UC Santa Cruz realized they had to find a way to expand the scope of their work. Marine biologists couldn't ask the same questions terrestrial biologists were asking because events in marine systems happen on much different scales and on terrain much more difficult to study. The dispersal of marine organisms, for example, is massive compared to that of terrestrial organisms.

Faced with the enormity of the task of understanding vast stretches of offshore and even nearshore environments, most marine biologists are forced to extrapolate conclusions from a few small studies conducted over relatively short periods of time. They often must select their research locales more for convenient access than for biological significance. And their studies last only as long as the funding holds out, usually no more than two to three years.

"We didn't feel we were going to make much progress in the field," Raimondi explained, "unless we could spin up to something bigger in scale and longer in time." What Raimondi and Carr wanted to do was set up longer term research projects that would track changes in marine processes over a five- to ten-year period. They realized year-to-year changes weren't as ecologically significant as chronic change that persists over five or six years. They also understood that observing changes at many different sites is more likely to bring significant insights than observing changes at a single site, which might have natural variations.

Back in the late nineties, the two researchers were in the throes of applying to the David and Lucile Packard Foundation for a grant to study California's central coast. Apparently, the UCSC pair's aspirations were shared by marine biologists at other institutions, for almost simultaneously the foundation received similar applications from researchers at UC Santa Barbara, Stanford University, and Oregon State University to study *their* portions of the coastline.

The Packard Foundation encouraged all four groups to further expand their thinking and resubmit a joint application for a single coordinated study of the entire U.S. Pacific coastline. In 1997, the groups met and submitted a single proposal: thus was born PISCO, the Partnership for Interdisciplinary Studies of Coastal Oceans.

PISCO includes eight primary investigators — Carr and Raimondi at UC Santa Cruz; Steve Gaines (an NRS faculty reserve manager) and Robert Warner at UC Santa Barbara; Mark Denny and George Somero at Stanford University; and Bruce Menge and Jane Lubchenco at Oregon State — as well as a full complement of research fellows, technicians, policy and outreach coordinators, and postdoctoral researchers. The team's breadth is matched by its ambitious goal: to use the latest technology to develop a comprehensive understanding of how our coastal marine ecosystem functions.

PISCO's research is split equally between experimental and survey work conducted at over 100 sites from La Jolla, California, to Cape Flattery at the northern tip of the Olympic Peninsula in Washington. Their sites are part of, or adjacent to, seven NRS reserves: Scripps Coastal Reserve (San Diego County), Santa Cruz Island Reserve (Santa Barbara County), Coal Oil Point Natural Reserve (Santa Barbara County), Kenneth S. Norris Rancho Marino Reserve (San Luis Obispo County), Landels-Hill Big Creek Reserve (Monterey County), Año Nuevo Island Reserve (San Mateo County), and Bodega Marine Reserve (Sonoma County). The group attempts to conduct both intertidal and subtidal surveys at each site, though sometimes subtidal effort is impossible. At Año Nuevo Island, for example, the intertidal zone has been surveyed, but the presence of sharks makes diving unsafe further offshore.

PISCO researchers use NRS reserves both as sampling areas and for logistics support. Along California's north central coastline, Bodega Marine Reserve is an area of focus not only because it has an excellent intertidal zone, but also because of its convenient facilities. The same is true for the Landels-Hill Big Creek Reserve at Big Sur: it offers comfortable researcher quarters and excellent intertidal and subtidal sampling areas more or less clear of major human impacts. At Coal Oil Point Natural Reserve, on the other hand, PISCO researchers take advantage of the reserve's proximity to UC Santa Barbara to carry out manipulative experiments compatible with the site's heavy public usage.

From a marine biologist's perspective, one of the gems of the NRS is the Kenneth S. Norris Rancho Marino Reserve. "It's far and away the best intertidal, and probably the best subtidal, area in the whole system," Raimondi said, praising the site. "It's spectacular, it's in great shape, and it's expansive. As you head to the southern part of the reserve, away from the areas where people can walk in, it becomes absolutely pristine. There's a really extensive subtidal area offshore, there's a harbor seal haulout, and it's the south-

ernmost population of healthy black abalone. That's important because they've pretty much gone extinct below that."

Headed up by a specially assembled and equipped "SWAT Team" (see page 9, "Science SWAT team takes aim along U.S. Pacific Coast"), the PISCO staff has developed two separate intertidal surveying protocols. The first — a long-term dynamic survey — targets specific assemblages of organisms and focuses on how the communities change over time. Raimondi and his colleagues have been surveying these coastal sites in this manner for 10 to 12 years; each is resurveyed at least once a year.

