OceanBights

The Magazine of the Catalina Marine Society

Winter 2013

Volume 4, Number 2

Contents

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The Catalina Marine Society is a nonprofit membership corporation founded in 2009 in Los Angeles to marshal volunteer resources to study the marine environment of Santa Catalina Island and the Southern California Bight.

Submissions. The magazine may publish submitted articles that pertain to our mission statement. Contact the e-mail address below for more information.

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Where's the DDT?

Some of us who cut their diving teeth off White Point on Palos Verdes know of the DDT accumulation from the outfall there. We had shoreline discussions about the safety of diving the cove with the consensus that it was not a problem for divers. And later, we witnessed barges dumping sediment excavated from the port of Los Angeles to cover the contaminated Palos Verde sediments. Now, the story is that the DDT is disappearing much faster than expected.

DDT (dichloro-diphenyltrichloroethane) is a colorless pesticide that was used during World War II to control vectors of malaria and other diseases and subsequently adapted for agriculture and household uses. As such, it has been said to have saved millions of lives. The chemical is not soluble in water but is in lipids (fats) and embeds itself in cell membranes, which have a fatty layer. There it interferes with the transport of other substances between the cell and its environment, particularly chemicals used by nerve cells, causing the nerve cells to malfunction. **DDT is very effective at killing insects**. The discovery of this fact led to a Nobel Prize in 1948 for the Swiss scientist Paul Hermann Muller.

DDT is not absorbed through the skin, so direct contact with it isn't considered harmful. However, it is known to be dangerous for humans, with concentrations of 10 mg/kg said to cause headache, nausea, vomiting, confusion, and tremors. It is classified as a B2 carcinogen, meaning that it is known to cause cancer in lab animals. These concentrations come about from eating contaminated food, such as fish. However, DDT is not an immediate poison as there is little direct evidence of ill health in humans produced by DDT. Indeed, it has been applied directly to people to control lice without ill effects. Nevertheless, it is a poison to be eradicated from the environment. ➔ *see **DDT** pg 5.*

Spotlight on: Southern California Coastal Water Research Project

Over the last couple of years we have reported on several projects that have been connected to the Southern California Coastal Water Research Project, SCCWRP (I have heard it pronounced as "squerp"). Some of these projects involved organizations that have been previously researched for *OceanBights* articles, and include Heal the Bay, Algalita and the Jet Propulsion Laboratory. However, SCCWRP is not well known among *OceanBights* readers, though SCCWRP's work is of tremendous interest.

SCCWRP describes itself as a public agency for

environmental research. It is a research institute focusing on the practical aspects of the ecosystem of the Southern California Coast. The word water in its name really signifies the general nature of the organization's research. They are interested in wetlands, storm water, beach-water quality, marine debris (see picture above) and the usual nutrients and contaminants that are significant to or may affect ocean life, including the humans who use it.

Marine debris. Have you seen any of these? Courtesy of SCCWRP.

Understanding our local water is a very difficult task. The natural sources of nutrients must be unraveled from the man-made ones, significant properties must be understood, sources of pollutants and contaminants must be tracked and measured.

SCCWRP is funded mostly by local sanitation districts and grants from other agencies under a Joint Powers Authority, the meaning of which I had to look up. Essentially, it is an entity whereby two or more public authorities, such as local governments, utility districts, etc., can operate collectively. SCCWRP has 14 founding agencies, mostly sanitation districts or other public authorities that may be responsible and therefore must seek answers for water-related issues. SCCRWP is located in Costa Mesa and employs about 50 people, making it one of the larger local marine research institutions.

Reading through their web site (www.sccwrp.org), I get the impression that SCCWRP is slanted differently than most marine research organizations. There is a strong emphasis on collaborative research, on defining protocols and methods, and getting colleague organizations to adopt standards that permit comparison of data taken by various groups. The concept of consensus among groups is also mentioned. Perhaps that is not surprising given the funding structure and the desire to have managers make non-controversial decisions, at least from the science viewpoint.

Examples of the collaborative efforts SCCWRP leads are the regional monitoring campaigns, with the ongoing one denoted as Bight '13. SCCWRP leads such an effort every 5 years and begins with a series of topics to be addressed. For Bight '08 questions such as the nature of algal blooms and the state of rocky reefs in the Southern California Bight, including the range of biological conditions and how these conditions correlate with anthropogenic factors, were addressed.

