California Sea Grant

Biennial Report 2003 & 2004

Sea Grant California

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It is a national network of universities meeting
changing environmental and economic needs
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Cover: A fisherman deploying traps near Point Lobos, California.
Photo: Daniele Ardizzone

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The rocky shoreline at Point Pinos, Monterey Peninsula. Photo: Captain Albert E. Theberge, NOAA Corps (ret.)

Introduction...

In the following pages, we highlight selected research and outreach topics undertaken by California Sea Grant from March 2002 through February 2004. In doing so, it is our hope to provide a record of accomplishments for the general public and individuals in government, industry and academia.

California Sea Grant, the largest of 30 such programs located in the Great Lakes and coastal states, serves the community through university-based research and outreach. The primary mission of the program is to expand the base of scientific knowledge necessary to promote the sustainable use of California's coastal and marine resources. California Sea Grant supports research that helps people solve the challenges of a modern world, and provides public outreach and education to encourage stewardship and conservation.

The past year has seen remarkable transitions for California. In a rarely exercised recall election, the leadership of state government was changed overnight. With that change came a new sense of hope and energy to resolve the problems of 2001 and 2002 and see the state resume a position of leadership in many important areas.

The transition in California's approach to marine resources could not be more dramatic. A new secretary for Resources and secretary of the California Environmental Protection Agency have worked with the new governor to reinvigorate approaches to the study and conservation of marine resources. In particular is a refreshed interest and emphasis on the Marine Life Protection Act and marine reserves.

California Sea Grant has played in the past, and will continue to play, a key role in the future of marine resources both in California and the nation. The topic of marine reserves is charged with emotion, yet it is of vital importance for ensuring our coastal heritage. The best path to resolving conflict and moving forward with well-designed and carefully placed reserves is a reliance on good science and outreach—the strengths of California Sea Grant. Two key questions under consideration by our program are: do reserves protect the marine communities we hope to preserve; and how large does a reserve have to be to serve its purpose?

The quest for new knowledge about the coastal environment goes well beyond the issue of resource protection. Enduring topics such as water quality, human and ecosystem health, sustainable aquaculture, and novel products from marine organisms continue to be a staple of Sea Grant research and outreach.

Accordingly, I believe the relevance for a program such as California Sea Grant continues to grow. A central tenet of the California Sea Grant mission is to support research and education on our marine environment. At the same time, if we are to have a vibrant and resilient economy and yet conduct commerce in an environmentally responsible manner, we must seek to further our knowledge and understanding of where we live and work.

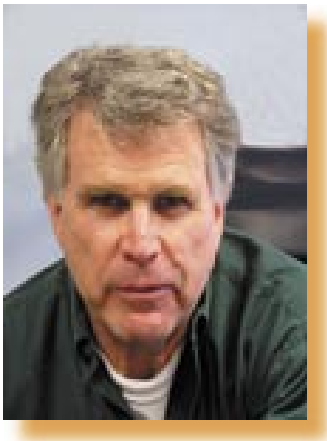
This annual report provides the reader insights into several of the issues addressed by California Sea Grant: support for an emerging aquaculture industry, management options for shark fisheries, antibiotics from marine organisms, methods to improve nearshore stock assessments, and a study of recreational fishing impacts on coastal life.

I encourage you to learn about California Sea Grant by reading this report. All of us in the program anticipate you will be intrigued by these findings and that you will join with California Sea Grant in seeking ways to preserve our precious marine environment.

Russell A. Moll
Director, California Sea Grant College Program

Sea Grant Supporting Research to Assist Shark Conservation…

In 2002, California Sea Grant began funding a leading marine biologist to gather information that will make it possible to protect sharks from intense fishing activity. The project will further a number of ongoing projects and federal initiatives, including the National Plan of Action for the Conservation and Management of Sharks.



Fish physiologist Jeffrey Graham. Photo: Christina Johnson, California Sea Grant

The Southern California Bight: A Nursery Ground for Sharks and the Center of the State's Drift Gillnetting Fishery

The mako shark (*Isurus oxyrinchus*) is the quintessential shark—an awesome swimming machine, spectacularly acrobatic, fast, sleek and muscular, with a mouth full of razor-sharp teeth. As with tunas, makos maintain body temperatures in their locomotor muscles above ambient water temperatures. This regional endothermy, as it is known technically, is believed to enhance muscle power and efficiency while swimming.

In the Southern California Bight—the indentation along coastal Southern California that extends about 100 miles into Baja California, Mexico—mako sharks are a secondary target of the swordfish and thresher shark drift gillnet fisheries. Although larger mako sharks have commercial value, smaller ones are often discarded. Many blue sharks are also caught inadvertently and discarded as bycatch.

Because sharks are exceptionally vulnerable to fishing pressure and because the bight is a nursery ground for newborn and juvenile sharks, biologists have expressed concerns that gillnetting might cause the mako shark population to crash suddenly and remain chronically suppressed. These concerns were heightened recently with the passage of a new regulation banning drift gillnetting north of the Southern California Bight, a measure taken to reduce bycatch of endangered leatherback sea turtles. Some biologists are concerned the regulation will heighten fishing activity in the bight, further intensifying pressure on mako sharks. Given the expected southward shift in fishing effort, it has become even more important to understand the movements and preferred habitats of both target and bycatch species.

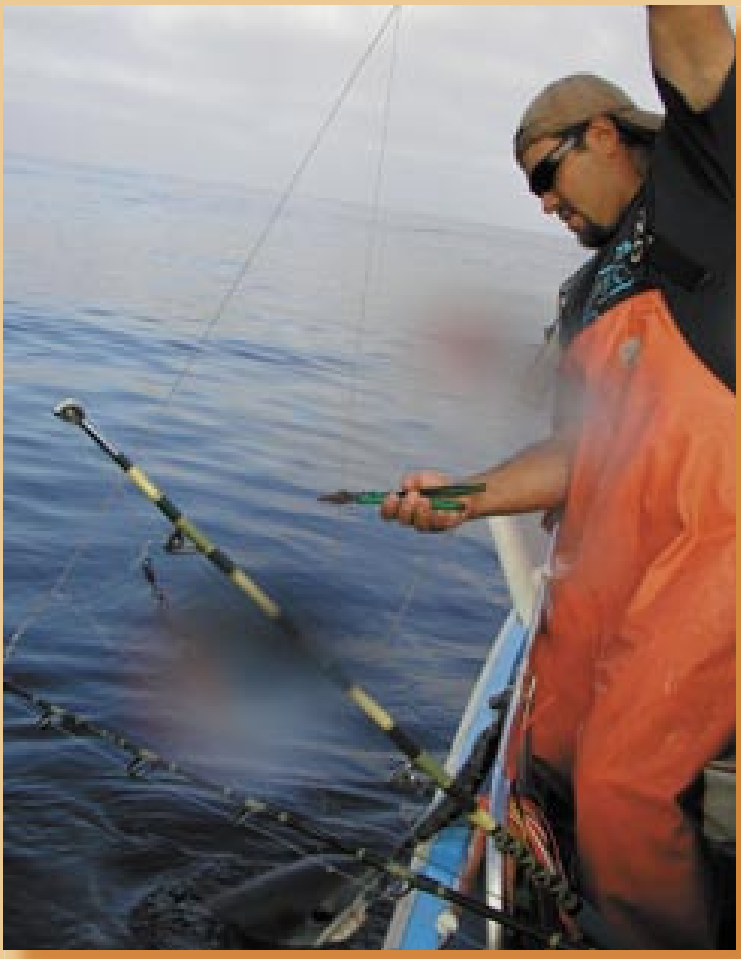
Shortfin mako shark photos pages 3–6: David Itano, Pelagic Fisheries Research Program, Joint Institute for Marine and Atmospheric Research, University of Hawaii

Tagging and Tracking Mako Sharks

Fish physiologist Jeffrey Graham and graduate student Chugey Sepulveda were funded by California Sea Grant to track and study the movements and bioenergetics of mako sharks in the bight, the main goal being to identify habitats essential to the animals' growth and survival. Such information will help fishery managers craft regulations for ensuring the long-term sustainability of sharks and thus the health of the marine ecosystem in which these top predators play a key role.

