OceanBights

The Magazine of the Catalina Marine Society

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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.

Letters to the editor should be sent via e-mail to the address below.
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Introducing *OceanBights*

Welcome to *OceanBights*, the magazine of the Catalina Marine Society. This is one of the Society's tools wielded to accomplish our mission, namely, marine-related research conducted in Southern California. We will employ the magazine to introduce ourselves to the community, learn about ongoing local research in the local ocean, understand current issues, debate possible CMS projects, focus ourselves on our chosen projects, and keep the community informed on the Society's activities.

Through our "Spotlight" columns, we will familiarize you and ourselves with research activities being conducted by local institutions. In turn, these institutions will learn about the CMS as we interact with them to produce the columns. We plan to feature two organizations each issue: a large institution; and, a smaller, more intimate and less known research entity.

We use the same strategy with our guest columns in which we will hear from, and interact with, individual researchers who discuss their specific projects, identify research issues and perhaps suggest projects for the CMS to undertake or contribute to.

As in this issue, we discuss possible CMS projects with the intent of receiving valuable comments, suggestions for collaborations, etc. And, we will forthrightly document the status of ongoing CMS programs. The pressure of an *OceanBights* deadline may be just the impetus required to keep programs moving forward.

We will have a section on upcoming local meetings of interests and where to find more information on them. And we will publish submitted meeting reports if they are supplied by attendees.

The magazine will also function as a newsletter for the Society's membership. We will include notices of Board meetings, significant decisions made by the Board, fundraising activities, social events and, in general, all Society activities. Of course, we will report directly to the membership via private e-mail activities that are internal to the membership (e.g., board elections).

The planned publication interval for *OceanBights* is every six months. This schedule depends on resources and demand and we may adjust the publication schedule and length accordingly.■

Spotlight on: California State University, Long Beach

Perhaps one of the largest institutions doing marine research in Southern California is California State University, Long Beach (CSULB), also

known as “The Beach”. As can be expected from such a large university their efforts are diverse and include work in both marine biology as well as marine geology. Their biological studies emphasize life in extreme environments and the impact and effects that humans have on the local fauna and flora of the Southern California Bight, while the geologic studies pertain to the discovery of past (and perhaps extreme) environments.

The Marine biology labs at The Beach include Aquatic Toxicology, Aquatic Microbiology, Echinoderm Evolution and Development, Environmental Endocrinology (EEL), Invertebrate, Phycology, Shark and Wetlands Ecology.

The Microbiology Lab focuses on studying the ecology, physiology and diversity of microorganisms in extreme aquatic environments. Local extreme environments include the Salton Sea (extreme salinity) and sulfide vents off Cabrillo Beach (who knew?). I asked CSULB Prof. Jesse Dillon if these extreme environments included the famous hydrothermal vents off White Point with their notable hydrogen sulfide odor. Prof. Dillon writes that little is known about these vents but assumes they are part of the same complex. He notes that there are two distinct bacteria that use sulfur in their metabolism but little else is known about the springs, but he hopes to study them in the future. The importance of life in these extreme environments is that they can tell us much about life and its origins on the early earth when chemical and physical conditions differed substantially from the present nominal environment.

Perhaps our era of pollution represents another form of an extreme environment. The Beach also emphasizes environmental issues and uses its expertise in microbiology to understand problems associated with pollution and toxic materials in the Southern California Bight. For example, a primary focus of the toxicology laboratories is to study the effects of anthropogenic chemicals and pollutants on aquatic organisms and the ecosystems in which they dwell. Areas of current research include finding the molecular and cellular mechanisms that permit pollutants to enter aquatic organisms and then determining their impact on the health of the individuals and the community structures they inhabit, and perhaps how the communities resist, acclimate or adapt to these conditions.