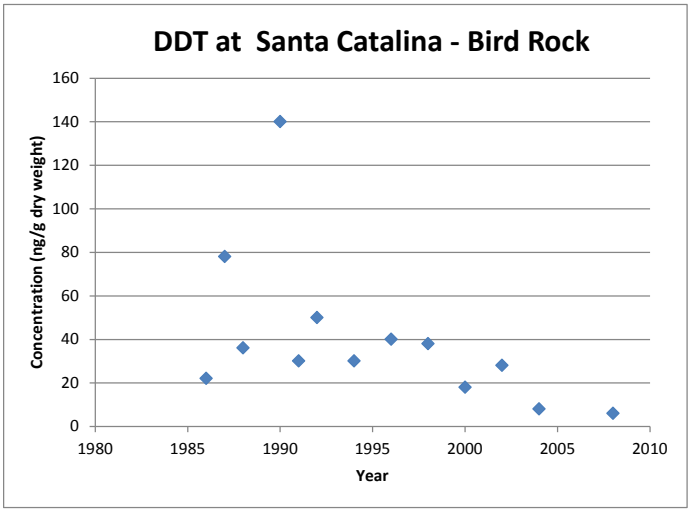
Regarding the latter, a survey found 120 rocky reefs shallower than 30 m and totaling slightly over 48,000 hectares in the Bight (how many have you fished or dived?) with 75% located at the islands. The smallest was Begg Rock at 6.2 hectares. Sixty eight of these reefs were sampled by SCUBA divers from 9 organizations, which is a very large effort. They found giant kelp at every reef but 2, but also found urchin barrens at 38% of the reefs sampled. The SCB reefs generally appear competitive with coral reefs and Mediterranean reefs in fish biomass, averaging roughly 330-550 g/cubic m. But this distribution among the 78 fish species found varied greatly, especially when giant black sea bass (*Stereolepis gigas*) are present. Apparently the biomass density is then the product of one fish!

Analysis of algal blooms was also an important part of Bight '08. The study was to determine if algal blooms are increasing in frequency and are there blooming "hotspots"? What are the relative nutrient contributions of natural and man-generated sources to blooms, on large, Bight-wide scales and more local scales and what are the mechanisms behind how algal blooms develop.

Using mostly satellite data, the study did find that algal blooms are increasing, especially where there are wastewater discharges or where coastal waters tend to linger. As studies by the CMS have found, the Santa Barbara Channel is a hotbed of algal blooms, some of which are advected to Santa Catalina Island. Regarding the nutrient source that powers the blooms, the study found that natural sources within the Bight, that is, upwelling, provide ten times more nutrients than man-associated sources. However, the anthropogenic sources could be very important in localized regions, especially for those with recurring blooms. Blooms were found to originate both offshore and inshore as well as near surface and subsurface. It was documented that subsurface blooms, undetectable by satellite remote sensing, could be upwelled to the surface and then enhanced by the greater amount of sunlight there.

Dario Diehl retrieving mussel samples at Mugu Lagoon. Courtesy of SCCWRP.

Other projects that SCCWRP organizes include the local Mussel Watch program. The National Oceanic and Atmospheric Administration (NOAA) gathers samples of mussels at a large number of sites around the country and tests them for various contaminants, including DDT. Mussels, being filter feeders, naturally concentrate contaminants, making it easier for analysts to measure them. There are many local sites where mussels are gathered,



DDT sampling at Bird Rock. Adapted from NOAA Mussel Watch

including Mugu lagoon and also Bird Rock off Santa Catalina Island. The accompanying figure is drawn from a similar one produced by NOAA Mussel Watch for Bird Rock. It seems to indicate that DDT levels are decreasing there. Of course, the first question that comes to my mind is: how does DDT get to Bird Rock? (See the accompanying article on DDT.) But don't worry, the DDT levels are low and will not affect you, so keep diving Bird Rock.

Of more direct concern is how contaminants affect people who use the ocean. To this end, SCCWRP collaborates on epidemiological studies. To find out more, I chatted with the deputy director, Ken Schiff, about epidemiological studies performed by SCCWRP, as this would seem to be beyond their expertise. But understanding the relationship between health risks and water quality is of direct concern to them. Water quality near locations where sewage enters the ocean is a known problem, but Ken says that California has been good about closing such open pipes and concern has focused on less obvious sources of pollution and trying to determine if urban runoff and stormwater discharge is a problem for people entering the ocean. Viruses that cause disease are closely associated with larger bacteria that are easy to identify. These bacteria can thrive in storm drains, where it is dark, warm and nutrient rich. Hence, if there is a pathway to the sea, these bacteria and perhaps correlated viruses can also contaminate the ocean.

SCCWRP has performed epidemiological studies at Mission Bay, Malibu's Surfrider Beach, Avalon Bay and Doheny Beach, where a study has determined that when the sand berm is open to the ocean, the near-shore water becomes contaminated. I asked if the contamination could reach divers offshore but Ken did not think that to be a problem.

