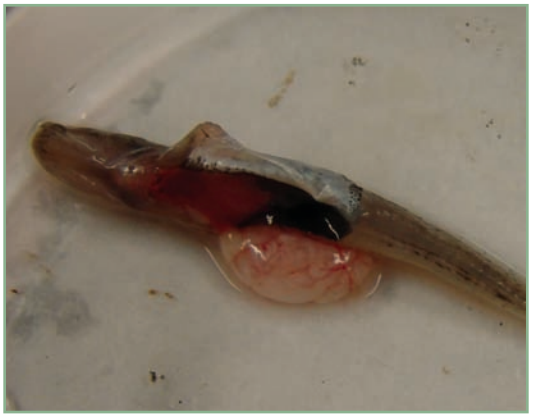
Sea Grant California

Sea Grant News

JULY 2008

Coastal Science Serving California

Tumors in Morro Bay Fish Point to Contaminants



Lars Tomanek

Arrow goby from Morro Bay with tumor.

California Sea Grant has awarded a one-year, $30,000 grant to a Cal Poly biologist to investigate the cause of cancerous tumors in arrow goby fish in Morro Bay.

The grant's recipient, biology professor Lars Tomanek, believes the tumors, which can be as large as the fish's liver, are being caused by endocrine disrupting contaminants in the bay.

In dissections of 150 fish collected from mudflats in the bay, about 8 percent had large gonadal tumors, Tomanek said.

A subsequent histological analysis of 12 fish, led by researcher Swee Teh in the School of Veterinary Medicine at UC Davis, revealed that even the apparently healthy fish, sent in as control specimens, had abnormal liver cell growth, indicative of early stages of liver cancer.

Another 250 arrow gobies were collected from the bay and tested for 40 common persistent organic pollutants (POPs)—toxins that accumulate in the environment. The livers of these fish were found to contain relatively high levels of nonylphenol, which is the break-down product of nonylphenol ethoxylates, compounds added to industrial and household detergents to help break apart oil and grease. Nonylphenol ethoxylates are banned in Europe.

Arrow gobies are small, 2-inch long, bottom dwellers that seek protection from predators by occupying ghost and mud shrimp burrows. The fish are abundant in mudflats in Morro Bay, and they are year-round bay residents. These characteristics make the goby a natural species for studying the bay's ecological health.

The goal of the Sea Grant project will be to use proteomics to investigate whether there is a causal link between nonylphenol and tumor growth. In laboratory experiments, fish will be exposed to varying levels of POP contamination and their subsequent responses, as measured via protein expression, will be studied and compared to that of fish collected in the wild.

Morro Bay is considered a relatively uncontaminated waterway and current environmental testing in the bay has not revealed high levels of POPs in either the water or sediments, Tomanek said. High levels of PCBs, DDTs and PBDEs have, however, been detected in Central Coast sand crabs and adipose (fat) of sea otters.

POPs exist in very low levels in the water. "The goby data suggests that existing water testing is overlooking pollutants that exert detrimental effects on marine organisms in the estuary," Tomanek said. "Proteins are an ideal indicator of the physiological state of an organism to evaluate the biological impact of POPs."

Tomanek is a member of the San Luis Obispo Science and Ecosystem Alliance (SLOSEA), a partnership of scientists, resource managers and stakeholders to improve the health and management of Morro Bay. He presented his preliminary research on arrow goby tumor rates at a recent SLOSEA advisory committee meeting.

"Proteins are an ideal indicator of the physiological state of an organism to evaluate the biological impact of POPs."

in this issue:

Antibiotic-Resistant Bacteria Detected in So Cal Wetlands


PLNU

Sea Grant biologist David Cummings of PLNU collects sediments from a tidal channel of the Tijuana River Estuary.


PLNU

In many wetlands, the sub-surface sediments are black and anoxic. The Sea Grant-funded study is focused on the oxygenated surface sediments.