During the course of the grant, the biologists tracked eight juvenile makos tagged with acoustic transmitters that emit electronic signals of water temperature and depth (pressure). Seven of the sharks were tagged within five miles of the Scripps Pier in La Jolla. One was tagged near Carlsbad Canyon about 15 miles north of La Jolla. The sharks were tracked between eight and 56 hours. Tagged sharks ranged from 75 centimeters (the length of a newborn) to 150 centimeters (the length of a two- or three-year-old) and weighed between 6 kilograms and 45 kilograms.

Mako Facts



- *Adult females are bigger than their male counterparts, often growing to exceed 4 meters in length and as much as 500 kilograms in weight.*

- *Like other top predators such as tigers and falcons, makos do not reproduce in large numbers. Females carry litters ranging from four to 25 pups; pups can be cannibalistic* in utero.

- *Makos have conical snouts, long gill slits, dark blue/gray coloring on upper body, and white on the lower.*

- *They are fast swimmers, propelling themselves through the water with short strokes of their thick, powerful tails.*

- *Makos are worldwide in distribution in both temperate and tropical seas.*

- *While primarily pelagic, they may also be found inshore.*

- *Makos do not school and are seldom seen together in large numbers.*

- *Their diet consists mainly of bony fishes such as mackerels, tunas, bonitos and swordfish.*

Tagging Technique

As part of the project, Sea Grant Trainee Chugey Sepulveda developed a tagging technique in which a transmitter—about the size of a small pencil—was inserted into a dead mackerel. By chumming with ground-up fish, Sepulveda attracted makos to the boat. He was then able to get a mako to voluntarily swallow a mackerel—and hence a tag.

Placing tags inside the makos was an important part of the project because it allowed researchers to record stomach temperatures, believed to reflect an animal's feeding behavior.

Findings

Data from the eight tagged sharks showed that juvenile makos spend about 80 percent of their time within 12 meters of the surface; 15 percent of their time between 12 and 24 meters depth, and five percent of their time at depths greater than 24 meters.

In the tagging technique developed by trainee Chugey Sepulveda, a shortfin mako shark voluntarily swallows a mackerel containing an acoustic transmitter.

Body size (and hence age) was positively correlated with maximum swimming depth. In other words, larger, older sharks spent relatively more time at greater depths than smaller, younger ones. Sharks were also observed to continue foraging after being tagged, suggesting the tags had not altered normal activity—a concern when basing scientific findings solely on observations of tagged animals.

Four of the eight tagged sharks were lured back to the boat, captured and brought to a laboratory for further tests. Necropsies confirmed that shark stomachs contained prey, suggesting that abrupt drops in

stomach temperature observed in the tracking record were associated with feeding.

Impacts and Relevance to Regulations

Under current regulation, drift gillnets can only be set at night and nets must be submerged at least 12 meters beneath the surface to reduce the risk of entangling whales, dolphins and other marine animals.

Based on the findings of this California Sea Grant project, this same regulation is likely reducing the risk of entanglement to juvenile mako sharks. This information has been shared with NOAA Fisheries, the federal agency that manages highly migratory shark species.

Since completing their tagging study, the scientists have received a second grant from California Sea Grant to conduct a similar study of thresher sharks in the bight. This project will add to what is known about the essential habitat requirements of two commercially important sharks in the region. A goal is to identify the relative amount of time different age groups of sharks spend in the depths that make them vulnerable to gillnetting.

Sea Grant trainee Chugey Sepulveda. Photo: Christina Johnson, California Sea Grant

(Above and lower right) Attaching archival tags to thresher sharks. Photos: Dan Cartamil, Scripps Institution of Oceanography

Although mako sharks were observed to spend most of their time above the minimum-depth requirement for gillnets, Graham emphasized that sharks still dive to deeper depths regularly. During these times, he said, they are at risk of being caught. If fishing pressure (i.e., gillnetting) were to intensify significantly, the depth-minimums would offer progressively less protection from overfishing. There would be more nets in the water to ensnare sharks going up and down, Graham said.

"In the bight, the mako is overfished," Graham said. "Both young and old sharks are targeted, particularly the young. Sharks take a long time to reach sexual maturity. By removing large numbers of young sharks, a serious detriment to the future population is occurring. We have no basis yet of knowing the size of this detriment for makos and threshers. However, we could be moving toward a time when the adult makos become very rare and the population crashes."

The data from these two projects will contribute to a number of ongoing projects and federal initiatives, namely the Fishery Management Plan for Highly Migratory Species Fisheries off the West Coast, the National Plan of Action for the Conservation and Management of Sharks, the Census of Marine Life program and its pilot project, Tagging of Pacific Pelagics.

In addition to Sea Grant marine advisors, NOAA Fisheries, the California Department of Fish and Game, and other university scientists, the researchers will share their results with recreational fishing groups such as the United Anglers Association, commercial organizations such as the Western Fishboat Owners Association, and fisheries scientists and resource managers in Mexico. ■ ■ ■

"All the information from this Sea Grant project can be used to define different management options for shark fisheries."—Dave Holts, shark biologist, NOAA Fisheries

"…we could be moving toward a time when the adult makos become very rare and the population crashes."—Jeffrey Graham

In Search of New Antibiotics, Researchers Probe Sea Life ...

One of the most important medical discoveries of the 20th century in the fight against bacterial infections was *Penicillium* sp., extracted from common mold sources. Photo: Keith Weller, Agricultural Research Service

In hospitals across America, doctors are witnessing an alarming rise in the number of patients with antibiotic-resistant infections. A handful of marine researchers are now looking to the massive liquid environment of the sea for cures.

Why the sea? Historically, molecules found in nature have been the foundation for modern pharmacology. Molecules from terrestrial plants and microorganisms have inspired the development of about half of all drugs. Aspirin from willow bark, penicillin from bread mold, and morphine from poppies are just a few examples. The expectation is that the ocean, once properly explored, will yield as many discoveries and further enrich our understanding of human disease and treatment.

Here we highlight two California Sea Grant projects that investigate the biomedical potential of marine organisms. Both address the issue of finding cures for antibiotic-resistant diseases.

A yellow-orange ascidian or sea squirt. Photo: William Fenical

Sea Squirts

In the first project, a team of scientists led by Robert Lehrer, an immunologist at the David Geffen School of Medicine at UCLA, and Steven Taylor, now a senior scientist at Amylin Pharmaceuticals in San Diego, elucidated the structure and action of peptides (small proteins) extracted from the blood cells of sea squirts.

Sea squirts, also known as ascidians, are a type of tunicate. Some species are common fouling organisms in California. Like other marine invertebrates, such as horseshoe crabs, shrimps and mussels, sea squirts rely heavily on antibiotic-like peptides in their blood cells to protect themselves from infection.

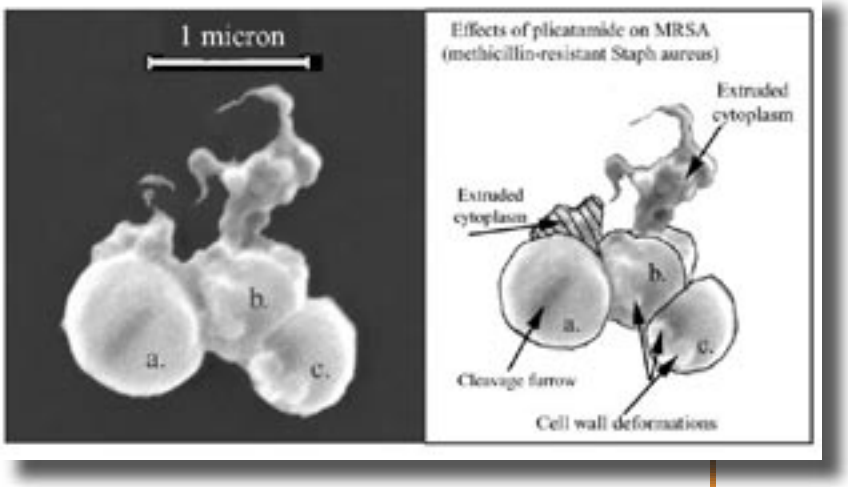
Robert Lehrer

Despite the fact that these marine invertebrates are unable to produce antibodies or other components of an adaptive immune system, such as T-cells, many thrive in microbe-rich environments, such as polluted marinas and bays of Southern California. Their heartiness to bacterial pollution has led scientists to believe that the blood peptides may help to fight infection and are therefore worth examining as potential human therapies.