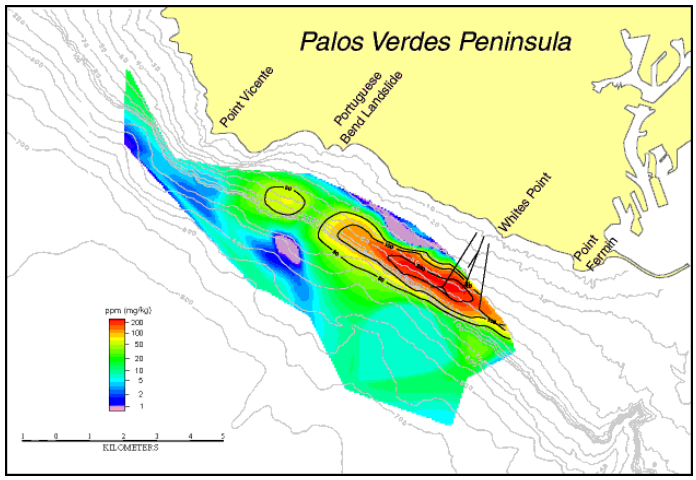
SCCRWP does the water analysis while another organization, such as UC Berkeley, does the epidemiology analysis. Thousands of beachgoers are questioned while the near-shore water is sampled. Correlation analysis is then performed between the incidence of illness and the quality of water as determined by bacterial measurements. The results are that, indeed, there is a noticeable correlation between contaminated water and illness.

What is SCCWRP doing now? Well, Bight'13 is underway and one question to answer is how are the Marine Protected Areas doing? Another question is What is the role of anthropogenic contributions to primary productivity? And has it changed over time? Hopefully, we'll see contributions to these issues as the monitoring program proceeds. ■

➔***DDT*** *continued from pg 2* Its use provides a classic story of the interconnectedness of the local ecology. The story begins with the Montrose Corporation in Torrance dumping DDT and polychlorinated biphenyls (PCBs) into the sewer system beginning in the late 1940s. The sewage is conducted via an outfall
located on the Palos Verdes shelf near White Point. It and its toxins accumulated there for over 20 years. Meanwhile, the dangers of poisons such as DDT in the environment were becoming known through efforts such as those of Rachel Carson (see the *RV Rachel Carson* in an adjacent article). After some legal wrangling, there was a settlement to remediate the stuff. Details regarding how these monies are being spent can be found at http://www.montroserestoration.noaa.gov/.

Although the toxins are in the sediment, they still make their way to strange places. Worms live in the seabed where they ingest DDT while feeding. The worms are picked off by benthic-feeding fish such as white croaker, who concentrate the poison as they eat more worms. These fish, in turn, may be prey for other fish nearer the surface. Due to its solubility properties, DDT is not eliminated as a waste product, but instead accumulates in the fatty tissues of the animals that ingest it.

Fatty fish are eaten by sea birds such as bald eagles. Besides being a nerve poison, DDT affects the egg shells of birds. Some think that DDT morphs into a closely related poison that interferes with the aggregation of calcium, causing eggs to be fragile and leading to reduced numbers of hatchlings. This pathway has been implicated in the demise of bald eagles on the islands, especially on Santa Catalina, but also throughout the Channel Islands. The islands were the last bastion of bald eagles as their mainland habitat was lost to development. The fish-eating bald eagles kept the mammal-eating golden eagles at bay, so to speak. When the declining bald eagle population was not up to the task, golden eagles invaded the islands and picked off the island foxes (*Urocyon littoralis)*, nearly extirpating the polar-bear icon of the American Galapagos. Hence, the deposition of DDT on the seabed at 200-ft depth threatened the island foxes tens of miles away, as well as fish off the peninsular.



Location of DDT in sediments. Courtesy of EPA.

The situation was considered serious enough for the Environmental Protection Agency (EPA) to declare the Palos Verde Shelf a superfund site in 1997. Such sites undergo remediation efforts as well as educational outreach to inform the fishing public not to eat affected seafood (you've seen the signs). Remediation of a site 200-ft deep does not appear to be a trivial matter. Options include dredging the sediments, neutralizing the DDT or capping it. The latter appears to be most cost effective operation but several issues have been put forth: what material to use for the cap, how thick should the cap be, how much area should it cover, where can the material be obtained from, etc. **The key is to cap with enough safe and stable material so worms cannot burrow into the DDT layer and the cap remains in place**. The cap should be some tens of centimeters thick.

The EPA executed a test project to cap portions of the contaminated seabed in 2000. Sediment obtained from the Angels Gate area via Los Angeles Port dredging operations was transported to White Point and dropped. This was the operation we saw years ago.