The other PISCO protocol was designed for broader, more comprehensive surveys intended to capture a site's true biodiversity and relate that diversity to its topography. The results from these surveys are depicted in vivid three-dimensional maps, georeferenced and spatially explicit to give future researchers a true sense of how these communities are organized. PISCO teams have conducted comprehensive surveys at about 100 sites over the last four years.

The scope of these surveys has recently been expanded deep into Mexico, where researchers worked last year to determine southern range limits of biogeographic areas. This summer they're extending the work into Alaska to look for the northern limits of those ranges. Their goal in moving beyond the geographic scope of their original research area was to plot the entire range of known or presumed biogeographic areas from Cape Spencer, Alaska, to Punta Eugenia, Baja California Sur.

The PISCO team has pioneered the use of a number of powerful technologies for marine biology. For example, geographic information systems (GIS), global positioning systems (GPS), and a surveyor's laser-based theodolite are enabling scientists to make 3-D maps in the field, dramatically improving their ability to visualize and present information. Theodolites, or optical transits, have been used by surveyors for centuries to measure horizontal and vertical angles, but only in the last decade have advances in laser technology made these devices powerful enough for (and affordable to) field researchers.

Another critical technology employed by PISCO is that of sophisticated databases which share data among oceanographers (who focus on the ocean's physical characteristics) and marine biologists (who focus on the organisms that make the ocean their home). Greater understanding of the impact of wave action, climate, temperature, and geomorphology on different species is now possible because PISCO has built databases that combine biological data with oceanographic and meteorological information.

New molecular genetics techniques are also proving extremely valuable for the researchers. Whereas

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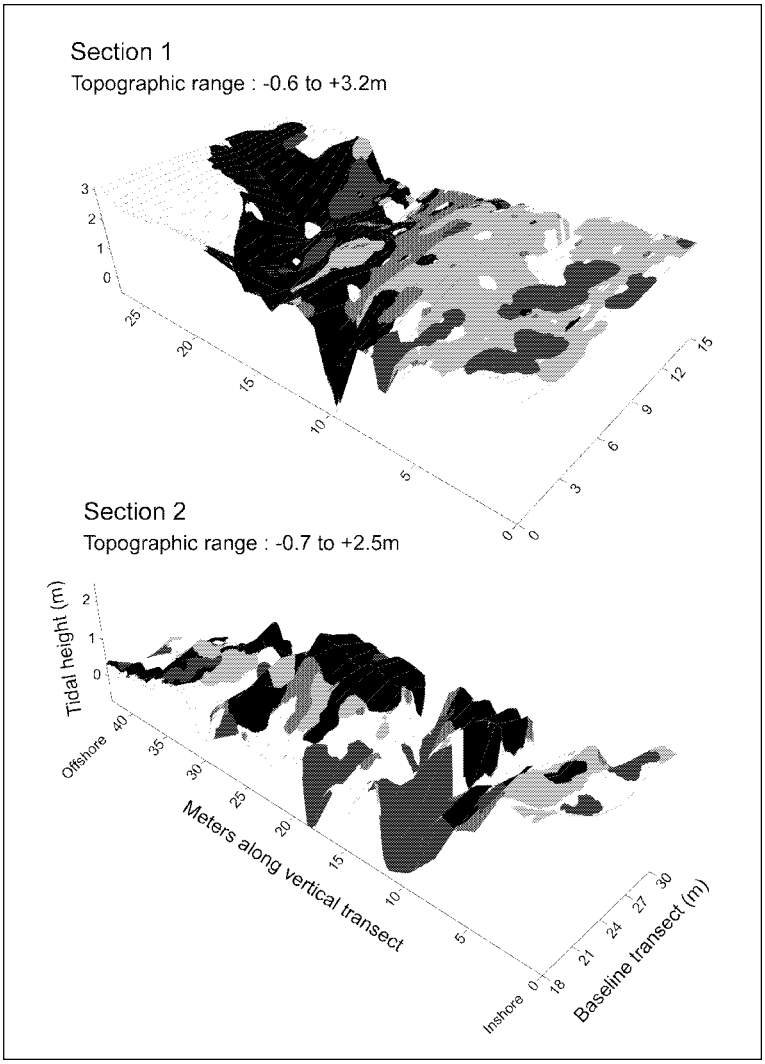

Topographical map of PISCO's Bodega Marine Reserve site, with the vertical distribution of four species and the location of tidepools overlaid. In order to sample a 30m baseline, the site was split into two sections. Section 1 is upcoast of section 2. The technology used to create this map and help researchers visualize and present their data was unavailable only five years ago. Map courtesy of Pete Raimondi and Christy Roe, UCSC

The Big Picture

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once they might only have known that a particular species' range extended along the entire Oregon-California coastline, now they can understand the connections among populations of the species throughout that range. Understanding how populations are linked and how larvae are dispersed are important biological challenges with crucial implications for conservation biology.