Microbial mat at Cabrillo beach sulfide vent.
Image courtesy of J. Dillon

The Phycology lab works in the area of marine algal physiology and biochemistry. Many of their specimens would be familiar to SoCal ocean lovers as the lab is particularly interested in the physiology of kelps (Order Laminariales, including our giant kelp), algal halogen (elements such as bromine, chlorine and iodine) metabolism, and the biogeochemistry of halogens in the marine environment. Algae are well known to concentrate iodine and other halogens from the surrounding seawater. The lab has been investigating the dynamics of algal halomethane production. Halomethanes are chemical derivatives of methane containing halogens and are important in atmospheric chemistry. They have been elucidating the physiological and environmental factors that influence this process using phytoplankton, seaweeds, coastal salt-marsh plants and other angiosperms (flower-bearing plants).

While The Beach’s biology department concentrates on local marine organisms affected by present-day conditions, the geology department is working to determine local conditions of

the far past. Specifically, some members are working in paleoceanography, or the study of ancient oceans. **This academic field has risen in popularity as we struggle to understand what the effects of global warming** are likely to be. We can address this question by first understanding how and why climate changed in the past.

Past changes in global climate are often recorded in sedimentary processes, including compacted snow and ocean sediments, and drilling cores extracted from undisturbed areas can provide a chronology of events surrounding global climate epochs. Ice cores from Greenland have samples of ancient atmospheres laid out in the order that snowfalls trapped them. An analogous situation occurs in our own Bight, where sea sediments have accumulated undisturbed in the Santa Barbara Channel for millennia.

Staff from the university are analyzing cores taken by the Ocean Drilling Program in the Santa Barbara Channel and are learning fascinating things. I asked CSULB Prof. Richard Behl what makes the Santa Barbara Basin a good location for taking ocean cores. He wrote that the **Santa Barbara Basin is spectacularly good at recording environmental change with great temporal resolution**. The abundant plankton accumulate rapidly on the basin floor as they die, providing a strong signal of what conditions were when they lived near the surface. The low oxygen at the bottom of the basin and the high-sedimentation rate combine to keep the sediments relatively undisturbed and a good record of historical events. The cores are relatively shallow compared to petroleum-well depths, being a few meters to 45-m deep, but the cores occasionally reach 200 m into the sediment in water depths that are 100 to almost 600-m deep.

Knowing our interest in ocean temperature, I asked Prof. Behl how past sea-surface temperature is reconstructed. He responded that there are a number of ways, including the assemblages of plankton and various chemical ratios found in minerals produced by living organisms. I tracked down one method, the oxygen isotope ratio in the calcium carbonate shells of Foraminifera. The oxygen isotopes 18 and 16 differ in their atomic weight by more than 10% and this is enough to differentiate their rate of absorption into the ocean from the atmosphere (via water vapor evaporation and condensation). Cooler water collects relatively more ^{18}O than ^{16}O. The isotopic composition is impressed on the shells as the forams take the oxygen from sea water to construct their calcium carbonate shells when they are alive, and then recorded in the sediments when they die. Hence, past oceanic temperature changes can be reconstructed.

Preliminary and ongoing studies of these cores by

Evaporative saltworks in Mexico is an extreme environment. Image courtesy of J. Dillon.

CSULB and others have employed sedimentologic and paleoceanographic methods (grain size, mineralogy, ichnofabrics (e.g., worm holes), microfossils, carbonate and carbon content, and stable isotopes) to understand changes in the ancient California Current System. They have discovered amazing and important fluctuations in climate and environment that have taken place over the past 60,000 years, as well as clues to what may have influenced their occurrence and timing. These studies have documented dramatic changes in bottom-water oxygenation, sea-surface temperature, productivity, and organic matter preservation during the later Quaternary (the Quaternary being the last 2 million years or so) that correlate with variations in global climate change. They have recently pushed our knowledge of climate change back to 700,000 years and are currently proposing additional coring and seismic survey expeditions for the upcoming years to continue this work.

One interesting (and frightening) question is what caused repeated, global warming events that occurred in less than one human lifespan during the late Quaternary. CSULB is investigating the role of methane hydrates (also known as clathrates) in rapid climate change. A vast reservoir of frozen methane in ocean sediments is in the form of methane hydrates (methane trapped in a crystal structure of water). These clathrates may have been responsible for the failure of the first attempts to gather oil from the spewing well of the Deep Horizon disaster. Methane is also a significant greenhouse gas (see above). Destabilization of the reservoir through changes in seafloor temperature and pressure may release methane into the ocean and then into the atmosphere, dramatically changing the amount of solar energy that is absorbed. The "Clathrate Gun Hypothesis" proposes that through geologic time the marine methane hydrate reservoir was repeated reloaded and discharged as clathrates accumulated during cold glacial intervals only to be dissociated when triggered by pulses of warmer intermediate water impinging on the continental slopes. This mechanism could have greatly amplified and accelerated global warming episodes.