The data used to generate the map in the figure were taken in 2004 and clearly show the affected area – some of our favorite dive spots. Additional data were taken in 2009 and the results of its analysis were released early this year. (Nasty aside – four years to analyze data from a superfund site- come on!) The results were unexpected, the concentration of DDT diminished by an order of magnitude in 5 years! This reduction is what the EPA hoped to achieve via capping.

The trouble with DDT is that it hangs around a long time. It doesn't dissolve in water so it is not transported away by currents. It is not destroyed while performing its nefarious operations. It is transported by

biological activity - that is how it got to the islands. But there has been no suggestion of the biological flux being sufficient to reduce the DDT to the measured levels. Some have measured its half-life in soil to be more than a decade, too long to account for the difference measured in 5 years.

The data acquired in 2009 could just be a statistical fluke. More sediment for testing are currently being collected off PV for verification of the last results, see the article in the Los Angeles Times (http://articles.latimes.com/2013/nov/17/local/la-me-palos-verdes-shelf-20131118).

Meanwhile significant efforts have been undertaken to restore bald eagles to the islands. Mainland birds were reintroduced to the islands and eggs from their nests replaced with decoys while the real ones incubated to hatching, reducing the chances of shell breakage. The hatchlings were returned to the nest. The operation was performed by a **brave man** dangling from a helicopter (the so-called "dope on a rope" technique). Success has continued with natural hatching without man interference. The latter result appears to be consistent with declining DDT levels.

Hopefully, the 2009 results are real and the 2013 data will be analyzed quickly to confirm them. Considerable money is at stake, as a capping operation will cost tens of millions of dollars. Perhaps the DDT-contaminated sediments have been naturally capped by landfalls in the area as PV is eroding quickly. Or maybe DDT succumbs faster under pressure than it does in the soil, as the pressure at 200 ft is about 7 atmospheres. Whether statistical fluke or hoped-for outcome, we are sure to hear more on the DDT story.■

Northrop Grumman Corporation awards Community Service Grants to Catalina Marine Society.

Thank you very much!!

CMS presents to Sharkbait Dive Club

With an encore slideshow, CMS met with the Sharkbait Dive Club in Yorba Linda on Sept.10th. The initial presentation, made in November 2010, described CMS projects that were in their infancy. The latter presentation used the same slides, though recently annotated to describe the current status of all programs. We took great satisfaction in how far many of the proposed studies have progressed.

The club was very enthusiastic and the animation of both the audience and speaker increased as dinner and wine disappeared. **Good to return as Sharkbait!**

Sharkbait Logo.

Calamari Steaks vs Rings

The Life and times of California's squids

By Danna Staaf, Ph.D.

"Guess what we found!" My excited bunkmate woke me from a nap. I was exhausted from babysitting squid embryos all night, and she was wet from blue-water diving in the Gulf of California. I could guess. "An egg mass!" I scrambled out of bed to follow her to the ship's lab, where the rest of the divers proudly presented me with three glass jars full of transparent gelatinous goo and squid eggs the size of rice grains.

It was the high point of my doctoral research. And it was the blindest luck. The divers weren't expecting to see a Humboldt squid egg mass sixteen meters below the surface on that warm June day in 2006. They'd been looking for jellyfish when they noticed the car-sized blob, studded with at least half a million eggs. (That may sound like it would be easy to find, but it's a mere smudge in the gargantuan vastness of the open ocean. And a fleeting smudge at that--it may last no more than a week.)

Of the many squid scientists on board the R/V New Horizon, the egg-filled jars came to me because I was the one obsessed with baby squid. Up until then, I'd been generating all my babies in vitro. A Petri dish on a lab bench is quite a different environment from a big blob in

Author Danna Staaf

the sea, so I was pleased to find that the egg-mass babies agreed with my artificially fertilized babies about some important things, like temperature.

The water in the Gulf at the depth of the egg mass was warm, about 25°C. I kept the jars at around that temperature, and within hours the eggs began to turn into adorable little specks that squidged through the water, while the jelly disintegrated and sank. Artificially fertilized eggs also thrive at 25°C, developing healthy eyes, arms, ink sac, and so forth, and hatching in less than a week. Based on these and further studies, and maps of ocean temperature, I guessed that Humboldt squid have two main spawning grounds: off the coast of Mexico and off the coast of Peru.

Adults may travel to these spawning grounds from the broader range of the species. Humboldt squid live throughout the eastern Pacific, from Mexico to Chile, with periodic expansions further north and south. In the last decade, Humboldt squid have become regular visitors to California, with occasional appearances as far north as Alaska. However, my in vitro experiments imply that these polar explorers must return all the way to Mexico to have their babies. Egg development slows as the temperature drops, and arrests completely below 15°C.