A final major breakthrough has been the increased focus on oceanographic input, such as wave and current motion, wave impact, and stratification of water masses. Newly developed instruments now make it possible for scientists to model the nearshore environment in ways unavailable five years ago — and to explore the biological significance of the oceanographic information they collect. PISCO's use of ADCPs (Acoustic Doppler Current Profilers) in the nearshore environment provides a perfect example. At several sites along the coast, divers mounted ADCPs on the sea floor, temporarily and on rocks, in 20 feet of water. The sensors detect water motion at one-meter intervals up through the water column. This information allowed researchers to develop an accurate picture of how the movement of currents affects the delivery of the larvae that replenish intertidal and nearshore populations. (Certain species of intertidal animals drift around on the ocean currents during the larval stages of their lives, then later come ashore and attach to the rocks.) Now, for the first time, scientists are beginning to understand the factors involved in replenishing fish, invertebrates, and kelp populations. Future marine reserves will be designed to promote the delivery of larvae so the young animals will thrive and grow, creating a healthy ecosystem and fisheries.

PISCO researchers "at the office" — UCSC marine biologist Pete Raimondi in the center. Photo courtesy of Pete Raimondi/PISCO

PISCO's work, with its unprecedented scope, comes at an opportune time, because it coincides with new efforts in California to protect nearshore environments as well as fisheries. Since the passage of the Marine Life Protection Act in 1999, the state Department of Fish and Game has been challenged to use scientific data to identify and protect critical marine ecosystems. Before 1999, fisheries were protected with no special consideration of ecosystem. Currently, Fish and Game is adapting PISCO's subtidal protocol for evaluating and establishing new marine reserves, while other researchers are using its intertidal protocols to evaluate the ecological significance of sites that interest them.

Policy planners will also find a wealth of information in PISCO's databases to support different marine reserve strategies. The team's intensive sampling of a large number of areas, for example, will help identify concentrations of biodiversity and fish assemblages. Their oceanographic and biological sampling will reveal which sites are most likely to be replenished with larvae.

Raimondi is confident PISCO has important data for a range of marine conservation strategies: "If policymakers want to come up with a strategic plan for the placement of marine reserves, they might want to consider what areas are likely to act as source populations for larvae. We hope our research will allow us to answer this question, because we'll know where the populations are biggest and where water motion would allow for export of larvae. On the other hand, if the question is, *What areas are the most important for biodiversity?* — we can provide detailed information about what areas we think are worthy of protection from a biodiversity standpoint. This is exactly the sort of information that is required if you are going to make informed biological decisions about the placement, size, and extent of marine reserves."

PISCO's work highlights the importance of the protected intertidal and subtidal environments adjacent to, or included in, NRS reserves all along the California coast. By providing support and a range of healthy research locales, the NRS is helping Carr and Raimondi and their colleagues push marine biology in important new directions, connect scientists working in related disciplines, influence the state's policymakers, and educate the general public. — *JB*

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Science SWAT team takes aim along U.S. Pacific Coast

When UC Santa Cruz marine biologist Peter Raimondi began to consider the logistics of conducting extensive intertidal surveying as part of the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), he drew on his earlier experiences fighting forest fires. He wanted a well-trained team that could move into an area, conduct its work with special tools, and move on to the next site as rapidly as possible.

PISCO SWAT team member Megan Williams spends her day, nose to the rocks, surveying the Bodega Marine Reserve's intertidal area. Photo by Jerry Booth

Raimondi's vision is now a reality: for the past two and a half years, PISCO has had its own four-person, currently all-woman team called "SWAT." Alison Kendall, Megan Williams, and Kristen Kusic have been part of the team since SWAT's inception, shortly after they all graduated from UC Santa Cruz. The fourth member, Haven Livingston, joined them earlier this year. Together they travel continually along the U.S. Pacific Coast, setting up survey sites and collecting data for comprehensive maps that combine topography and detailed species assemblages.

A recent SWAT visit to the NRS's Bodega Marine Reserve typified how they work. The team arrived late the day before and spent some time getting GPS readings for the survey area on the rugged rocks in front of the marine lab. To catch the lowest tide, they began work the next morning well before dawn, attaching a giant transect grid to the rocks and setting up survey lines. By the time the sun crested the coast ranges, the women were hard at work, entering species identification into handheld PDAs and chatting amongst themselves on walkie-talkies.