PLNU

Professor David Cummings of PLNU and undergraduate students extrude a core of channel sediments from Ballona Creek Estuary.

The widespread use of antibiotics, by both people and animals, has left its mark on Southern California's urban wetlands. Antibiotic-resistant bacteria have been detected in sediments of Famosa Slough in San Diego, Ballona Creek Estuary in Los Angeles County and the Tijuana River Estuary in Imperial Beach. The bacteria, resistant to some of the most common antibiotics, were sometimes the dominant cultivable bacteria.


PLNU

Professor David Cummings of PLNU collects channel sediments from Ballona Creek Estuary.

According to unpublished findings from a study led by biology professor David Cummings of Point Loma Nazarene University in San Diego, more than 80 percent of cultivable bacteria collected from Famosa Slough were resistant to tetracycline. More than 60 percent of bacteria from one site in the Tijuana River Estuary were resistant to erythromycin and nalidixic acid, while in Ballona Creek Estuary, more than 35 percent were resistant to nalidixic acid.

Antibiotic-resistant bacteria were uncommon at three control sites: the relatively pristine Stone Lagoon and Dry Lagoon, both in Northern California, and Pine Valley Creek in eastern San Diego County.

Samples were collected at select sites in 2007, during the summer, when bacterial counts might be expected to be lower due to the infrequency of summer rainfall. Cummings believes the origins of the resistant bacteria are likely human and animal feces, washed to the coast during heavy rains.

Taking antibiotics can change the flora of the human intestinal track, leading to resistant strains of normal and pathogenic intestinal bacteria that may be excreted in feces, he says, explaining one source of resistant microbes. Because livestock are also fed antibiotics, animal waste is also a potential source.

Besides finding resistant bacteria in sediments, Cummings and his undergraduate biology students have also detected the tetA, tetC and qnrA genes, which code for antibiotic resistance, in sediments from the Tijuana River Estuary. The samples for this component of the study were collected after a winter rainfall. The genes were not detected in any of the wetlands in summer.

The tetA and tetC genes confer resistance to tetracycline by encoding for an efflux pump mechanism that, as the name suggests, pumps antibiotics out of the cell before the drugs destroy the bacteria. The qnrA gene, in contrast, confers resistance to fluoroquinolone drugs by protecting the target of the antibiotic, DNA gyrase.

Sequencing has shown that these genes are nearly identical to ones found on plasmids in clinically relevant enteric (intestinal) bacterial species. Plasmids are circular pieces of DNA that can insert themselves into new bacterial hosts. "Clinically relevant" means the bacteria can cause infection in humans or animals.

The resistance-encoding genes may actually pose a greater human health threat than the antibiotic-resistant bacteria. "Unlike chemical pollutants, DNA pollutants have a natural mechanism for their own amplification," Cummings says. "They can actually increase in concentration on their own, under the right conditions."

The real question, one that he has new Sea Grant funding to answer, is whether these genes are accumulating in wetlands, creating reservoirs of resistance. His work to answer this will focus on the Tijuana River Estuary, which receives waste from Tijuana as well as San Diego County. "Is there cause for alarm?" he asks. "That is really what we are trying to figure out."

PLNU

PLNU undergraduates (from left) Kelsey Unruh, Cody Ryan, Nathan Singh and David Arriola. A primary objective of the project is to prepare undergraduate biology students for post-graduate studies.

3D Animations of Fish Movements in MPAs Underway

Two CSU Monterey Bay biologists have been awarded a $10,000 grant from California Sea Grant to produce pilot 3D animation videos of fish movements in the Carmel Bay State Marine Conservation Area and Carmel Pinnacles State Marine Reserve.

The recipients of the award, biologists James Lindholm and Fred Watson, say the videos will help people see what fish are doing and how they interact with complex seafloor topography.