But that's just where it starts to get cozy for the babies of another species: the market squid, whose embryos prefer 9-13°C water. California is their perfect nursery. In these cooler waters, market squid eggs take much longer to develop than Humboldt squid eggs—weeks rather than days—and when they do hatch, baby market squid are twice the size of baby Humboldts (although twice the size of a grain of rice is not exactly large).

Curiously, these relationships are reversed in the adults. Grown Humboldt squid are famous for their size, reaching over a meter in mantle length (the length of the main body, excluding head and arms) and dwarfing the typical 10-15 centimeters of market squid mantles. Then, despite their speedy development in the egg,

Humboldt squid can live up to two years--a respectable age for a squid. Market squid tap out at 6-9 months.

The two species' reproductive habits are wildly different as well. Scientists may have seen Humboldt squid mating once. We're not sure. We've never seen them lay their tremendous egg masses--and we haven't seen another mass since 2006. On the other hand, most recreational divers in California have seen or at least heard of the spawning grounds where market squid gather by the millions to mate, lay their eggs, and die. Females package one or two hundred eggs into a finger-sized capsule, which they glue to the sand, or a rock, or a weed . . . again and again, until the seafloor is strewn with "mops" of eggs.

A concurrent aggregation of fishing boats takes place overhead, using bright lights and big nets to collect the conveniently assembled squid. At my home lab in Monterey, we would wander out from our offices and count the boats during squid season, keeping a running tally on the whiteboard. Sometimes when we needed some squid for a research project, we would grab a cooler and a small net, fire up the motor of our little Boston Whaler and putt out to visit. "Hello there, we're scientists, we sure do admire how hard you're working, and could we please take a small scoop from your magnificent net?" (It may have been phrased differently; I don't remember the details.) The fishermen were generous and obliging, and that night we would have market squid swimming in our tanks, the females periodically affixing egg capsules to the fake ones a postdoc had made.

Author jigging for squid.
credit: Ashley Booth

Humboldt squid make no such net-friendly gatherings, and must be caught one at the time with a jig and a line. Humans are pretty capable with a jig and a line, though: in 2011, almost a million tons of Humboldt squid were landed, making it the largest invertebrate fishery in the world. Market squid aren't too far behind; they support California's largest fishery of any kind.

Though both Humboldt and market squid live in the eastern Pacific, many are shipped west after being fished. But some stay home, and you may well have eaten them. The mantles of the smaller market squid are cleaned out to make tubes, which are then sliced into the familiar forms of calamari rings. To do the same with a Humboldt squid would make girdles rather than rings; instead, they are prepared as squid steaks.

Popular as they are with human diners, squid are arguably even more popular with other marine predators. Fish, sharks, seals, whales--all are eager to chow down on these swimming protein bars. And squid are equally happy to eat each other. Humboldt squid

being so much larger than market squid, it's obvious who would be eating whom. In the past, the ranges of the two species haven't overlapped much, perhaps partly because their babies prefer to develop at different temperatures. But as Humboldt squid move north, could they threaten California's biggest fishery?

The answer depends on how the two species respond to a changing ocean. At first, it might seem that Humboldt squid are the clear winners. The ocean is warming, and their eggs prefer warmer temperatures. Meanwhile, their range expansion is thought to be tied to the expansion of low-oxygen zones, a normal part of the deep ocean that has been stable for a long time. Now these zones seem to be growing in all directions, spreading out and getting shallower. Although most large animals can't stand the low oxygen, Humboldt squid are specially adapted to take advantage of it.

Author at scope
Credit: Ashley Booth

But environmental changes have complex repercussions, and the results aren't so clear as "winners" and "losers." The recent 2009-2010 El Niño caused the Humboldt squid fishery in Mexico to crash spectacularly. The animals may have adapted to their altered habitat by maturing at smaller sizes and moving further out to sea, and as conditions return to normal, Humboldt squid may as well. Market squid also respond strongly to El Niño, which has historically caused declines in the fishery catch. Yet in 2010, fishermen caught so many market squid that they reached the management quota of 118,000 metric tons for the first time. It happened again in 2011 and 2012. The simplest explanation: it's complicated.

A baby Humboldt squid
Credit: Danna Staaf

Squid are more resilient and responsive than many other animals, thanks to their quick generations, abundant babies, and the ability to migrate. These "weedy" traits might be enough to let squid—or at least some squid—survive climate change, even thrive with it.

They also lead some people to consider squid fisheries the ultimate in sustainability, but other people are concerned that squids' quick

responses to environmental changes could actually make them more vulnerable.