SWAT set up this site two years ago, mapping the topography, drilling and installing the bolts for the grid, and conducting an initial survey. Their return visit was to resample the site, but their survey protocol is the same at every site and includes two separate processes. They survey 100 contact points on each of 11 transect lines on the grid; for each point, they record three species and their relationships. These efforts give them a good estimate of the sessile species, both algae and invertebrates, which are not free to move about. The team then uses comprehensive surveys at three points along each transect line to record more mobile species.

Many survey processes have been automated. Team members capture data in PDAs from a sheet of bar codes that identify individual species. Mapping points are also recorded, using a laser theodolite to determine elevations and topography. At the end of the day, all these data, along with digital photos, are downloaded into a laptop computer and backed up on a Zip disk.

Nowadays SWAT members move quickly across the rocks, identifying organisms and entering data about them, recording the tide's height. But things haven't always gone so smoothly. In the beginning, the women spent a lot of time trying to figure out what they were looking at. Now that they know their species better, they can work much faster. However, any time they visit a new site, they still try to bring along a local expert to get them started.

(Left to right) Kristen Kusic, Alison Kendall, Haven Livingston, and Megan Williams comprise PISCO's SWAT team. And what does "SWAT" stand for? Some say "SeaWeed Action Team" or "Scientific Women And Tides." But team members prefer "Soaking Wet And Tired" and "Stinky, Wrinkled, And Tough." Photo by Jerry Booth

The SWAT team members are surprised at how their survey's scope has expanded. "When we started, PISCO had no intention of it being such a huge study," Kristen Kusic noted. "They said, maybe you'll go out to Big Sur or the North Coast. But then it was Oregon, San Diego, Baja California, Washington, Mexico — it just kept getting better and better. In the beginning, we'd joke about going to all of the Channel Islands. And now we've done that!" — *JB*

Editor's note: The scope of SWAT's project evolved again this past summer. After their North Coast trip, the team was scheduled to travel to the Gulf of Alaska. Their goal: to identify the northern limits of California species.

Reality training at Bodega Reserve launches careers

The library at Bodega Marine Reserve protects a special collection of almost three thousand student research papers. Many of the papers were produced by students in a UC Davis Environmental Science and Policy (ESP) course. Carefully catalogued and filed, the papers are consulted regularly by Bodega staff, UCD faculty, visiting researchers, and students seeking inspiration or background materials for potential projects.

Numbered and titled *124. Marine and Coastal Field Ecology*, this intensive 10-unit course provides an overview of current ecological theory and problems. It has been held at Bodega Marine Reserve each summer quarter since 1984. Admission is competitive. For two decades, students have seen the course as a launching point for successful careers. Sarah Morgan, for example, just graduated from UC Davis and has long dreamed of a career in marine biology. She wants to get some field experience as she contemplates grad school. Jim Graham, on the other hand, is a returning student. After working for Hewlett-Packard as an engineer and running his own Internet company, he's looking for experience and contacts as he begins a new career that combines technology and field research.

Vic Chow, who received his doctorate in ecology from UC Davis in 1983 and did his dissertation work at Bodega, has taught the six-week summer session of ESP 124 since its inception. With research interests that include intertidal ecology, remote environmental sensing, and population ecology of marine invertebrates, Chow has the expertise to mentor students in a wide variety of research projects. "It's easy to teach these kinds of classes," he says, "because you get motivated students who are thinking about a career or at least graduate school, and this course is a good way for them to get a feel for what it's like to do independent research."

Vic Chow works with student Emily Jones in the Bodega Marine Laboratory. Photo by Jerry Booth

Environmental studies student Bria Backhaus (left) receives help from instructor Vic Chow to identify intertidal fauna at Bodega Marine Reserve. Photo by Jerry Booth

Bodega is the perfect place for the hands-on field course. The rugged, wind-blown location, with its dramatic headlands and crashing waves, is inspiring, and on-site housing allows students to focus intensively on their work 24 hours a day. The reserve also offers a wide range of engaging ecosystems where students can work — coastal prairies, isolated pocket beaches, sand dunes, rocky intertidal shelves, tidepools, a salt marsh, and bay mud flats. Bodega Marine Laboratory, the UC Davis-administered facility located on the Bodega Marine Reserve, offers excellent facilities. Students have access to working space and microscopes, wet labs and aquariums supported by a computer-controlled, seawater system, and even a genetics lab complete with staff scientists willing to provide advice and guidance.