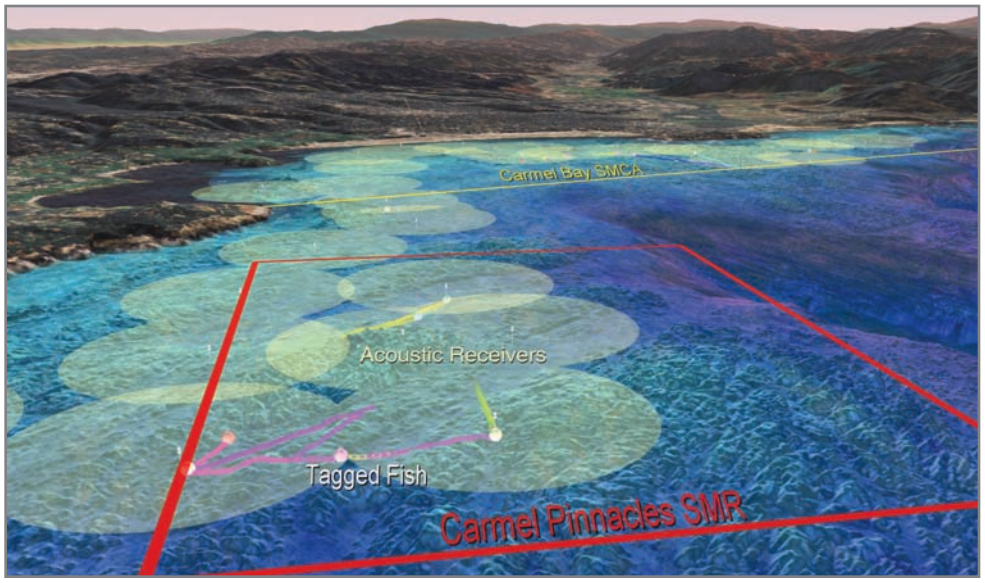
For the pilot project, only one species of fish will be modeled, the blue rockfish, which was selected, in part, because it is commonly seen during California Department of Fish and Game diver surveys. The fish tracking data that will be rendered into images of swimming fish will come from existing tracking data, collected by an acoustic array deployed in Carmel Bay by California Sea Grant Marine Advisor Rick Starr.

This array has collected more than three years of tracking data for several species, including blue rockfish. An additional 10 blue rockfish will be tagged in the study sites and actively tracked for three one-month periods.

"There is no make-believe here," said Lindholm, who is the director of CSU Monterey's Institute for Applied Marine Ecology. "It is real data rendered in three dimensions. It is compelling."

The video animation clips will be shown to stakeholder groups such as SCUBA divers and sport fishers to explain the purpose and goals of marine reserves. Where appropriate the animations will also show reserve boundaries, and the scientists plan to calculate the percent of a fish's time spent inside and outside the reserve.

"We can test the efficacy of existing reserves," Lindholm said.



Alberto Guzman, CSU Monterey Bay

Video still of the study areas off Carmel.

The seafloor habitat in Carmel Bay consists of rock reef, kelp forest and sand flats, while Carmel Pinnacles is the site of dramatic steep peaks. Besides outreach to the public, a goal of the project is to compare fish movements in the different habitat areas.

Animation videos similar to the ones that will be produced during this project were created for Yellowstone National Park to visualize the extent of the snow pack and bison migrations. There is also a pilot project underway to visualize marine life at Cordell Bank National Marine Sanctuary. Demonstration clips can be viewed at http://ecoviz.csumb.edu/home/.

Bring That Rockfish Down!

Sea Grant and the California Department of Fish and Game are partners on a new brochure for anglers that explains how and why to return rockfish to depth quickly. A PDF of the brochure can be downloaded at no cost. Hardcopy brochures may be requested by mail.