The importance of squid as a food item for so many marine animals and, yes, humans, is enough reason to hope they stick around. But there are other reasons, too: beauty, wonder, mystery. Consider the vast market squid egg beds, piles and heaps and mountains of gently swaying mops, shining white in the green murk (worth braving 9° C water), and the sudden appearance in blue water of a dim gelatinous mass large enough to swim through, filled with eggs so tiny you can barely see the Humboldt squid pulsing inside (worth getting out of bed).■

Mooring Sensors pulled

After an approximately two-year effort, the sensors located at WIES have been permanently pulled. The diving and calibration tempo could not be maintained, especially with the increased activity at the WIES labs. Data, such as chlorophyll, conductivity, water pressure, temperature, pH and dissolved oxygen were successfully gathered on 11 deployments. These data will be analyzed over the next several years to determine temporal changes and also will be compared to corresponding datasets measured off the mainland by other institutions.

The data collection and research are aimed to contribute to our understanding of biological functioning of the island as well as ocean acidification and reduced oxygen levels, and their impacts on local fauna. Anthropogenic effects, such as increasing atmospheric CO_2, lead to a more acidic ocean. The carbon dioxide dissolves into seawater where it undergoes chemical reactions and changes the pH of the water. Although the expected increases in ocean acidification are probably too small to be measured with the equipment we deployed, we can measure some of the dynamics. Measurements in the Point Loma kelp forest have indicated very large variability in pH and O_2 levels. Understanding such variability will definitely increase our knowledge of the oceanography of Santa Catalina Island. It may also enable us to predict effects of climate change. ➔ *see **Sensors** continued pg 14.*

Adopt-A-Thermograph Program

The CMS is seeking donors and site managers for its Adopt-A-Thermograph program. These sponsors will extend and complete the Continental Thermograph Array that is currently under development.

Participants will donate the minimum cost for a single thermograph setup, currently totaling $150. The Catalina Marine Society will supply the sensors and associated mounting hardware and will perform QA and calibration procedures on the sensors before they are deployed and when they are retrieved. The sponsors, if they desire, may also be the site manager, providing the resources for deploying and retrieving the thermograph, or have the CMS arrange for the diving.

The Adopt-A-Thermograph is directed by David Tsao. For more details, contact David at david@catalinamarinesociety.org or Craig at craig@catalinamarinesociety.org.

Plea for Volunteers

We need more volunteers! CMS wants to increase its social activities. We need fundraisers, event initiators, party animals, and, in general, good, ocean-loving people. We could also use grant writers, *OceanBights* authors, public relations experts, etc. And, of course, experiment sponsors and data analysts. Amateur scientists are also encouraged to get involved. E-mail us with ideas!
craig@catalinamarinesociety.org■

Predicting Winners and Losers in a Warmer Intertidal Zone

By Mary Ann Wilson

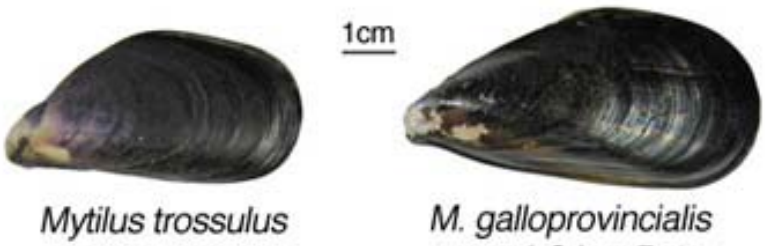
Along every seashore lies an abundance of marine life that has evolved to thrive in two different environments: underwater at high tide and above water at low tide. This unique zone is expected to be strongly influenced by rising air and sea temperatures. In fact, the distribution of intertidal species along the California coast has already shifted in response to climate change.

In 1931, a marine biology student named Willis Hewatt screwed bolts onto rocks in the tide pools at Pacific Grove in Monterey Bay, set a line a hundred meters long, and counted every invertebrate creature in 105 square plots. Sixty two years later, graduate students Raphael Sagarin and Sarah Gilman resurveyed 57 of his plots and documented changes in the abundance of 46 of 62 species that were present in the 1930s. Most southern species (10 of 11) increased in abundance, while most northern species (5 of 7) decreased. During this period, shoreline ocean temperature had warmed by 0.790° C, with average summer temperatures up to 1.940° C warmer in the 13 years preceding Sagarin and Gilman's study than in the 13 years preceding Hewatt's.