During the course of the project, Taylor, Lehrer and colleagues discovered one intriguing peptide that was highly effective at killing methicillin-resistant *Staphyloccus aureus* (MRSA)—bacteria that cause serious staph infections. "We think of such peptides as templates that can be used to design new peptide antibiotics directed against human pathogens that, like MRSA, are getting out of control," Lehrer said. The next step is to see if the peptide could be modified to be active against a suite of pathogenic human bacteria.

"There is no question that medical doctors are seeing more and more cases where diseases are resistant to standard antibiotic therapies," Taylor said. "Even though you cannot put the peptide in a pill or needle as it is, this discovery gives us insights that might be useful for fighting disease resistance."

"Basically, we have to stay ahead of the bacteria so that if they do become resistant to one drug, we will always have another effective one in reserve," Lehrer said. Both investigators say that finding antibiotics that work through novel biochemical pathways, as is the case with the sea squirt's peptides, could be a good way to stay ahead.



Three staphylococci after being treated with a compound extracted from a sea squirt. Photos: Robert Lehrer Lab

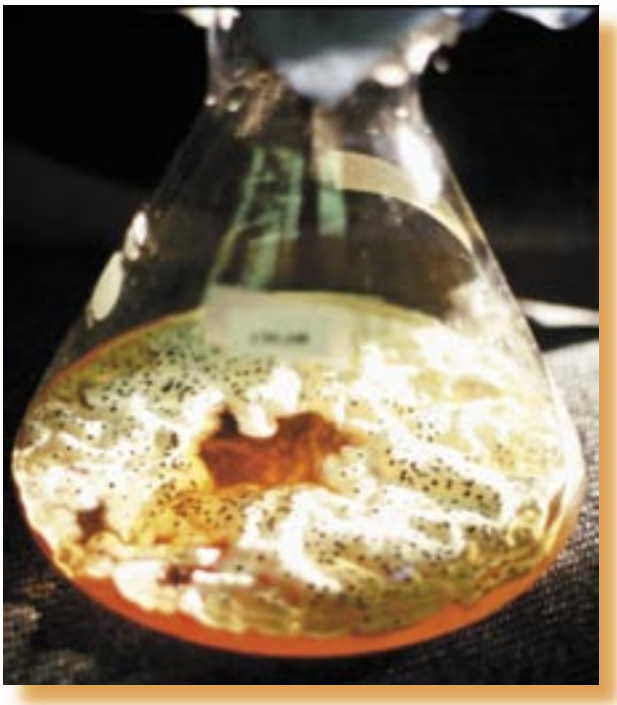
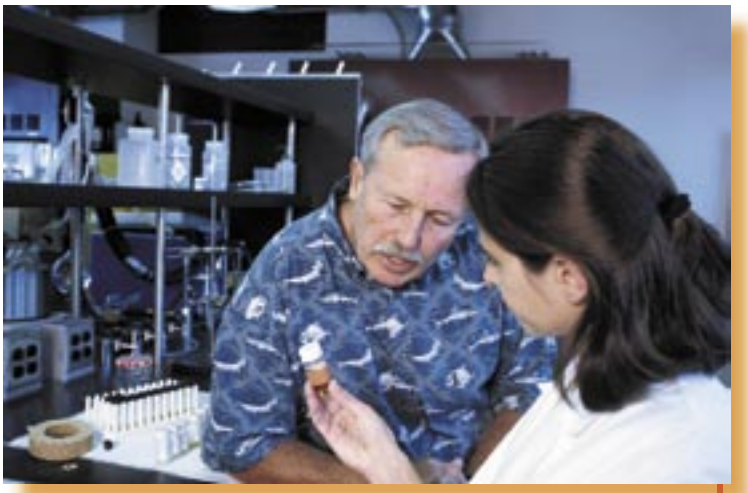


Photo: William Fenical

Deep-sea Bacteria

In a second and ongoing Sea Grant project, William Fenical, a marine chemist at Scripps Institution of Oceanography, is testing the anticancer and antibiotic activity of metabolites produced by a newly discovered group of marine bacteria. In 2002 Fenical discovered these bacteria in sediment samples drawn from the inky depths of the sea.

The new group of bacteria, which he named marinomyces, is amazingly similar to the actinomycetes—soil bacteria that have been the source of dozens of antibiotics, including streptomycin, erythromycin and the tetracyclines. Prior to Fenical's discovery,



William Fenical and student in his lab at the Center for Marine Biotechnology and Biomedicine. Photo above and lower right: Scripps Institution of Oceanography

scientists speculated that no marine version of actinomycetes existed. His discovery debunks this theory and has given further impetus for exploring the sea.

Tests have shown that 35 percent of these new species of marine bacteria produce compounds with a high level of antibiotic activity. Fully 80 percent produce molecules that inhibit colon cancer. More importantly, chemical analyses have shown the presence of never-before-seen molecules. This suggests the compounds may be killing bacteria and inhibiting cancer through biochemical pathways that have not yet been exploited for human purposes. Fenical believes some of this novelty may be related to the fact that the marine bacteria have adapted to the sodium ion, in other words to the sea.

During the course of his Sea Grant project, Fenical and colleagues will continue to develop techniques

The soft yellow coral *Eleutherobia* contains a compound with a similar chemical action to the drug Taxol, which is used in the treatment of breast cancer. Photo: William Fenical

for culturing marine bacteria and further test their antimicrobial and anticancer activity. They will also continue to search for new species of marinomyces.

"The average person thinks of the bottom of the ocean as a dark, cold, and nasty place that is irrelevant, but we've shown that this environment may be a huge resource for new antibiotics and drugs for the treatment of cancer," Fenical said. ■ ■ ■

Highlights

In these Sea Grant projects, researchers discovered that…

• A compound extracted from the blood cells of sea squirts kills antibiotic-resistant staph bacteria.

• Another team of Sea Grant researchers are investigating the antibiotic and anticancer activity of compounds produced by a newly discovered group of bacteria living in deep-sea muds.

A View Into a Common Sportfishing Practice ...

Sportfishers are taking a greater toll on the sea than previously thought, according to a study published in 2004 in the prestigious journal* Science. *This study scrutinized a 22-year record of fishing data and showed that recreational anglers off California, Washington and Oregon catch about 59 percent of total landings of several depleted coastal stocks—including lingcod, bocaccio and six other species of rockfish. California Sea Grant is supporting efforts to help anglers, scientists and resource managers work together to minimize the impacts of recreational activities on coastal life.

Catch-and-Release Practices Trigger Cascade of Stress Effects

Addressing a critical question for sportfishing, marine biology professors Chris Lowe and Kevin Kelley of California State University, Long Beach (CSULB) examined the physiological effects of catch-and-release practices on California sheephead, a popular sport and commercial fish.

A major focus of the research was to gauge stress levels in fish by measuring hormonal changes—in particular, levels of the stress hormone cortisol and insulin-like growth factor, which regulate growth, metabolism and tissue repair. They also tagged fish to study mortality rates of released fish and to monitor behavioral changes that might reduce an animal's long-term chances of survival.

The research is of immediate relevance to fisheries management as the California Department of Fish and Game (CDFG) recently imposed a 13-inch minimum size limit for all recreationally and commercially caught sheephead. The regulation, which in 1999 began as a 12-inch limit, is designed to improve the likelihood that female sheephead reproduce before being harvested. Fishermen, particularly hook-and-line anglers, have criticized the regulation, arguing that undersized fish that are caught and released likely have high mortality rates, especially when they are brought up from depth. Hence, they argued, the regulation may be ineffective at protecting the species from overfishing.

A keystone predator within the kelp forests of Central and Southern California, the California sheephead (*Semicossyphus pulcher*) is a popular target species for anglers and recreational spear fishers. Within the last 15 years, it has also become highly sought after by commercial trap fishermen, who sell the fish live to Asian markets and restaurants at a substantial premium. At birth, all sheephead are female. They turn into males as they age and grow—a fact that adds complexity to managing the fishery. Photos this story: Chris Lowe, CSULB

Research Findings

At a very basic physiological level, sheephead respond to stress in much the same way other animals do. Fish that are caught, handled, exposed to envi-

ronmental stressors or held in captivity exhibit a rapid but temporary elevation in adrenalin. This is followed by a prolonged surge in plasma cortisol levels, which in turn is associated with a rise in a growth-inhibiting protein called insulin-like growth factor-binding protein (IGFBP). Higher than normal levels of this protein can disrupt the regulation of fish growth, impair tissue repair, lower disease resistance and adversely affect egg production.