The brochure, "Bring That Rockfish Down," gives a basic physiological explanation of why rockfish are prone to pressure-induced injuries. Every rockfish has a gas-filled organ called a swim bladder that expands and contracts to control its buoyancy. When a fish is caught and reeled in, this mechanism for moving vertically in the water column is thrown out of whack. As the fish ascends, its swim bladder can overinflate, forcing the stomach out of its mouth.

The brochure also discusses the pros and cons of different methods for returning fish to depth quickly and shows pictures of these devices.

USC Sea Grant research—led by former Sea Grant Trainee Erica Jarvis, now a marine biologist at Fish and Game—documented the viability of

continued on page 4 …

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returning fish to depth quickly as a means of increasing post-release survivorship in sport-caught rockfish.

The research, which has been accepted for publication in the *Canadian Journal of Fisheries and Aquatic Sciences*, shows that the degree of barotrauma in a fish is not for many species a reliable predictor of post-release survivorship. Even fish with bulging eyes and protruding stomachs can pop back to life when returned to a native depth—quickly. Post-release survivorship is determined, more than anything, by the time a fish spends at the surface.

In experiments with vermilion, flag, squarespot and honeycomb rockfish, among others, 83 percent of fish caught at depths between 217 feet and 350 feet survived when returned to depth within two minutes. The odds of a fish dying following recompression nearly doubled with every 10-minute increase in surface time.

Tagging and recapture studies showed some released fish were still alive 18 months later.

"We are hoping the brochure will inform and educate anglers about barotrauma and give them some reasons to want to bring fish back down," Jarvis says. "Anyone who has seen a slick of floaters behind a party boat (rockfish floating on the surface because they are too inflated to re-descend on their own) knows this brochure is needed."

To order a brochure, contact the California Sea Grant Communications Office at 858-534-4446 or email sgabrysh@ucsd.edu. Brochures can be downloaded at http://www.csgc.ucsd.edu/.

Temperature and Salinity Constrain Mitten Crab Abundance

It may be possible to predict Chinese mitten crab numbers in the San Francisco Bay-Delta four years out by measuring water temperatures and salinity in San Pablo Bay, a Sea Grant biologist reports.

Cal State Fresno biology professor Brian Tsukimura has found that Chinese mitten crab zoea (larvae) cannot tolerate waters colder than 11.7 degrees Celsius. The zoea also appear to thrive only when salinities in San Pablo Bay in northern San Francisco Bay range from 10 to 22 parts per thousand (ppt).

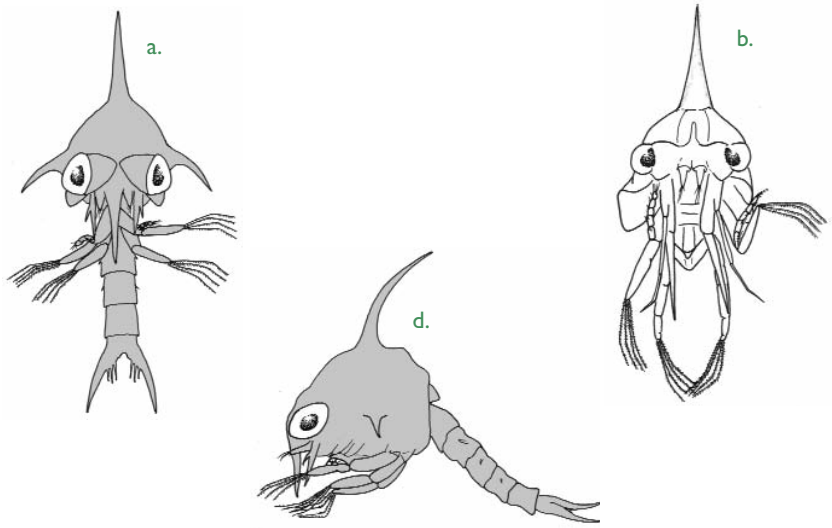
Low zoea survivorship translates (or in theory should translate) into low numbers of adult mitten crabs four years later since it takes about four years for the crabs to reach full size. Tsukimura's theory is that adult mitten crab numbers are modulated by the duration in which water temperatures and salinity are optimal for zoea survival.