In the 1980s, biologists discovered that the Mediterranean mussel (*Mytilus gallo-provincialis*) had been introduced to Southern California sometime in the last century. Originally from the Mediterranean Sea, the non-native looks so similar to the native Pacific blue mussel (*Mytilus trossulus*), the two mussels can only be distinguished from each other using genetic tools. Pacific blue mussels, once abundant along much of the coastline, have now been replaced by the Mediterranean mussel all the way from San Diego up to Monterey Bay. The non-native is less successful than the native mussel in colder northern waters, but survives even at warm temperatures that cause heart failure in the native species. To make matters worse, related studies show that predatory snails in Oregon and central California prefer eating the native mussel rather than the invader, most likely facilitating the spread of the invading mussel. It is expected to expand its range at the expense of the native as temperatures continue to increase.

Author Mary Ann Wilson

But climate change isn't just about rising temperatures. Other factors may complicate the picture. Wesley Dowd, a biologist at Loyola Marymount University, noted in a



Mytilus trossulus
Alaska to central CA

M. galloprovincialis
central CA to Baja

presentation there this past March that besides increased temperature, additional environmental stressors are emerging such as increasing ocean acidification, changing rain patterns leading to diluted salt concentration, rising sea levels and habitat loss. He compared mussels exposed to

Mussel bed at Little Dume
Courtesy of Ms. Wilson

increased temperatures with and without more food available, and found that having enough food is of equal or greater importance to their survivability. "There's interaction between these different factors," he said. "To look at just one thing could result in misleading predictions."

Besides resorting to migration or just dying out, organisms have two other options. The first is to utilize an existing mechanism to acclimate to new conditions. California mussels (*Mytilus californianus*) have some potential to respond to rapid weather events. Their membranes can be restructured within hours in response to temperature fluctuations during the tidal cycle, but only when they inhabit high intertidal sites during the summer.

Identifying when organisms will have exhausted their tolerance threshold in response to ocean change could help target the most vulnerable of them for conservation. The cardiac function of the porcelain crab (*Petrolisthes cinctipes)*, for instance, collapses at 31.5° C—very near the maximum temperature it currently experiences in nature (31° C). The survival of these intertidal crabs, which are found above water on the shore and underwater at depths of up to 90 meters from the northern Channel Islands to Alaska, could be threatened by just a slight increase in temperature.

Most cells respond to acute environmental change by inducing a specific set of proteins that function to prevent and repair macromolecular damage. This reaction, termed the cellular stress response (CSR), is key in determining the range of environmental conditions which an organism can endure. Targeting genes involved in the CSR is a relatively new way to define thresholds for physiological function. For example, when mussel body temperatures reach 32° C, often attained on hot days during low tide, genes encoding proteins that repair heat damage in their bodies become active. By 36.5° C, genes are activated to clear cells of proteins that can no longer perform enzymatic activities, leading to a disruption of the organism's biological rhythms. Researchers Andrew Y. Gracey and Kwasi Connor observed rhythmic or periodic gene expression patterns of mussels, which signified that these animals have a natural rhythm. But when the mussels were heated to the mid-to-upper 30s° C, their natural rhythm became disrupted.

Finally, an organism could respond to shifting environmental conditions over time through genetic change and evolution. That may not happen quickly enough, given that a study in June 2013 suggests species including birds, reptiles, mammals and

amphibians need an average of one million years to adapt to a single-degree increase in overall temperature. But Dowd said "the underlying genetic variation upon which physiological variation rests and upon which natural selection might act may rescue populations from the consequences of climate change."

He and his colleague Mark Denny, a biologist at Stanford University, found that rare heat waves lead to the evolution of a high safety margin in limpets (*Lottia gigantea*) on the California coast—5 to 7° C above the maximum body temperature they are likely to encounter in an average year. Pointing out that most limpets are unlikely to experience such high temperatures in their lifetimes, Denny and Dowd suggested that the limpets' generous thermal tolerance is due to the rare thermal events that wipe out the least tolerant individuals, shifting the gene pool towards greater temperature tolerance.

Denny, who is studying next-generation sequencing, is also finding genetic differences between mussels on the sunny and dark side of a rock, where the difference in temperature that two individuals next to each other experience can be up to 15° C. Such genetic variation is the raw material for natural selection. Since mussels mature within a year, a new generation is born every year with the potential for rapid evolution.

"When you put these things together and model how species are going to adapt or evolve in the face of climate change, depending on how much variation exists within the species, you can actually get pretty rapid evolution," Dowd said. He hopes conservation efforts will focus on preserving enough variation so that there are some genotypes left which can tolerate extreme conditions, and added that it's not enough to preserve around the mean but to maintain pools of genetic diversity. Perhaps, when further research leads to a more comprehensive understanding of what physiological abilities genes actually control in order to tolerate different conditions, adaption and rapid evolution can be facilitated in species with the greatest genetic variation.■

➔ ***Sensors*** For a simple example, if there are large variations in ocean pH during the time our sensors were deployed, then we may expect our local animals to be able to handle expected variations produced by climate change.