The course itself would make a top-rated reality TV show — *Field Science Survivor,* perhaps, or *All-American Biologist*. Twenty-four extremely competitive students from around the country gather at a remote seaside reserve. Their challenge is to conduct an original research project. With no distractions except the pounding surf and a few old films on DVD, their days are filled with lectures, fieldwork, and lab experiments. Nights and weekends are often spent in the library or the lab. The tides of stress ebb and flow as the students face a series of challenges throughout the course.

Their first task is to develop a research proposal. Most proposals evolve during the first week when the class investigates the reserve's diverse habitats. Rather than take a show-and-tell approach, Chow designs these trips to immerse the

students in hands-on research. He presents one example from a recent class: "On the first day, we went to Horseshoe Cove to do a mini-research project on the shell preferences of hermit crabs. But, once we got in the field, the students made some observations that totally shifted our original concept. And that's an important lesson: as much as you plan for something, it's always different in the field. Instead of following a set recipe, the class has the freedom to go with what interests them, and that leads on to paths of discovery for teachers and students alike."

Based on these field trips, mini-research projects, and library readings, the students develop their proposals and submit them for staff approval. Once their research proposals are approved, they set up their experiments and begin to collect data. But often the process does not go smoothly.

Graham, for example, is deep into his research on species diversity in mussel beds. After several frustrating days trying to identify the hundreds of organisms he collected, he's receiving help from half a dozen students and staff. His project back on track, Graham's optimism is palpable: "The class is great. It's hard work, but there aren't a lot of distractions here. Even the first week, everybody was at the library or in the lab working on their projects. You drop into a really intense educational environment pretty naturally here. But everyone is supportive. At the end of the day, you're tired, but it's fun."

Student Jeannine Toy found that hours of tedious labwork are easier to endure with a portable CD player for company. Photo by Jerry Booth

Morgan's project, on the other hand, is still in jeopardy. She's investigating whether isopods will change color to adapt to different environments, but a malfunction in the lab killed all her research subjects. She and another student are busy collecting a new group of specimens. She seems visibly relieved when Chow appears to help her: "Vic is a calming influence. He really thinks about what you're saying to him and tells you, in a nice way, whether or not he thinks it's going to work. You can always depend on getting good feedback from him."

Chow is sympathetic to his students' situation. "In many ways, they have a harder time than the professionals," he observes. "They're trying to do a novel and substantial project within a short amount of time. They only have six weeks, so, with all the prep work, they essentially have three weeks to actually conduct the research. Then they have to write it up and get ready to make a presentation. Yet they do a fantastic job. Look through the papers in the library."

Chow isn't particularly interested in whether or not his students get "right" answers — he wants them to pursue interesting questions. "It's important they have an open mind for the unexpected," he says. "Invariably, students will tell me the data didn't come out like they expected, or maybe they noticed something else while doing their research. I encourage them to pursue those observations, because they're probably the more interesting result."

Once the data have been gathered, the students must still make oral presentations as well as write their final papers. The oral exam is their final challenge. Chow understands that it's stressful, but he also thinks it's important. "The exam really isn't about testing their knowledge. It's more a way of giving them a feel for what it takes to talk off the top of their heads in an organized and logical fashion. We coach them on that. For many people, the first time they have to present orally is for their thesis defense or preliminary exam. I think it's much better to have this experience now."

Like the hundreds of students who've gone before them, Graham and Morgan will persevere and complete their research projects. Even if they never do intertidal research again, they will come away with new confidence in their ability to ask questions, conduct research, and come up with answers. As this session's students scatter and return to their homes across the country, Chow and his teaching staff will meet to refine the course and prepare for next year's students. Meanwhile, the library's collection of student research papers continues to grow. — *JB*

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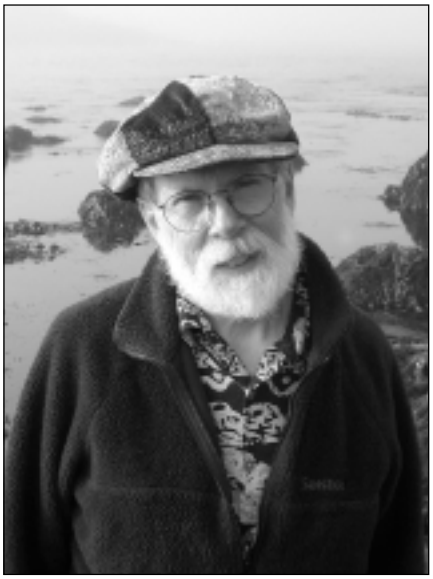
What's in a name? Will a marine managed area by any other name smell more sweet? (Quite possibly)

California's marine protected areas have evolved on a case-by-case basis, determined by various agency decrees, legislative acts, and ballot initiatives. The result has been a haphazard mix of names and regulations that confuses both the public and enforcement agencies. With increased public awareness of and concern for our offshore environment — which has stimulated efforts to protect more marine areas — the California Legislature decided it was time to establish a coherent naming system in which the designation of each area accurately conveys its status. Peter Connors, reserve manager of the Bodega Marine Reserve, is the University's representative on the committee charged with this task. He recently sat down with science writer Jerry Booth of Transect *to discuss his committee's work.*

JB: What is this committee? Who's on it?