Perhaps the most intriguing aspect of the research, however, was the discovery that IGFBP remains elevated even after cortisol levels subside. This implies that catch-and-release fishing has longer-lasting effects than might be expected based on cortisol levels alone. Fish exposed to high-levels of stress may, for example, reach sexual maturity later in life.

In field experiments at Catalina Island, the marine biologists caught sheephead by hook-and-line and in

Sea Grant trainees Darin Topping and Maelanie Galima taking blood samples from a sheephead. Cortisol levels in the blood indicate stress levels.

commercial wire fish traps, subjecting fish to varying levels of stress. "We fought them like an angler would for different amounts of time," Lowe explained. "Fish caught in commercial traps were allowed to soak for different lengths of time."

In all cases, plasma cortisol levels increased rapidly and dramatically proportional to the duration and intensity of handling or trapping. Plasma glucose levels also rose, as did levels of IGFBP. Angled fish, however, had higher levels of lactate in their muscles, a sign of anaerobic activity, caused by struggling against a line. Trapped fish, in contrast, had lower lactate levels, which is not too surprising since these fish were passively lured into the traps.

By tracking fish, the marine biologists discovered

Sheephead…12

One of the traps set by researchers.

that angled fish moved around less—a sign of stress—for about 12 hours after being released. After 18 hours, many fish showed remarkable recovery, both physiologically and behaviorally. The degree of recovery, however, depended on the intensity at which they had been angled or the duration left in a trap. It also depended on whether fish were held in captivity or released into the wild. "The more you stress them, the more they respond," Lowe said. "However, in the field, fish recovered very quickly. Fish held in captivity at the lab remained stressed for a month."

Another significant result: none of the caught-and-released fish died while being tracked. The post-release survivorship rate for angled fish was 100 percent as long as a fish's swim bladder was deflated so it could descend. "People argued a lot of fish would die," Lowe said. "Our study confirms this is not the

Darin Topping with male sheephead.

case," if fishermen understand the importance of swim bladder deflation and learn simple techniques to accomplish it.

Applications for Fisheries Management

The research reinforces the CDFG's minimum size limit for sheephead. It may also affect how the agency interprets fishing mortality rates, statistics used to estimate the effects of fishing on stock size, said Deborah Wilson-Vandenberg, a research manager with Fish and Game, who is coordinating the implementation of the state's Nearshore Fishery Management Plan (NFMP). Sheephead is one of 19 species covered under this plan.

The Department is in the process of finalizing its stock assessment for sheephead—the first state-sponsored stock assessment for a nearshore fish species in the NFMP. The outcome of the stock assessment and peer-review of the report will form the basis for a revised strategy for managing the sheephead fishery, both commercial and recreational, she said.

Marine biologists Kevin Kelley (shown above) and Chris Lowe of CSULB organized and led a symposium on stress-related impacts of catch-and-release practices at the 2004 annual meeting of the Southern California Academy of Sciences. This event brought together experts from around the U.S. to discuss the biological and management implications of catch-and-release practices, as well as other human-induced stressors, on fisheries management.

Kevin Kelley and Juli Kalman (symposium participant) sampling fish.

Next Step

Researchers don't know how long the stress-induced growth inhibitor IGFBP remains elevated in angled fish. For this reason, the long-term implications of catch-and-release practices remain unknown. How fish respond to being repeatedly angled is also a mystery, but it is believed that in some highly fished areas, undersized sheephead may be trapped and released, or angled and released, many times before they are legal size. A better understanding of whether (or the degree to which) stress slows growth and reproduction may further improve the management of this economically important fishery. ■ ■ ■

Highlights

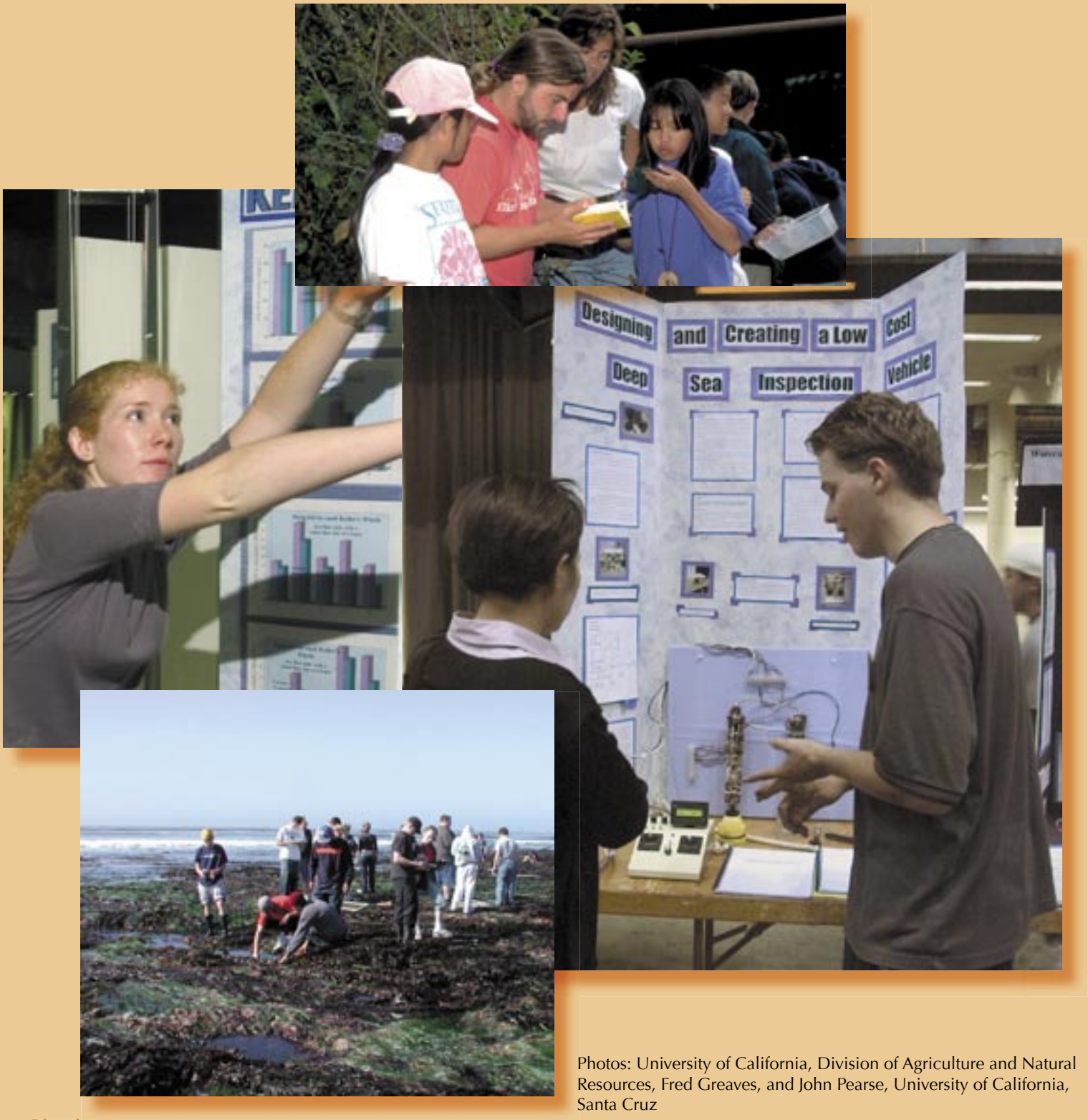
In this Sea Grant project, researchers learned…

• Post-release mortality rates of sheephead are very low as long as the fish's swim bladder is deflated before release.

• Being caught on hook-and-line stresses fish more than being caught in a trap. Regardless of gear type, however, the stress of being caught and handled has longer-lasting physiological effects than previously thought.

• The secondary effects of stress may slow fish growth and delay sexual maturity.

A Track Record of Excellence in Educating the Next Generation...



Photos: University of California, Division of Agriculture and Natural Resources, Fred Greaves, and John Pearse, University of California, Santa Cruz

Underlying NOAA Sea Grant's mission is a strongly held belief that educating the next generation of marine scientists—and attracting the best talent to marine disciplines—is a prerequisite for advancing national ocean science and governance.

Toward this end, California Sea Grant offers scholarships, fellowships and traineeships that provide outstanding students with financial support and mentoring opportunities with senior marine researchers and resource managers.