Portions of the collected data have already been presented to a scientific conference. We have reported on the correlation between chlorophyll measured by satellite sensors to that measured with the YSI sonde. We did not find much of a correlation, maybe because the satellite sensor measures the surface and the sonde measures at 60-ft depth. However, we did find that there is a dearth of chlorophyll around the island, consistent with a previous study performed by UCLA. Our plan is to continue to investigate this phenomenon using spacecraft data.

We are contemplating the future of the instrumentation. There are several venues in Santa Catalina that may want to support a scientific mooring. If you know any group that may be interested, please contact us. In the interim, the instruments will next be used in a pilot profiling project

Upcoming Meetings

Ocean Sciences Meeting
February 23-28 2014
Hawaii Convention Center, Honolulu
http://www.sgmeet.com/osm2014/default.asp

Southern California Academy of Sciences Annual meeting
May 2-3, 2014
California State University Channel Islands

12th Annual H2O Conference
May 27-29, 2014
Catamaran Resort Hotel on Mission Bay, San Diego, California
http://www.coastalconference.org/h20/index.php

in which they will be deployed from a boat, slowly lowered and raised through the water column to measure how water properties vary with depth. The experience gained with this project will enable us to employ volunteer boaters to measure ocean chemistry.■

CMS at Ocean Sciences 2014

CMS will present a poster at the Ocean Sciences Meeting 2014 in Honolulu. The biannual conference is one of the largest collection of ocean scientists in the world.

The CMS research, coauthored with UCLA researcher Dr. Anita Leinweber, describes analysis on the propagation of wind-generated disturbances (momentum diffusion) from the surface to deeper depths. UCLA maintained a scientific mooring, the Santa Monica Bay Observatory-SMBO) off Malibu, between 2001 and 2008. The mooring supported 3-dimensional current measurements, as well as ancillary quantities such as temperature and conductivity. The immediate research goal is to determine the rate of momentum diffusion at the mooring and to compare it to the measured rate of heat diffusion previously measured by the CMS. The ultimate goal is to understand mixing in the Southern California Bight.■

Handsome adventurer Kevin Lee

CMS sponsors first lecture

CMS sponsored a lecture by Kevin Lee at the John M. Olguin auditorium of the Cabrillo Marine Aquarium.
The topic of the August lecture was opisthobranchs, a term meaning gills behind and to the right of the heart. To SoCal divers, it means nudibranchs.

Kevin is noted for his worldwide diving expeditions, photography and diverse knowledge of the animals. He has received many awards for his work. **Recently the Orange County Register named Kevin its 2013 outdoor sportsperson of the year**. All this and he has a day job, too, so Kevin really embodies the CMS spirit.

His presentation described the natural history of opisthobranchs illustrated with specific examples photographed by him, with special emphasis on fauna found at Santa Catalina Island. The audience was extremely interested and kept Kevin busy with many questions.■

CMS attends water-monitoring workshop

CMS attended a Xylem workshop at the Monterey Bay Aquarium Research Institute (MBARI) located at Moss Landing. We attended to understand the state of the art regarding water chemistry measurements that we are conducting with our sonde. ■

Workshop participants on the dock at MBARI with *RV Rachel Carson* in background.

Catalina Marine Society Membership

Catalina Marine Society Members support the goals of the Society through their dues and also elect the Society's directors. Membership is described in the bylaws and is granted to those who: 1) agree with the mission statement; 2) pay the annual dues (currently $20); and, 3) submit an application that is approved by the board. An e-application is available on

http://www.catalinamarinesociety.org/CMSMembership.html

Manual Membership Application

Please send the following required information to the Catalina Marine Society via e-mail or post to the address below.

Name, e-mail address, postal address, reason you wish to join the Society, and that you agree with our mission statement.

Dues can be paid through the "Donate" link or checks made payable to the "Catalina Marine Society" sent to the following address:

Catalina Marine Society
15954 Leadwell Street
Lake Balboa, CA 91406

If you are interested in contributing to the work of the Society in other ways, please let us know. Categories and examples of needed volunteer work are listed below.

Lab

Data analysis
GIS
Programming

Field

Boating
Diving
Instrument calibration
Hardware/Equipment fabrication and mounting

Office

Web design/programming
Graphics
Photography/Videography

Magazine/newsletter

Reporting
Publishing
Editing
Departments

Fund raising

Event planning
Event volunteer
Grant writing

Press/publicity

Public speaking
Newspaper articles