CSULB has resources and facilities for doing field research, including 4 boats, and is also a member of the Southern California Marine Institute. They are located only a few miles from the Pacific Ocean, which places their marine work within a local context. And they are sometimes the venue for marine-related meetings.

The Beach is actively involved in many local marine research projects and trains many of our local scientists and resources managers. Their location and size (they are one of the largest universities in California) makes them one of the more important marine-related research centers in the Southland. ■

Scientific-Mooring Pilot Project

The position of Santa Catalina Island, in the center of the Southern California Bight, is an ideal spot to study many Bight properties. Surprisingly, there are few long-term ocean monitoring programs located near Catalina. The CMS is examining the feasibility of deploying and maintaining a long-term scientific mooring off the island. One long-term (>10 years) monitoring program on Catalina is the Catalina Conservancy Divers (CCD) thermograph program. This program has been very successful in elucidating the temperature dynamics of the inner Bight.

Long-term monitoring of physical and biological properties of the ocean provides valuable data for understanding seasonal processes, trends and anomalous behaviors and characteristics. We think that long-duration time series of biological activity, temperature, visibility, tides and currents at Catalina can assist in understanding how the presence of the island affects the local ocean, including the spreading

of nutrients, mixing of the water column and their resulting effects on primary and secondary production. Data measured at Catalina could be compared to that measured at continental locations, such as the UCLA mooring off Malibu to determine similarities and differences between continental and island ocean processes. These data sets could also be used to put into context the measurements of other researchers who typically conduct much shorter campaigns at the island. The long-term temperature time series collected by the CCD has been used successfully in this manner. For these reasons, the CMS would like to execute a long-term monitoring program at the island.

The idea for a CMS scientific mooring originated in discussions between Lauren Czarnecki and Craig Gelpi. Lauren expressed an interest in obtaining oceanic biological and physical measurements to assist researchers at the Wrigley Institute of Environmental Studies (WIES). Craig was working with data from the Santa Monica Bay Observatory, a UCLA scientific mooring program sited several miles south of Malibu. The outcome of the conversations was that a scientific mooring off WIES would be a very useful field program that the CMS may be able to conduct. It has many appealing elements that address issues of scientific significance while providing interesting work for CMS volunteers. The pilot project will satisfy several goals of the CMS.

The first goal of the pilot project is to expand our efforts to include biological studies. The logical path is to evolve our established data analysis techniques to include physical measurements of biological-related material, such as chlorophyll and oxygen, as well as various nutrients.

Second, the CMS wants to establish a field program. Up to this time, the CMS has taken little field data. These were collected during the CHIVE experiment or measured by a thermograph sited at Corral Beach in Malibu and discussed elsewhere in this issue of *OceanBights*. We want a field program that broadens our activities and appeal as well as utilizes the talents of our membership.

Third, from our work with CCD data, we appreciate both the advantage of quantitative data collection provided by automated sensors and the utility of high sampling frequency, long-term measurements. We suspect that scientific institutions find such long-term collections difficult because the funding cycle is typically only a couple of years and not conducive to long-term studies. The CMS, not facing this pressure, could perform a valuable service by maintaining a scientific mooring that collects appropriate data for many years.

The YSI 6600 to be deployed.

The proposed scientific observatory would be an ambitious undertaking for the young CMS. It involves planning, acquiring the instrumentation, deploying the sensors, retrieving them for data collection and re-calibration, and redeploying them. The measurements would have to be quality assured, formatted,

stored, analyzed and aggregated for future use.