"There is a window in which these zoea can survive," Tsukimura reports. "When the window is small, you are going to have a small adult mitten crab population four years later. When the window is big, you can expect a large population later."

The window is defined on one end, at the beginning of the zoea life cycle, by temperature. If mitten crab eggs hatch before the bay has warmed to 11.7 degrees, which usually occurs in March, the zoea die.

It takes about two months (less in warmer waters) for zoea to develop into the next life-history stage, megalopa (post-larvae). As zoea near metamorphosis, the survival window is defined by salinity, he theorizes. Zoea perish if the salinity drops below 10 ppt. If salinity tops 22 ppt, however, plankton-eating anchovies can enter the bay and prey on young crabs. Water diversions in the Sacramento-San Joaquin Delta raise salinity levels in San Pablo Bay and likely help reduce adult mitten crab numbers, he says.

Tsukimura's research, which is now being funded by the U.S. Fish and Wildlife



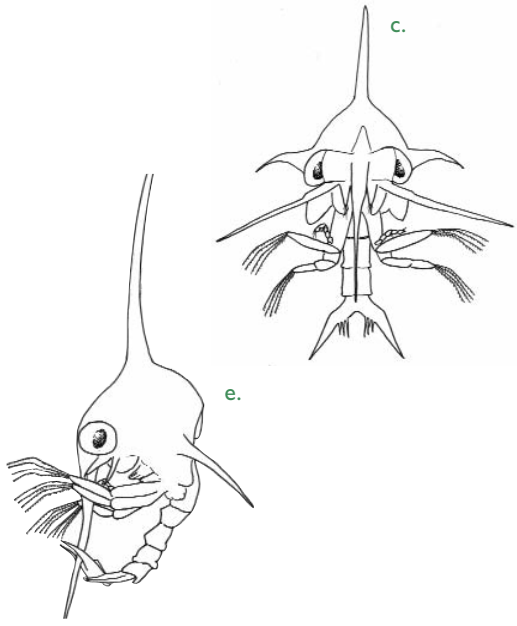
Top row left to right:
Drawings of front and side views of different species of crab zoea between one and 10 days old.
Top row, left to right: a) Front view of Chinese mitten crab;
b) Front view of American spider crab, *Pyromaia tuberculata;*
c) Front view of black-clawed crab, *Lophopanopeus Bellus*;
d) Side view of Chinese mitten crab;
e) Side view of pea crab, *Pinnotheridae sp.*
Ammon Rice, former CSU Fresno student

An adult Chinese mitten crab. Note its furry claws, for which is it named.

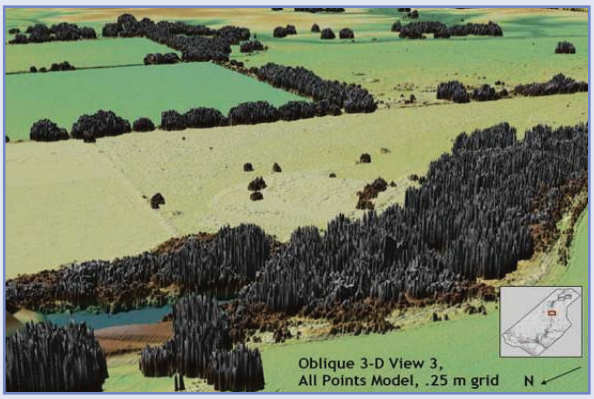
Lee Mecum, California Department of Fish and Game

Service, is based, in large part, on analyzing the contents of plankton trawls in San Pablo Bay, led by the California Department of Fish and Game.

To identify mitten crab zoea from zoea of other crab species, such as the European green crab, another invasive, Tsukimura and students developed a zoea key for identifying 14 common crab species. A key of megalopa is under development.