Sea Grant also supports curriculum development and summer camps for under-represented youth, funds educational Web pages, and administers a research fellowship program for the CALFED Bay-Delta Science Program. Presented are short descriptions of programs illustrating the breadth and depth of Sea Grant education. For details about any of these programs, see http://www.csgc.ucsd.edu/EDUCATION/SgEducationIndx.html

Graduate Trainees

Sea Grant trainees are graduate students working with Sea Grant-funded researchers. Outside reviewers have ranked this program for supporting graduate students as a "best practice" among the nation's network of 30 Sea Grant programs. Its merits are even more evident in the impressive accomplishments of former Sea Grant trainees: people like Julie Packard, executive director of the Monterey Bay Aquarium; Elizabeth Fuchs, coastal program manager at the California Coastal Commission; David Aubrey, director of the Coastal Research Center at Woods Hole Oceanographic Institute; and Michael Orbach, director of Duke University Marine Laboratory.

John D. Isaacs Scholarship

Aaron Sargent Goldin, a junior at San Dieguito Academy High School in Encinitas, California, was the 2004 winner of California Sea Grant's John D. Isaacs Scholarship—a four-year, $12,000 college scholarship awarded annually at the California State Science Fair.

In his award-winning project, Goldin designed, built and tested an instrument that converts surface wave energy into electricity, using gyroscopic precession to turn a crank connected to an electric generator.

Aaron Goldin solders resistors on the electric generator inside Gyro-Gen. The wheel in center of photo is the gyroscope. Gyroscopes are used to navigate planes and space shuttles; a typical plane has about a dozen of them. Photos this page: Michael Goldin

Goldin's invention, which he named Gyro-Gen (short for gyroscope and generator), produces about three watts of clean, sustainable energy and holds promise for advancing autonomous ocean instruments—ones that don't require batteries. As far as anyone knows, Goldin is the first to place a gyroscope inside an ocean instrument. This innovation is what impressed the judges.

Goldin tests his invention off the Scripps Pier in La Jolla.

Knauss Fellowships

In 2004, California graduate students won three of the 33 prestigious Sea Grant Knauss fellowships in marine policy. All three spent the year working in Washington, D.C., at various offices within NOAA. The winners were Shannon Dionne of the Monterey Institute of International Studies, who was placed in the NOAA Office of International Affairs; Julie Kellner from the University of California at Santa Barbara, who is spending the year at the NOAA Biogeography Program; and Kristan Blackhart of the University of California at Santa Cruz, who is at the NOAA Fisheries Office of Science and Technology.

Vice Admiral (Ret.) Conrad C. Lautenbacher, head of NOAA, shown with 2004 Knauss fellows Shannon Dionne (left), Kristan Blackhart and Julie Kellner. Photo: NOAA

"The Knauss Fellowship is an opportunity to get things done at the ground level. I feel I'm really able to make a difference," Kristan Blackhart said.

State Fellowships

California Sea Grant offers its own marine policy fellowship that places fellows with hosts in Sacramento, such as the California Legislature's Joint Committee on Fisheries and Aquaculture and the California Coastal Commission. Illustrating the program's success at preparing scientists for careers in policy, Christine Blackburn was a state fellow at the California Resources Agency and then got a position with the U.S. Commission on Ocean Policy. As support staff for the 16 commissioners, Blackburn wrote chapters of their 400-page report and incorporated comments from the nation's governors into it.

"Working at the U.S. Commission on Ocean Policy has been a once-in-a-lifetime experience," said Christine Blackburn, who earned a doctorate degree in marine science from Scripps Institution of Oceanography in 2002. "My Sea Grant fellowship at the California Resources Agency made it possible. My time in California was invaluable for understanding the policy implications of science and how science fits into policymaking."

Industrial Fellowship

Technology transfer is at the core of Sea Grant's mission and a mainstay of Sea Grant education. One vehicle for transferring technology is the Sea Grant Industrial Fellowship, which pairs graduate students in marine science with mentors in industry. Host companies provide matching funds to support the fellow's training.

Eric Miller, a doctoral student in marine natural products chemistry at Scripps Institution of Oceanography, recently completed a two-year Industrial Fellowship with Nereus Pharmaceuticals, Inc., a drug discovery company co-founded by Sea Grant researcher William Fenical. As a fellow, Miller spent

Photo: Nereus Pharmaceuticals, Inc.

Industrial Fellow Eric Miller. Photo: Christina Johnson, California Sea Grant.

"Now that I've been immersed in both academia and industry, I'm sure I'll go back to industry," said Eric Miller. After receiving a B.S. in aquatic biology from UC Santa Barbara in 1996, Miller worked for five years at two small pharmaceutical companies. "I like the pace in industry. The fellowship has been excellent in making contacts there. These contacts will carry forward throughout my career."

Camp SEA Lab counselor and student venture out into the kelp beds of Monterey Bay.

two days a week at Nereus, working on developing assays for testing the anticancer properties of compounds extracted from marine bacteria. The research will be a significant focus of his doctoral thesis.

A young Camp SEA Lab student proudly displays the "jellyfish" he made from a shower cap and ribbons. Counselors led discussions on the natural history of this odd invertebrate. Camp SEA Lab photos this page: Christina Johnson

Camp SEA Lab

Working on the premise that the best way to get young children interested in science is to make learning fun, California Sea Grant supports an educational marine science camp for students, ages 8–13, in Monterey Bay. Short for Science, Education and Adventure, Camp SEA Lab is built around the idea of learning by doing. "Doing" means exploring tide pools, touring the Monterey Bay Aquarium, building "plankton" and remotely operated vehicles, and kayaking through the kelp forests, among the sea otters, dolphins, seals and sea lions of the Monterey Bay National Marine Sanctuary.

In an age where most children spend many, many hours in front of a computer screen, TV or "GameBoy," Camp SEA Lab offers youngsters a much-needed opportunity to actively and intelligently explore the wonders of the natural world. Since 1998, more than 940 children have attended the camp and more than 40% have done so with the assistance of scholarship aid.

Camp SEA Lab is committed to providing opportunities for disadvantaged students and is supported with grants from California Sea Grant and the National Science Foundation and receives substantial support from local businesses. Sea Grant Marine Advisor Rick Starr was one of the camp's founders and continues to lead its board of directors.

For more information about Camp SEA Lab, please visit http://www.campsealab.org. ■ ■ ■

Halibut Aquaculture: Sea Grant Supports an Emerging Industry ...

California Sea Grant has a long tradition of investing in the early stages of aquaculture. Pioneering Sea Grant research, for example, led to the creation of a sturgeon aquaculture industry (from which cultured caviar is produced) and to hybrid striped sea bass farming.

The legacy of investing in the early stages of aquaculture continues today. With the hope of developing a scientific basis for managing and rearing a native flatfish species, scientists from the United States and Mexico are collaborating on a series of projects aimed at understanding the basic biology and life history of California halibut.

California halibut (*Paralichthys californicus*) is a type of flatfish that inhabits shallow sand and mud bottom waters off the U.S. West Coast and Baja California, Mexico. Unlike fish that swim upright, flatfish lie flat on the seabed. The eye on their "downside" migrates to the "upside" early in life to make this possible.

A juvenile California halibut that has undergone metamorphosis approximately 42 days post hatch. At this stage, juveniles resemble miniature adults, but their scales are not yet formed. Photo: Enric Gisbert

Halibut...18

Declines in commercial landings of California halibut—from highs exceeding 2,000 metric tons falling to 450 metric tons a year—have stimulated interest in managing wild stocks better and with greater appreciation for the species' binational geographic distribution. Declines have also kindled interest in halibut farming.

Although halibut aquaculture may take a decade to develop fully, in 2004 Sea Grant researchers Drs. Raul Piedrahita and Douglas Conklin of the University of California at Davis reported substantial progress in efforts to initiate a commercially viable halibut farming industry.

These scientists and their graduate students have identified the relationship between diet, water quality and culture on fish growth. The team was also able to develop a halibut diet that promotes the conversion of protein into fish growth.

In collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) in Baja California, scientists are also working on pinpointing the optimal time at which to wean halibut larvae from live prey to formulated diets.

Besides understanding the nutritional requirements of halibut, there are many engineering issues that must be worked out if halibut farming is to become a reality. Two major ones are reducing wastewater pollution and energy use from the system of tanks in which halibut are raised.