After a short study on what could be done, how it could be accomplished, and what are the required resources and the risks involved, a plan was documented and circulated among the Board and interested parties. The plan recommended a one-year pilot study that would quantify and evaluate some uncertainties and risks so that the true scope and costs of the undertaking could be computed before we committed to a long-term program. The pilot study would employ existing instrumentation housed at WIES and use American Academy of Underwater Sciences (AAUS) certified divers supplied by the CCD to deploy and retrieve the sensors near WIES. Additional surface support would perform calibrations and maintenance using WIES facilities when the instrument is out of the water.

The major uncertainty is the frequency of instrument maintenance. Maintenance includes battery and fluid replacement, cleaning and recalibration. Reports indicate deployment intervals as short as 1 month and as long as 3 months. A one-month maintenance cycle requires 48 individual dives annually, with the attendant significant logistics of transporting and housing the divers and calibration crew.

At this time, an instrument has been secured and discussions between CCD, WIES and CMS have gone well. The work will be partitioned among the three organizations. The CCD will provide the instrument from their inventory and also the AAUS-certified divers. The divers will coordinate instrument retrieval with other data-gathering activities. WIES, which paid for the initial calibration of the instrument, will provide laboratory facilities for future instrument calibration. They will also permit the instrument to be sited at one of their deep-water boat moorings. The CMS will be responsible for continued instrument calibration, surface support, data quality-assurance, data storage, and data analysis.

In return, WIES will have use of calibrated data for educational purposes, the CCD will get to dive an exciting new project and the CMS will continue its mission of marine research with new data. Assuming a successful one-year deployment, we will be able to develop tidal harmonic coefficients for Two Harbors, examine the start of the spring bloom, and compare the seasonal timings of biological factors with other known seasonal cycles.

Although the pilot project is designed to collect valuable scientific data, we also expect it to be a learning exercise that teaches us the difficulties of operating a maintenance-intensive, long-term experiment. It will focus us to assemble and train the team necessary to execute all aspects of the experiment. If successful, we hope to expand the instrumentation to include measurements at other sites, of different data types, and depth profiles.■

The Experiment

The formation of the Catalina Marine Society is an experiment, an experiment to see if the promotion, enjoyment and pursuit of science can be accomplished by amateurs in the original sense of the word, i.e., lovers of science. The genesis of the Society is in local oceanography where lovers of the ocean are naturally curious about the fantastic life forms within and the beautiful and sometimes terrifying dynamics above.

Our experiment is to determine **if we can accommodate talented and motivated non-professionals** who wish to contribute to marine science in a significant way, providing them resources necessary to obtain useful results from their donated labor and then place those results into the scientific mainstream.

The Society will gathered the questions, design and execute experiments, retrieve data from our instruments and other freely available sources, collaborate with professionals, perform analyses and provide the results to the greater community. We will inform all who are interested in the answers and

make our data available to all. The Society will work with professionals in the field with the only requirement that the Society be actively involved in the collaborative research.

We will accomplish these goals through the resources provided by our membership, whether financial or in kind and contributed by any interested people: engineers, mariners, divers, and fundraisers, in short, anyone who enjoys making contributions to our efforts. We will do this within a framework of fellowship and camaraderie enabled by the love of the ocean and unencumbered by the usual workaday considerations and pressures.

The wonders and questions are endless. Let the experiment begin! ■

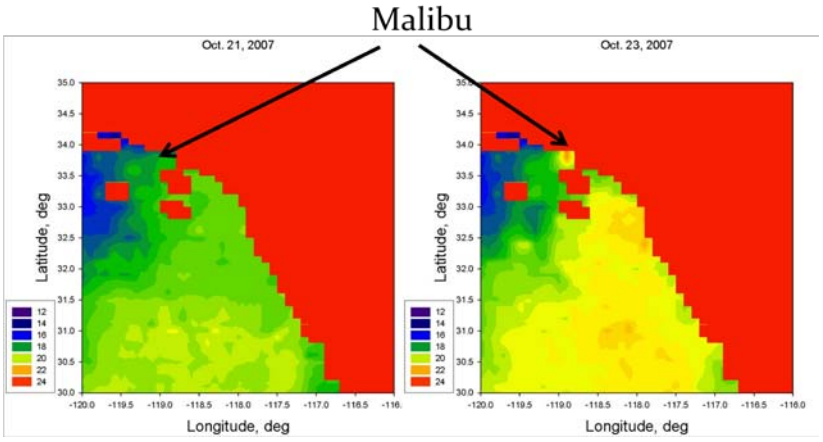
Possible CMS Projects

The CMS has begun putting together a list of research projects that pique our interest and can be accomplished with the available resources. Below are some of our thoughts. There is an emphasis on physical oceanography that reflects our origins but does not necessarily reflect our future.