Connors: The official title of our committee is the California State Interagency Coordinating Committee. It's run by the State Resources Agency and includes all agencies that manage offshore sites: Fish and Game, the Water Quality Control Board, State Parks, and the Coastal Commission. The only reason the University has a seat on the committee is because the Scripps Marine Reserve includes an underwater component. All the other NRS sites are terrestrial, even when they have a marine reserve on their doorstep. Here at Bodega, for example, the University only owns the land. But it just so happens that next to us is this Fish and Game-designated Marine Life Refuge. The refuge is an important research site for people working here at Bodega Marine Reserve, but it's not part of the NRS.



Peter Connors, who represents the University on the state's Interagency Coordinating Committee, has 20+ years of experience managing the Bodega Marine Reserve. Photo by Rico tinsman

JB: What's your committee trying to accomplish?

Connors: Our job was to simplify the system on the level of naming — not to change anything, but to establish some consistency in the names of sites and the way each site is treated. That was the first step. We've almost completed that. Next we will recommend a system for how people propose new marine protected areas or change the status of an existing one.

JB: What difference does it make what we call these diverse marine reserves? Why do we need a consistent system of names?

Connors: Right now, there really isn't a system at all. It's a lot of different kinds of marine managed areas established by different agencies and legislation. There are many different levels of protection. What we set out to do first was to simplify the system. Get fewer different kinds of names so the name of each marine managed area will tell people what it is managed for and what level of protection it receives.

JB: So, what new categories did you come up with? What do they protect?

Connors: Though we usually think of protecting biological resources, our categories encompass more than that. Altogether, there are six categories:

(1) State Marine Reserve
(2) State Marine Conservation Area
(3) State Marine Park
(4) State Water Quality Management Area
(5) State Marine Cultural Preservation Area
(6) State Recreation Area

JB: Which category offers the greatest protection?

Connors: State Marine Reserves are fully protected marine-life refuges. You can't take anything biological out of them, except in very specific situations. The Bodega Marine Reserve, for example, is completely "no-take," except for the University of California and people we designate who can remove specimens for research.

JB: Other categories of sites receive lesser levels of protection?

Connors: After State Marine Reserves, State Marine Conservation Areas are the next level. They protect some marine resources, but they're not completely no-take zones. They may protect one or two particular species, or a class of species, but not everything located there. There's no way for people to know, from the name alone, what's specifically protected in a Marine Conservation Area, but the name does alert them that *something* is protected and

tells them they'd better talk to the Department of Fish and Game to find out what that thing is.

JB: And the third category?

Connors: Next are the State Marine Parks — terrestrial parks that include marine segments and underwater parks. There are quite a few.

JB: You also mentioned State Water Quality Management Areas — why was it necessary to set up a category just for water quality?

Connors: The State Water Quality Management Areas were once called "Areas of Special Biological Significance." They were established by the State Water Quality Control Board to manage runoff and pollution, so it's much harder to get an outfall permit [which would be needed in order to install a pipeline to carry treated sewage] or do anything that might degrade the water quality of such an area. There are a lot of areas in this category as well.

JB: There are two additional types of areas — State Marine Cultural Preservation Areas and State Recreation Areas. I assume each of these last two categories has its own focus?

Connors: Right. State Marine Cultural Preservation Areas protect underwater wrecks or archaeological sites. State Recreation Areas are managed for recreation — specific activities are either allowed or not allowed. A State Recreation Area could be a place where you can't water ski or jet ski. On the other hand, the area might have been specifically established to promote recreation. With this designation, the focus is more on recreation than resources. There are very few of these right now.

JB: So, you've established your six categories — is your task of renaming nearly complete as well?

Connors: We're now finishing the renaming of all the current marine protected areas. One that required a lot of attention was Scripps. Violet [Nakayama, coordinator in the NRS Systemwide Office] helped track down its history. The situation was very confusing, but we ended up calling it the San Diego-Scripps State Marine Conservation Area because it's not totally a no-take zone.

JB: What's next for the committee?