Mapping Central Valley Bird Habitats with Aerial Laser Surveys



Joshua Viers, UC Davis.

A LiDAR image of the study site, the Cosumnes River Preserve in Sacramento County.

In the hope of improving bird conservation in the Central Valley, a CALFED Fellow has developed a new tool for identifying habitat areas for 10 common riparian bird species.

The tool is based on an aerial laser technology known as LiDAR, short for light detection and ranging, originally developed for the military, as a means of quickly mapping topography to identify things like tank routes and landing strips. As this project has demonstrated, LiDAR can also be used to map the canopy heights of vegetation. The project's core discovery is that these plant elevation data are relatively good indicators of where different bird species can be found.

Nat Seavy

Mark Dettling, a biologist at PRBO, checks a song sparrow nest along the San Joaquin River.

"We can predict where the birds will be over areas impossibly large to survey by foot," says CALFED Fellow Nat Seavy, an ornithologist with PRBO Conservation Science and UC Davis, explaining the project's significance.

Working with UC Davis ecologist Joshua Viers and PRBO Conservation Science biologist Julian Wood, Seavy tested the LiDAR technique in the Cosumnes River Preserve in southern Sacramento County. The preserve includes part of the Cosumnes River, the only free-flowing river in the western Sierras, and adjacent riparian cottonwood forests, which are in the process of being restored.

According to Seavy's analysis, the black-headed grosbeak, oak titmouse, ash-throated flycatcher, house wren, spotted towhee and Bullock's oriole are all associated with areas in which plant heights are greater than five meters—that is, cottonwood forests.

Other species, such as the bushtit, song sparrow and wrentit were correlated with intermediate canopy heights or areas of complex vegetative structure, including a mix of young trees, various willows, blackberry and rose bushes, grasses and sedges.

"Our results are very obvious for anyone who knows about birds," Seavy says. "What is not obvious is that we could use LiDAR to map habitats for so many species."

None of the 10 bird species modeled for the project is threatened or endangered. All, however, are dramatically less abundant than they were a century ago.

"We want to make sure common birds stay common," says CALFED community mentor Chrissy Howell, an ornithologist at PRBO Conservation Science. "There is a great relationship between songbirds and habitat quality. Birds are a great way to score the success of restoration projects."

song sparrow

Stanton F. Fink, Wikipedia

An artist's rendition of what the flightless duck, *Chendytes lawi*, might have looked like. The ducks are swimming beside 9-foot-long sabertooth salmon.

Flightless Sea Duck Died Off Slowly

Flightless birds such as those depicted in the image to the left are something of an evolutionary oxymoron, up there with nonswimming fish or vegetarian carnivores. They are painfully vulnerable to extinction, Exhibit A being the dodo bird. (The obvious counterexample, the penguin, has had the survival advantage of living on the one continent uninhabited by humans.)

As it turns out, California once had its own version of a dodo bird, a flightless marine duck known in scientific circles as *Chendytes lawi*. Like the dodo bird, which inhabited the Indian Ocean island of Mauritius, but not the African continent nearby, Chendytes escaped terrestrial predators, two-legged and four, by colonizing the Channel Islands off Central California.

Unlike the dodo bird, Chendytes was a proficient swimmer, which may partially explain its longevity as a species under prehistoric fire.

Cal Poly

Terry Jones of Cal Poly San Luis Obispo

In research findings published in a March issue of the *Proceedings of the National Academy of Sciences*, archeology professor Terry Jones of Cal Poly San Luis Obispo and Judith Porcasi of the Cotsen Institute of Archeology at UCLA used carbon dating of bone fragments excavated from 14 prehistoric settlements in California to make a case that humans began hunting the veritable sitting duck about 11,000 years ago. They found that it was hunted for fully 8,000 years before it went extinct about 2,400 years ago. (It took Europeans less than a century to wipe out the dodo bird.)