A two-year-old California halibut. Photo: Julie Doroshov

With Sea Grant funding, Piedrahita and Conklin were able to build a prototype closed recirculation system at Bodega Marine Laboratory that is serving as a model for designing and operating a commercial halibut farm—one that can pass California's relatively high environmental standards.

The design of their recirculation systems enhances fish growth rates while minimizing pollution. This is achieved through a number of ways, not the least of which is the presence of an innovative, low-energy biofilter that continuously removes nitrogenous waste from seawater. Re-circulating water through the tanks helps retain heat, making it possible to keep water temperatures high for faster fish growth without adding significantly to energy costs.

To date, the tank system requires only two liters of fresh seawater water every minute to maintain optimum growing conditions. Ultimately, however, researchers hope to design one requiring almost no fresh seawater input. This would enable businesses greater freedom in where they could build commercial facilities.

Another major advance made during the course of this grant was the success in developing techniques

California Halibut…Why It's an Excellent Candidate for Aquaculture

• California halibut are a mild-tasting fish and much sought after by gourmet restaurants and sushi bars.

•As adults, they spend their life nearly motionless on the sea bottom. This lazy lifestyle translates into high feed-conversion rates. Since feed costs can be the most expensive part of raising fish, good conversion rates are key to successful halibut farming.

• They are quite tolerant to crowding and grow rapidly even when reared two-layers thick on the bottom of a tank.

• A halibut hatchery has been in operation at Redondo Beach for more than a decade, so basic techniques for hatching fish already exist.

Sidebar photo pages 19, 20 Mark Drawbridge, Hubbs-SeaWorld Research Institute

Highlights

In this Sea Grant project, researchers have developed…

• A low-impact, energy-efficient culture system for halibut that ultimately could be operated away from the coast, where real estate is more affordable.

• Reliable techniques for rearing halibut larvae. With a new tank design and better nutrition, the scientists were able to increase larvae survival rates from less than five percent to 50 percent.

The project's success has led to…

• The Cultured Abalone in Goleta hiring a graduate student who worked on the Sea Grant research project. The student, Douglas Bush, will be developing abalone diets and investigating whether halibut should be a second product line at the abalone farm.

for rearing halibut larvae. At the start of the grant, survival rates for halibut larvae were less than five percent. By changing feeding regimes and tank designs, the researchers have increased survival rates to 50 percent.

The success of Piedrahita and Conklin's prototype has revitalized interest in the potential for stocking coastal waters with hatched halibut. "The hatchery technologies we are developing for aquaculture can easily be used for producing juveniles for stock enhancement," Conklin said. In San Diego, Hubbs-SeaWorld Research Institute is developing methods for tagging juvenile halibut to see where fish go, what habitats they occupy and how long they live—all information that is needed for deciding whether, how and where to release hatched halibut.

In addition to advancing the promise of a new aquaculture industry, the Sea Grant research dovetails

Above: surgical implantation of a sonic tag into a cultured California halibut. Right: insertion of a coded wire tag into the opercular muscle on a halibut's blind side. Photos: Mark Drawbridge, Hubbs-SeaWorld Research Institute

with ecological studies being led by Sharon Herzka of CICESE and Lisa Levin of Scripps Institution of Oceanography. In separate but related research, the biologists are attempting to quantify the number of juvenile halibut residing in different habitat types in California and Baja California—research that may improve the management of commercial and recreational halibut fisheries. ■ ■ ■

Communications—Reaching Our Audiences...

The Communications Office at California Sea Grant employs a variety of tools to put the results of research and outreach projects in the hands of end users.

News Media

Articles about our research have appeared in such publications as *National Fisherman,* the *San Diego Union-Tribune, Coast & Ocean*, *San Diego Westways* magazine and *Science News Online*.

Project Profiles

These popular one-page summaries of funded projects now number more than 50 and can be found on our web site at www.csgc.ucsd.edu/RESEARCH/ProjProfIndx.html

Awards

California Sea Grant received two 2004 Apex Awards for Publication Excellence for its program newsletter, *Sea Grant News*, and a brochure, *Making Dollars and Sense*, about nontoxic hull paints; and received a 2004 Communicator Award for newsletter writing. We also received a 2004 award from the League of Communications Professionals for the feature story on sharks (p. 3).

Sea Grant News is published quarterly and mailed free of charge within the U.S.

This new, free booklet published by California Sea Grant's Extension Program compares the cost, durability and maintenance requirements of copper-based hull paints with new, nontoxic coatings. It includes a handy worksheet for boat owners to estimate their conversion costs.

National Sea Grant Library

This library houses the complete archive of publications from the 30 national Sea Grant programs. In 2003, the library reported more than 9,000 PDF downloads of California Sea Grant publications from their website (http://nsgl.gso.uri.edu/).

Meetings

Each year California Sea Grant supplies multiple copies of its publications for more than 40 workshops, conferences and meetings. If you are hosting a meeting and would like Sea Grant publications for attendees, contact Gretchen Frederick: 858-534-4446, gfrederick@ucsd.edu. Visit our website (www.csgc.ucsd.edu) for a complete list of publications.

Improving Nearshore Stock Assessment—An Extension Example...

West Coast rockfish populations declined precipitously in the 1990s. Concern that this downward trend, if left unchecked, could result in widespread collapses has led to major changes in state and federal fisheries management. To protect cowcod and bocaccio, for example, the Pacific Fishery Management Council was forced to close large areas of the continental shelf to groundfish fishing. Meanwhile, the California Department of Fish and Game Commission has put forth a Nearshore Fishery Management Plan to protect 19 nearshore species, most of which are rockfish, from overfishing.

As part of the state plan, and in recognition of the need for more comprehensive fisheries data, Fish and Game biologists have been conducting visual fish counts via scuba surveys. These diver data, as well as more traditional "fishery-dependent" statistics from landings tickets and logbooks, are used to set fishing quotas and other regulations and to guide strategies for managing the state's marine resources. As important as all these data are to crafting stock assessment models, there are major questions about the meaning and relevance of "fishery-dependent" and "fishery-independent" data. The core of the issue is this: what fishers catch and what divers see can lead to very different interpretations of the status of marine resources.

To help reconcile how to best use and interpret diverse datasets, California Sea Grant Marine Advisor Rick Starr has brought together commercial fishers, academic scientists and Fish and Game biologists on a unique project: to compare estimates of relative fish abundance obtained by diver surveys and fish catches.

As is the aim of the California Sea Grant Extension Program, the project serves dual, complementary purposes: to improve the scientific underpinning of policymaking and to facilitate the cross-pollination of ideas and expertise among stakeholders. Unlike most academic research, in this project fishers, divers and scientists sat together and planned the project's scientific objectives and sampling strategies. This collaboration made it possible to incorporate the experience and knowledge of fishers into the project's design and enhanced fishers' trust in the project's objectives. It

Fisherman displays catch from stick fishing gear. Photo: Rick Starr, California Sea Grant Extension Program

California Sea Grant Marine Advisor Rick Starr has organized a collaborative research project to improve stock assessments for nearshore fish species. Major funding for the project comes from the COMMONWEAL Foundation.

The Nearshore Fishery Management Plan covers 19 nearshore fish species, most of which are rockfish of the genus *Sebastes*. One of the state's ideas for improving stock assessment is to expand diver surveys and to perhaps employ fishers to collect catch data in certain areas. Shown above, a Vermillion rockfish (*S. miniatus*) caught and released in Carmel Bay. Photo: Rick Starr

also focused the project so that it would better address resource management issues.

"Both fishers and biologists have a common goal—to see a healthy resource," Starr said. "I thought it would be good to have fishers participate in designing a research project that addresses what fishermen see as key fisheries questions."

The project that the team designed involved surveying four sites in Carmel Bay during a 16-day period in fall 2003. To collect the fishery-dependent data, commercial fishers were hired to catch fish with four standard gear types—"sticks," hand lines, traps and rod-and-reel. All caught fish were identified, measured and released. Graduate students from Moss Landing Marine Labs worked on fishing vessels to record data and learn about commercial fishing techniques. For the scuba surveys, divers with the Department of

"We want to work with scientists because the more and better information we have on nearshore fishes, the better the management will be. That will lead to a stronger fishery and be better for fishermen."—Giovanni Nevoloso, commercial nearshore fisher in Central California

Fish and Game and UC Santa Cruz swam transects through the same areas, counting species and noting fish sizes. Both diving and fishing operations were standardized to make it possible to compare species compositions, relative fish abundances and fish-size distributions from the different surveys.