The largest of these projects is the long-term scientific mooring we want to deploy and maintain adjacent to the Wrigley Marine Science Center near Two Harbors on Catalina Island. This project will require the collaboration of several groups. To determine if the CMS is up to it, we have established a one-year pilot program that will deploy a reduced set of instrumentation (including biological data sensors) sited on a nearby boat mooring. The pilot study is the subject of a separate article in this issue of *OceanBights*.

Additionally, we plan to expand past activities that included temperature studies. Rapid temperature variations often signify the movement of temperature gradients by ocean currents and these currents are usually the primary research target. However, temperature is much cheaper to measure than currents. And we have access to large arrays of temperature sensors, including those maintained by the Channel Islands National Park (CINP), the Catalina Conservancy Divers (CCD), the National Oceanic and Atmospheric Administration (NOAA) and Scripps Institution of Oceanography.

We are currently exploring internal waves on Santa Catalina Island. Internal waves are like waves on the surface, being oscillations in the water column beneath the surface. These waves are thought to move larvae toward shore and help mix nutrients into the water. We have found intense waves off Catalina and have studied data from CINP and found them on the Northern Channel Islands, too. The significance of these waves to the ecology of the Southern California Bight is still to be determined. Meanwhile, researchers at UCLA are running computer simulations of the internal wave response to tides. Their simulations indicate a strong semi-diurnal response along Santa Catalina Island, and we are comparing our previous studies of temperature variations along the island to the UCLA computations.



Malibu fire signature found in satellite SST.

Another proposed project is the examination of the effects on the ocean of Santa Ana winds. Beach divers like Santa Ana winds in that the winds oppose the usual swell and wind waves, providing for calm entries and exits. The winds also push surface water seaward to be replaced with cold, clear, deep water. It is this latter effect which is of interest as the upwelling brings nutrients to the surface. The most notable Santa Ana winds come in the fall, when the surface nutrient supply is depleted due to the phytoplankton growth known as the spring bloom. We are investigating the use of satellite data to determine coastal locations in the Southland where Santa Ana winds are prominent. The satellites provide sea surface temperature, a prime marker for ocean upwelling. The satellite data could be supplemented by an array of coastal thermographs sited where the winds are usually strong. **We chose the strong Santa Ana winds responsible for the Malibu fires of 2007 as a case study.** In the figure you can see the fire's signature in the satellite data we downloaded (for free). These data are coincident with data measured by UCLA's Santa Monica Bay Observatory, a scientific mooring located 4 miles south of the fire. Signatures of this event appear in several instruments located on the mooring.

We would like to build on our previous work with the California Cooperative Oceanic Fisheries Investigation (CalCOFI), a research program establish by the state in response to the sardine collapse in the 1940's. The seasonal variations of CalCOFI biological data could be compared to mixing rates discovered using temperature variations to establish a nutrient budget for the ocean surrounding Santa Catalina Island. The CalCOFI data could also be correlated with satellite chlorophyll data to understand the differences between remote sensing and in situ measurements.

There is always more work than people to do it. If you wish to weigh in on proposed work or volunteer, please contact us via the e-mail address on page two.■

Spotlight on: Cabrillo Marine Aquarium

The Cabrillo Marine Aquarium has displayed marine life of Southern California to visitors since 1935. Although mainly known for its kid-friendly layout and exhibits, the Aquarium also conducts marine research. It is appropriately located at Cabrillo Beach, adjacent to the tide pools at Point Fermin, the fishing pier, fishing and dive boats and a host of other maritime activities. The Aquarium provides a view into the greater marine ecology that supports these activities but that are not easily seen by the casual observer. Perhaps surprisingly is the fact that the current facility was designed by the famous architect Frank Gehry, who also designed Walt Disney Concert Hall in downtown Los Angeles. It is quite distinct from the existing building which formerly housed the Aquarium at its previous location on the same beach where some of us remember showering after diving at the Point.