Connors: Our work led the state Legislature to enact AB2800, the Marine Managed Areas Improvement Act, in 2000. This act formalized the committee's role in establishing a process for proposing or changing the status of marine managed areas. Once we've established that process, our job will be to make sure applicants provide all the required information in their proposals. Then we'll forward each proposal to whichever agency has jurisdiction over the area under consideration. We'll just make sure the process works.

JB: How does your work relate to recent efforts to establish new state marine reserves as part of the Marine Life Protection Act (MLPA)?

Connors: That process has been going on at the same time as ours. The MLPA Master Plan Team has a much more difficult task that involves a lot of public interaction. Once the members of that committee reach their final recommendations, however, any new marine protected areas they propose would be named and evaluated using the criteria our committee has established.

JB: And how will the work of the California State Interagency Coordinating Committee affect the NRS coastal reserves?

Connors: The key right now is to understand that there's no change in the protective status of any area, just name changes. Every NRS reserve that has some connection to the ocean has a different interface with this system. Scripps Marine Reserve [San Diego County], for example, is the only NRS site directly affected by the committee's work: its underwater component will be renamed. Then, there are two other NRS reserves, Bodega Marine Reserve [Sonoma County] and Landels-Hill Big Creek Reserve [Monterey County], that are adjacent to marine managed areas that will become State Marine Reserves.

Año Nuevo Island Reserve [San Mateo County] is surrounded by a Water Quality Management Area. The Kenneth S. Norris Rancho Marino Reserve [San Luis Obispo County] and Coal Oil Point Natural Reserve [Santa Barbara County] are two reserves that don't tie into marine managed areas, though I could imagine both areas being recommended because of the research being done there. As for Santa Cruz Island Reserve [Santa Barbara County], that site has two marine protected areas right offshore: a marine reserve where nothing can be taken, and a marine conservation area where recreational lobster diving (for spiny lobsters) and fishing for pelagic finfish (yellowtail and tuna) are allowed.
— *JB*

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This year the Natural Areas Association confers its two annual awards on NRS managers

The early leaders of the UC Natural Reserve System were a visionary group. Their hard work established a foundation that is being built upon by successive generations of scientists, educators, and reserve managers. This year the Natural Areas Association (NAA) honors the NRS, past and present, by conferring both of its annual awards on reserve system managers. This is the first time in NAA history that both of its prestigious awards for a year have gone to members of a single organization.

UC Riverside Professor Emeritus Wilbur W. (Bill) Mayhew has been selected as the 2003 George B. Fell Award winner. This is the association's highest honor, reserved for "giants in their fields," according to Hank Tyler, former president of the NAA. The Fell Award was established in 1987 to honor George B. Fell, a pioneer in conservation biology and a co-founder of The Nature Conservancy. Mayhew, a founder of the NRS, devoted over 35 years to expanding the reserve system and was instrumental in bringing many thousands of acres under University stewardship.

Writing for the NAA awards committee, J. Michael Scott praised Mayhew's dedication and "[his] hugely successful efforts in California to establish 'natural laboratories' where students and researchers could find out how the natural world works." Mayhew's efforts, Scott explained, "became the cornerstone of the world-renowned University of California Natural Reserve System."

The NAA's other award for 2003, its Resource Stewardship Award, will be presented to Cristina Sandoval, Kendy Randasky, Jennifer Stroh, and Kevin Lafferty for their work in establishing the Western Snowy Plover Recovery Program at the NRS's Coal Oil Point Natural Reserve. This NRS site is located on UC Santa Barbara's West Campus and overlooks the Santa Barbara Channel.

Sandoval is the reserve's director; Randasky and Stroh represent the Audubon Society; Lafferty is a marine ecologist with the U.S. Geological Survey (USGS).

The NAA's annual Resource Stewardship Award honors individuals or groups who have resolved a significant issue, developed innovative strategies, or made a major advancement in the management and preservation of natural areas. In presenting this award to Sandoval, Randasky, Stroh, and Lafferty, the committee noted: "Particularly impressive was your record of building partnerships with the public. The quality of science in your projects and outreach efforts serve as a model for others involved in natural areas management to follow."

Faced with a host of competing interests and uses at the reserve, Sandoval and Lafferty teamed with Stroh and Radasky to design and implement a recovery program that has helped the threatened western snowy plover (*Charadius alexandrinus nivosus*) to reestablish its historic breeding site at Coal Oil Point — despite heavy public usage of the beach.