Jones and Porcasi argue that the slow demise of Chendytes undermines what is known as the "Pleistocene overkill hypothesis," the theory that Clovis hunters drove Pleistocene megafauna (such as mastodons and giant sloths) to extinction in a *blitzkrieg* fashion lasting a few hundred years. Some 35 genera of North American mammals went extinct toward the end of the last Ice Age.

"Why would it take 8,000 years to wipe out one species of flightless bird, and why would there be virtually no archeological evidence for human hunting of extinct Pleistocene megafauna, save the mammoth?" Jones asks.

Cal Poly

Leg bones from the flightless duck Chendytes. The top bone is a tibiotarsus, the bottom a tarsometarsus.

"We make the case that it must mean the Pleistocene megafauna were wiped out some other way besides having been hunted," he says. "If the overkill hypothesis was true, we would expect to see a more substantial record of exploitation in the archeological record. That record is not there."

California Sea Grant originally funded Jones to look at faunal remains from the earliest inhabitants of the California coast to better understand pre-industrial, long-term patterns of marine resource use. The discovery of Chendytes bones was unexpected and led Jones to focus his research on reconstructing a history of its exploitation and eventual demise.

Two Popular Sport Fishes Have Surprisingly Small Home Ranges

Chris Lowe

A female sheephead.

A recently completed tagging and tracking study funded by the California Department of Fish and Game and California Sea Grant shows that Catalina Island kelp bass and barred sand bass have small home ranges. Such information is important in designing marine protected areas, the scientists say.

One noteworthy finding is that species tend to spend the majority of their time near edge habitats (transition zones between reef and sand areas).

In terms of designing marine reserves, the results suggest reserve boundaries should be placed in the sand at least 100 meters from edge habitats, Lowe says. If "spillover" is desired to enhance fishing opportunities, boundaries should be placed closer to edge areas.

Chris Lowe

Sea Grant Trainee Tom Mason follows a tagged barred sand bass in the Catalina Island Marine Science Center Marine Life Refuge.

The average home range of an island kelp bass is less than half the size of an NFL football field, a paltry 3,200 square meters, reports CSU Long Beach biology professor Chris Lowe.

Barred sand bass, the main catch of summer party boats in Southern California, occupy a larger but still relatively cozy 10,000-square-meter area—about 1.5 football fields.

Besides tracking fish, Lowe and UC Santa Barbara researcher Jennifer Caselle, a co-investigator of the project, have been looking at how fish movement patterns, including home range size, are affected by seafloor terrain.

"The information Chris is collecting on fish movements is critical to understanding how effective marine protected areas will be in protecting various species as well as in determining their potential to provide new fishing opportunities outside their boundaries," says John Ugoretz, manager of the marine habitat conservation program at Fish and Game.

Below: Sea Grant Trainee Darin Topping changes an automated underwater acoustic receiver. An array of these receivers was used to monitor tagged reef fish in Catalina Island Marine Science Center Marine Life Refuge for more than a year.

Chris Lowe

Sea Grant News

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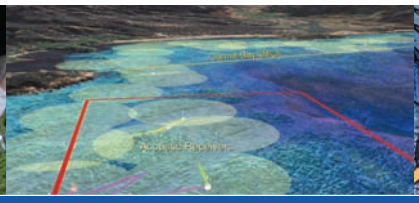

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CSG

California Sea Grant Director Russell A. Moll.

Sea Grant Director Appointed to MPA Federal Advisory Committee

California Sea Grant Director Russell A. Moll has been appointed by the U.S. Department of Commerce to the Marine Protected Areas (MPA) Federal Advisory Committee.

The 30-member committee advises the secretaries of commerce and the interior on aspects of MPA Executive Order 13158 of May 26, 2000, which among other things calls for the creation of new or expanded MPAs to help protect the "significant natural and cultural resources within the marine environment for the benefit of present and future generations."

The committee is supported by NOAA's National Marine Protected Areas Center.