The Aquarium's research facilities include an aquatic nursery and a research library. The nursery is equipped to support the study of larvae and juvenile animals. Besides the usual tanks of sea water that hold the specimens, there are also facilities to supply live food, including rotifers and brine shrimp, which are cultured to feed the analysis subjects. Larval stages are observed with a series of microscopes. Test equipment that measures water quality is used to map out parameters that influence survival or growth of baby animals. During our visit, the lab was trying to grow larval spiny lobsters, a delicate task indeed. The Cabrillo Marine Aquarium houses the Virginia Reid Moore Marine Research Library. Open to the general public, the library provides a non-circulating reference collection of approximately 9,000 books, periodicals and

audiovisual materials on the marine life of Southern California, the world's oceans, marine sciences and related topics. It is open Tuesday to Friday 12 noon to 5 pm and Saturday and Sunday 10 am to 5 pm. **Doing research in the library is a delightful experience**. There is a tremendous variety of ocean information laid out in an intimate atmosphere that makes perusal of the stacks inviting. Much of the material has been donated by researchers and contains their notes in the margins. When needing a break from literature searches, one can easily walk downstairs and peruse the exhibits. Watching the marine life brings life to the books.

Research Library at the Cabrillo Marine Aquarium.

Research at CMA usually falls into two categories: staff- and student-conducted. Both make good use of the Aquatic Nursery. Projects include both long-term monitoring of local marine habitats and laboratory-based husbandry projects to achieve a better understanding of basic marine life and their lifecycles. In the Aquatic Nursery, staff and students conduct research projects focused on helping threatened and endangered species in our coastal waters. They grow young sea animals, from abalone to lobster to seahorses. According to Dr. Kiersten Darrow, research curator at CMA, staff has focused on projects that apply to graduate work.

A partial list of staff projects completed over the last five years include: raising spiny lobsters from egg to settlement stage in different tank designs and with different population densities; describing developmental stages of red rock shrimp from egg to settlement; jaw development in larval white sea bass; physiology of larval grunion in delayed hatching conditions; and, optimal husbandry for raising larval garibaldi, goby, grunion, and rockfish.

In addition to the staff projects, students execute projects appropriate for science fairs. Some of these sound very interesting and include: raising local sea jelly species from polyp to medusa stage in different salinities, temperatures, and tank designs; cryopreservation of abalone gametes; bioluminescence of sea pansies in different calcium solutions; feeding habits of nudibranchs and hydroid culturing; and, sea urchin larval development in different pH levels.

Finally, Dr. Darrow indicates that the Aquarium also collaborates with other local institutions. One example is working with the California Institute of Technology to study the biomechanics of sea jelly movement. Another example is

CMS Awarded Grants

Northrop Grumman Corp. has awarded two Community Service Grants to the CMS. These grants recognize employee volunteer services to non-profit organizations.

an effort with California State University, Long Beach (the other institution spotlighted in this issue) studying halibut feeding behaviors in local restored saltmarshes.

The Aquarium is receptive to volunteer research projects using their facilities. Students and volunteers are given the opportunity to pursue research projects in the lab under staff supervision. Researchers exercise their investigative skills as they conduct sampling and measurement activities focused on baby animals that are raised for conservation, food or research. Possible projects should be discussed with Dr. Darrow, who can be reached via the CMA website. According to the website, all research conducted there is carefully guided by a Research Policy developed with the help of an External Research Review Committee. The Committee is made up of university faculty and research professionals who advise the aquarium's staff. Individual research projects require approval and must follow ethical guidelines promoting animal health and population conservation.

The CMA has much in common with the CMS. Both encourage volunteers to perform marine related research to understand the environment of Southern California.■

CMS presents to Sharkbait

On November 16, the CMS travelled to Brea to be the entertainment for the Sharkbait Dive Club. Our powerpoint presentation described the purpose and projects of the CMS as well as its origins.

Easily accessible exhibits provide an appropriate break from reading in the library.