(Top) A snowy plover at Coal Oil Point calmly guards hatchling and egg, unaware that it is being observed. Photo by Larry Wan
(Bottom left) An Audubon-trained docent at Coal Point Natural Reserve explains the reserve's plover recovery program to a local surfer. (right) The surfer takes a look for himself through a spotting scope set up to allow visitors to view the birds closeup from a noninvasive distance. Photos by Jerry Booth

(Above) Bill Mayhew releases a kangaroo rat for students at Boyd Deep Canyon Desert Research Center in 1983. Photo by Galen Rowell
(Right) Mayhew pays a visit to Boyd Deep Canyon in 1998. Photo by Alex Glazer

While Sandoval developed a management plan (with Lafferty, who quantified the human disturbance in the area) that involved rerouting trails around potential nesting areas, posting explanatory signs with maps, and installing fences to keep people and animals out of sensitive beach areas, Radasky and Stroh recruited and trained more than 70 docents to patrol the beach daily from dawn to dusk, watch over the plovers, and educate beach visitors about the plovers' presence.

The program succeeded beyond all expectations: in 2002, 21 eggs were laid, 16 chicks were hatched, and 14 fledged. Now this program has become a model for balancing environmental needs and conservation goals with public access demands and educational aims.

Regarding the NAA's 2003 awards, the association's executive director, Reid Schuller, emphasizes the national scope of the selection process. "Geographic proximity played no role in these selections," he emphasized. "The awards committee is drawn from organizations throughout the country. They received a large number of nominations this year and selected very deserving honorees."

The 2003 George B. Fell Award and Resource Stewardship Award are being presented at the NAA's annual meeting this September in Madison, Wisconsin. — *JB*

About the NAA

Shared knowledge is the best knowledge. That statement sums up the philosophy of the Natural Areas Association (NAA).

The NAA's mission is to advance the preservation of natural diversity, and, since its founding in 1980, the association has become a major nexus for the exchange of ideas and expertise between natural areas managers and researchers. Though its roots are in the Midwest, the NAA is now a national and international presence, drawing 2,200 members from all fifty U.S. states, as well as countries around the world.

The NAA does not own or manage any natural areas, nor does it promote a particular approach to natural area protection. Instead, it provides support and information services to persons concerned with the protection and long-term stewardship of natural areas.

The NAA publishes a periodic newsletter, *Natural Areas News*, and a quarterly research journal, *Natural Areas Journal*, whose readership *NAJ* editor Gerry Wright has described as largely "resource practitioners" — that is, "people who manage and use natural areas and apply that research to the specific management problems they are coping with" (*NAJ* 23:3, July 2003). In addition to its own annual meeting, the NAA sponsors international workshops and participates in the planning and development of natural areas and natural heritage policies and programs.

NAA membership is open to all professionals and amateurs involved with the identification, evaluation, management, protection, and study of natural areas and other elements of natural diversity. Current members include researchers, natural area managers, naturalists, university faculty, and conservationists working for both public agencies and private organizations. — *JB*

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A few words

Continued from page 1

rine ecosystems by loss of coastal habitat, through commercial and recreational fishing, as a result of pollution, and following many other human impacts. The report emphasizes how important it is to resource managers, decision makers, and the public to gain improved understanding of coastal and marine ecosystems, particularly in guiding the establishment of marine reserves. Such reserves play a key role in preserving and restoring ocean ecosystems. This *Transect* provides snapshots of the UC Natural Reserve System's involvement in research, teaching, and management pertinent to these objectives.

In the story that begins on page 1 of this *Transect*, Kaustuv Roy and his colleagues, based at UC San Diego, are shown integrating paleobiological, ecological, biogeographic, and molecular data in order to study how species and communities of gastropods and bivalves living on the eastern Pacific shelf respond to large-scale environmental perturbations (such as climatic changes during the Pleistocene) and to human-caused disturbance in recent times. Their results raise a concern that the entire intertidal community "may be in a slow-motion collapse that will be difficult to reverse."

The story that starts on page 6 describes the efforts of scientists participating in the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), who are conducting comprehensive multi-year studies of the near-shore ecosystems along the North American Pacific coast, to "determine the processes underlying the dynamics of coastal ecosystems" and to "establish a scientific basis for the effective design, monitoring, and evaluation of marine reserves and other conservation measures" (<http://piscoweb.org/>).

Training of future marine biologists, through the intensive course *Marine and Coastal Field Ecology* (ESP 124) at the Bodega Marine Laboratory/Reserve, is described in the story on pages 10-11.

Roy's studies and those of PISCO scientists are performed at multiple points along the coast. Several NRS reserves are among these places, and they provide particularly valuable, secure sites for long-term monitoring.

— Alexander N. Glazer
Director, Natural Reserve System

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