As expected, both divers and fishers saw and caught species common to kelp forests of Central California. Divers, however, saw more fish, more small fish and more species of fish as compared to what fishers caught. More specifically, divers counted 10,690 fish longer than four inches while fishermen caught 1,279 fish. Divers observed 38 different species while fishers caught 20. This discrepancy in the number of species observed was not a surprise either since fishers target only certain species.

Species composition also varied significantly depending on the survey method. For example, blue rockfish, gopher rockfish, black and yellow rockfish, cabezon, kelp rockfish, lingcod, and black rockfish comprised almost 90 percent of fishers' catch. In contrast, diver observations would have left one believing that blue rockfish comprise about 55 percent of fish. Based on diver observations, senorita, kelp rockfish, and striped surfperch counts represented fish percentages of 11, 6, and 5, respectively. These results underscore the difficulty in estimating stock size.

Starr and co-investigators Mark Carr, a professor at UC Santa Cruz, Dave Osorio, a biologist with the California Department of Fish and Game, and professor Pete Raimondi of UC Santa Cruz, are still analyzing the relative abundances of fishes calculated as a function of the four different types of fishing gear used. Preliminary analyses, however, show that estimates of fish abundance also vary greatly depending on fishing gear used.

"You cannot use these (survey) methods independently at different sites and combine the data to look for patterns of abundance across all sites," Carr said, explaining the results. "The best estimate of relative

fish abundance at a particular site requires a combination of different sampling methods—divers and fishing gear."

While the first stage of the project has highlighted differences in survey results, Starr says the next step is to determine the relative accuracy of catch and diver surveys – in other words, to figure out which of the survey methods is providing a better tally, on a species-by-species basis. Starr and colleagues hope to do this by intensively sampling areas, tagging and recapturing key nearshore species.

"We have a successful collaboration between fishers, the Department of Fish and Game, and university scientists," Starr said. "We have developed a smooth working relationship. We are all learning about fishing in the nearshore ecosystem. This collaboration should lead to improvements in estimating fish abundances in kelp beds and hopefully improve management actions." ■ ■ ■

Kelp greenling (*Hexagrammos decagrammus*). Photo: Rick Starr

Diver prepares to conduct an underwater transect survey. Photo: Dave Osorio, California Department of Fish and Game

"By working with California Sea Grant, the University of California, and fishermen, we are developing survey methods to expand fish abundance surveys…to get us out of a data-poor situation. This data-collection effort is one of the first big steps to implementing the 2002 Nearshore Fishery Management Plan. The department cannot do this alone. There is too much work to be done."—Dave Osorio, California Department of Fish and Game biologist and a project co-investigator

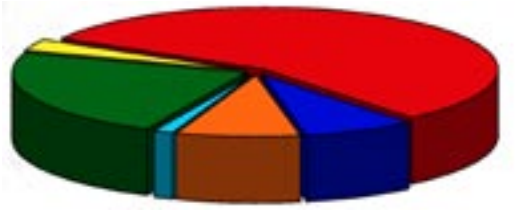
Financial Report

Sources of Funding

The majority of California Sea Grant (CSG) funding is from the National Sea Grant College Program (NSGCP), part of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Funding from the Resources Agency Sea Grant Advisory Panel (RASGAP) is from the state of California's Resources Agency, which oversees agencies that manage the state's natural resources, such as the Department of Fish and Game. When available, funding from the state's Environmental License Plate (ELP) income is allocated in support of the Sea Grant Extension Program. Special initiatives are separate competitions by the NSGCP. The Grantee's share reflects matching funds, generally a researcher's time, which is contributed by the scientist's institution. The source charts above show the relative proportions of funds.

2002–2003

- Federal (Core) $3,859,500: 56%
- Federal (Special) $545,888: 8%
- RASGAP $591,105: 9%
- ELP $99,000: 1%
- Grantee (Core) $1,615,466: 23%
- Grantee (Special) $216,305: 3%



Total: $6,927,264

2003–2004

- Federal (Core) $3,869,500: 59.2%
- Federal (Special) $497,172: 7.6%
- RASGAP $157,000: 2.4%
- Grantee (Core) $1,777,750: 27.2%
- Grantee (Special) $237,321: 3.6%

Total: $6,538,743

Allocations

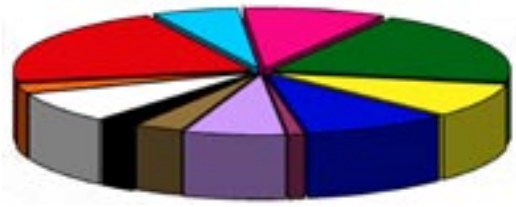
Core allocations are to projects selected by California Sea Grant for funding through an annual, competitive, peer-review process. The charts below show the relative percentage of combined Core and Special Initiative funds applied to various activities and subject areas of the program. These amounts change annually following the evaluation of all funding proposals, and the priorities defined by CSG, the NSGCP, and the RASGAP panel.

2002–2003

- Coastal $1,266,395: 18%
- Aquaculture $445,841: 6%
- Fisheries $1,140,689: 16%
- Ocean Engineering $61,598: 1%
- New Marine Products $461,621: 7%
- Marine Affairs $197,525: 3%
- Program Development $100,001: 1%
- Extension $1,366,724: 21%
- Communications $416,867: 6%
- Education $914,490: 13%
- Management $555,513: 8%

Total: $6,927,264

2003–2004



Total: $6,538,743

- Coastal $1,297,477: 19.8%
- Aquaculture $590,051: 9%
- Fisheries $651,721: 10%
- Ocean Engineering $76,508: 1.2%
- New Marine Products $447,802: 6.8%
- Marine Affairs $223,172: 3.4%
- Program Development $170,342: 2.6%
- Research Trainees $534,564: 8.2%
- Education $170,707: 2.6%
- Extension $1,359,578: 20.8%
- Communications $390,003: 6%
- Management $626,818: 9.6%

Honors and Awards

Christine Blackburn, former California Sea Grant State Fellow at the Resources Agency:
- Policy Fellowship, American Association for the Advancement of Science, Washington, D.C.

Ronald Burton, California Sea Grant researcher at Scripps Institution of Oceanography:
- Presidential lecturer, Florida International University

Patricia Conrad, California Sea Grant researcher at UC Davis:
- Oscar W. Schalm Lectureship 2003, School of Veterinary Medicine, UC Davis
- Aldo Leopold Leadership Program Fellow 2004, Connecticut and Washington D.C.

Paul Dayton, California Sea Grant researcher at Scripps Institution of Oceanography:
- California Assembly Resolution from the Joint Committee on Fisheries and Aquaculture
- E.O. Wilson Naturalist Award
- Faculty Research Lecturer Award 2003, Academic Senate, UC San Diego

California Sea Grant Communications
- League of American Communications Professionals 2003 Spotlight Awards (Silver) for excellence in development of the California Sea Grant Annual Report.

Christina S. Johnson, California Sea Grant Communications office science writer:
- The Communicator Award of Distinction 2003 for feature story, "Parasite in Cats Killing Otters."
- The Communicator Award of Distinction 2004 for "Sea Grant News" Summer 2003 edition.

Christina S. Johnson and **Joann S. Furse**, California Sea Grant Communications office science writer and graphic designer:
- Communications Concepts Apex Award of Excellence 2004 for *Sea Grant News*.

Leigh Taylor Johnson and **Jamie Anne Miller**, California Sea Grant Extension Program Marine Advisor and Program Representative:
- The Communicator Award of Distinction 2004 for the 2003 booklet, "Making Dollars and Sense of Nontoxic Antifouling Strategies for Boats."

John Largier, California Sea Grant researcher at Bodega Marine Laboratory:
- Aldo Leopold Leadership Program Fellow
- Appointee to San Diego Mayor's "Clean Water Task Force" and the state's "Clean Beaches Task Force"

Karen Martin, California Sea Grant researcher at Pepperdine University:
- Best poster in fishery biology award by the American Institute of Fishery Research Biologists, May 2003 for Carpenter, K.A., R. Pommerening, T. Speer, J. Flannery and K. Martin, "Does Beach Grooming Harm Grunion Eggs?"

Susan McBride, California Sea Grant Marine Advisor, Humboldt and Mendocino Counties:
- Certificate of Appreciation, Arcata High School 2003, Job Shadowing Program

John Pearse, California Sea Grant researcher at UC Santa Cruz:
- Monterey Bay National Marine Sanctuary Recognition Award for Education 2003

Pamela Tom, California Sea Grant Seafood Technology Program Manager at UC Davis:
- Selected to be an expert panelist to advise the UN Food and Agriculture Organization's Fisheries Department on the development of aquatic food case studies.

Mark Stacey, California Sea Grant researcher at UC Berkeley:
- 2003 Distinguished Teaching Award Finalist, UC Berkeley

Jim Waldvogel, California Sea Grant Marine Advisor for Del Norte, California and Curry County, Oregon:
- California Trout "Streamkeeper" Award 2003

James Wilen, California Sea Grant researcher at UC Davis:
- Supervisor of Outstanding Dissertation Award Winner, American Association of Agricultural Economics
- UC Davis Graduate Student Mentoring Award
- UC Davis Department of Agricultural and Resource Economics, Gordon A. King Research Award
- Quality of Research Discovery Award, American Association of Agricultural Economics

Collaborations

The projects funded by California Sea Grant take place at universities throughout the state and often involve many partners. The following is a list of these recent institutions and collaborators.

Alaska Department of Fish and Game
Amylin Pharmaceuticals
Aptos High School
AquaTechnics, Inc.
Australian Museum

Bay Foundation of Morro Bay
Birch Aquarium at Scripps
Bodega Marine Laboratory

Cabrillo Marine Aquarium
California Coastal Commission
California Coastal Conservancy
California Cooperative Fisheries Investigations
California Department of Fish and Game
California Institute of Technology
California Maritime Academy
California Mussel Watch Program
California Polytechnic State University
California Seafood Council
California Sea Grant Extension Program
California State Department of Parks & Recreation
California State Lands Commission
California State University, Chico
California State University, Fresno
California State University, Fullerton
California State University, Hayward
California State University, Long Beach
California State University, Los Angeles
California State University, Monterey Bay
California State University, Northridge
California State University, San Marcos
California State Water Resources Control Board
Camp SEA Lab
Central Coast Regional Water Quality Control Board
Centre for Environmental Fisheries and Aquaculture Science, England
Centro de Investigación Científica y de Educatión Superior de Ensenada
Channel Islands Marine Resource Institute
Chinese University of Hong Kong
City of Del Mar
City of Encinitas
City of Los Angeles: Department of Public Works
City of San Diego: Park and Recreation Department
City of Solana Beach
Coastal Marine Institute
Cordell Bank National Marine Sanctuary
County of Los Angeles: Department of Beaches and Harbors
County of Monterey: Department of Education
County of San Diego
County of Sonoma

Datacube, Inc.

East Bay Regional Park District
Elkhorn Slough National Estuarine Research Reserve
Environmental Protection Agency

4Cs Breeding Technologies, Inc.

Golden Gate National Recreation Area
Gulf of the Farallons National Marine Sanctuary

Harbor High School
Harbor of Monterey
Harbor of Santa Cruz
Heal the Bay, Santa Monica
Hopkins Marine Station

Hopkins Marine Station. Photo: Copyright ©2002–2004 Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org

North Gate, University of California, Berkeley.
Photo: Tony Morosco

Hubbs-SeaWorld Research Institute
Humboldt State University

Inter-American Tropical Tuna Commission

Lawrence Livermore National Laboratories
Louisiana State University

Marine Biological Laboratory, Woods Hole
Marine Conservation Biology Institute
Monterey Academy of Ocean Sciences
Monterey Bay Aquarium Research Institute
Monterey Bay National Marine Sanctuary
Monterey Peninsula College
Moss Landing Marine Laboratories

Natal Shark Board, South Africa
National Park Service
Natural Bridges State Park
NASA Jet Propulsion Laboratory
Naval Postgraduate School
NOAA Antarctic Living Marine Resource Program
NOAA Fisheries
NOAA National Environmental Satellite Data and Information Service
NOAA National Ocean Service
North Carolina State University
North County Transit District

Olympic Peninsula National Marine Sanctuary
Orange County District of Sanitation
Oregon State University

Pacific States Marine Fisheries Commission
Partnership for the Interdisciplinary Study of Coastal Oceans
Pepperdine University
Point Reyes National Seashore
Project Pacific

San Diego State University
San Francisco Estuary Institute
San Francisco State University
San José State University
San Lorenzo Valley High School
Santa Barbara Channel Keepers
Santa Barbara Harbor Waterfront Department
Santa Catalina School for Girls
Save Our Shores
Save San Francisco Bay
Scripps Institution of Oceanography
Southern California Beach Valuation Project
Southwest Fisheries Science Center
Stanford University
Surfrider Foundation

Taylor Shellfish Farms
The Abalone Farm
Tijuana River National Estuarine Research Reserve

University of California, Berkeley
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of California, San Francisco
University of California, Santa Barbara
University of California, Santa Cruz
University of Hawaii
University of San Diego
University of Texas, Medical Branch
University of Victoria, British Columbia
University of Washington
U.S. Army Corps of Engineers
U.S. Fish & Wildlife Service
U.S. Geological Survey
U.S. Marine Corps, Camp Pendleton

Watsonville High School
Wilder Ranch State Park

Russell A. Moll, Director
rmoll@ucsd.edu
California Sea Grant College Program
University of California
9500 Gilman Drive
La Jolla, California 92093-0232
Phone: (858) 534-4440 Fax: (858) 534-2231

Communications
Marsha Gear, Communications Director
mgear@ucsd.edu
Phone: (858) 534-0581
Communications Fax: (858) 453-2948

California Sea Grant Extension Program
Paul Olin, Extension Director
pgolin@ucdavis.edu
Phone: (707) 565-2621 Fax: (707) 565-2623

Marine Fisheries Specialist
Christopher M. Dewees
Wildlife, Fish, and Conservation Biology
University of California
1 Shields Avenue
Davis, California 95616-8751
cmdewees@ucdavis.edu
Phone: (530) 752-1497 Fax: (530) 752-4154

Seafood Technology
Pamela Tom, Program Manager
Food Science and Technology Department
University of California
One Shields Avenue
Davis, California 95616-8598
pdtom@ucdavis.edu
Phone/Fax: (530) 752-3837
http://seafood.ucdavis.edu

Marine Advisors

Del Norte (CA) & Curry (OR) Counties
James B. Waldvogel
Sea Grant Extension Program
586 G Street
Crescent City, California 95531-3735
cedelnorte@ucdavis.edu
Phone: (707) 464-4711 Fax: (707) 464-7520
http://cehumboldt.ucdavis.edu

Humboldt & Mendocino Counties
Susan Schlosser
Sea Grant Extension Program
2 Commercial Street, Suite 4
Eureka, California 95501
scschlosser@ucdavis.edu
Phone: (707) 443-8369 Fax: (707) 445-3901
http://cehumboldt.ucdavis.edu/Marine_Science-Sea_Grant/

Sonoma & Marin Counties
Paul Olin
Sea Grant Extension Program
133 Aviation Blvd., Suite 109
Santa Rosa, California 95403
pgolin@ucdavis.edu
Phone: (707) 565-2621 Fax: (707) 565-2623

San Francisco Bay Counties
Jodi Cassell
Sea Grant Extension Program
300 Piedmont Avenue
Bldg. B, Room 227
San Bruno, California 94066
jlcassell@ucdavis.edu
Phone: (510) 219-9125 Fax: (650) 871-7399

Santa Cruz & Monterey Counties
Richard M. Starr
Sea Grant Extension Program
Moss Landing Marine Laboratories
8272 Moss Landing Road
Moss Landing, California 95039
starr@mlml.calstate.edu
Phone: (831) 771-4442 Fax: (831) 632-4441

San Luis Obispo & Santa Barbara Counties
Deborah McArdle
Sea Grant Extension Program
305 Camino del Remedio
Santa Barbara, California 93110
damcardle@ucdavis.edu
Phone: (805) 448-5405 Fax: (805) 692-1731

San Diego County
Leigh Taylor Johnson
Sea Grant Extension Program
University of California Cooperative Extension
County of San Diego M18
5555 Overland Avenue, Suite 4101
San Diego, California 92123
ltjohnson@ucdavis.edu
Phone: (858) 694-2852 Fax: (858) 694-2849
http://seagrant.ucdavis.edu

University of California San Diego
California Sea Grant College Program
9500 Gilman Drive Dept 0232
La Jolla CA 92093-0232