CMS instrumentation is still missing!

A thermograph sited off Corral Beach in Malibu is still missing. This particular instrument has a storied past. It was originally deployed in 2008 to measure internal wave signatures and upwellings on the small-gradient Malibu beach. However, **after approximately 6 months it surfaced at a dive club show-and-tell**. A salvage diver noted the fishing float attached to a sand anchor and thought he had a wonderful find.

We recovered the instrument from the diver, retrieved the data and redeployed the thermograph again, this time without the attention grabbing garb, which was designed to keep the instrument from being buried. However, we have not been able to find it after 5 search-and-recover dives and the offer of a reward for its return. Too bad, because it was in a perfect location to record the upwelling associated with the Malibu fires noted in a preceding article.■

Green Abalone Monitoring at Santa Catalina Island May Provide Clues for Recovery Timeline

By Derek Stein and Kai Lampson

Southern California abalone were once a staple catch for sport divers and a cash crop for commercial fishermen. They were so plentiful that a recreational SCUBA diver could easily harvest a sport limit in a single dive. Commercial divers had no problem collecting full sacks of abalone, which for many years was a very lucrative business to be in. In 1997, the once productive sport and commercial fisheries were closed south of San Francisco in order to give those stocks the opportunity to recover to healthy levels of abundance. In contrast to southern California, a sustainable recreational red abalone fishery has continued throughout the years to be managed north of San Francisco.

If you have explored the reefs of southern California lately looking for these grand marine snails you would be fortunate to see one or two; you may even stumble upon an aggregation of three or four. More likely, you did not see any. It's come to the point where the newest generations of divers don't even know what an abalone looks like. The reality is that the status of abalone in southern California is a sad story with glimmers of hope, thankfully.

D. Stein

Currently, five of California's seven abalone species (red, white, black, pink, green, pinto, and flat) are on a federal species list. The white and black abalones are endangered species under the Endangered Species Act, meaning that they are in danger of extinction in the near future. Pink, green, and pinto abalones are on the federal list for Species of Concern; they are depleted and are in need of conservation. The specific reasons for the abalone collapse are debatable; however, it is a result of both human-related causes and disease. The imposed fishing moratorium is a major step toward abalone recovery in southern California, but the Department of Fish and Game's (DFG) currently directed fieldwork is on a small-scale level, and may only increase local populations at this time. However, our efforts may give us some insight on the current status of abalone populations and how we may bring them back to historical levels more quickly. The truth of the matter is that our greatest tool for restoration for most of the abalone species is natural recovery, and that will take a long time to achieve historical abundances.

K. Lampson

The Abalone Recovery and Management Plan or ARMP was adopted by the California Fish and Game Commission in 2005 for the *purpose of providing a cohesive framework to direct recovery efforts, and to manage existing and future fisheries.* The document lists the goals for recovery for all California abalones. These include reversing the decline of populations, establishing a self-sustaining population throughout historical ranges, and reaching sustainable fishing levels. Some possible methods to meet these goals include aggregation or translocation of adults and captive breeding for adult or larval out-planting. Not all of these have been explored

to their fullest extent; however, the DFG's aim is to determine which ones are most effective in the recovery efforts.

The DFG, funded by a grant from the NOAA Fisheries Service, and in collaboration with the Long Beach Aquarium of the Pacific, is making an attempt to facilitate restoration through abalone aggregation. Aggregation is defined as moving abalone closely together within a small area to aid in reproductive success. Abalone broadcast spawn, where males and females release sperm and eggs into the water column, thus fertilization is more successful in larger and tighter groupings. Scientific literature says that successful fertilization occurs more often when abalones are no more than five feet apart, and the probability for success greatly increases with an increase in population density. This is technically referred to as the Allee effect, and it is true of many of our invertebrate broadcast spawners. At Santa Catalina Island, the DFG has established two study sites for monitoring the successes of aggregating green abalone. Aggregating abalone will hopefully prove to be a useful tool for increasing the size of abalone groups within small areas. If so, this method can be used on a grander scale for restoring depleted areas.

The ARMP also addresses the need to conduct periodic surveys of the populations to determine the status of recovery. DFG divers have completed an assessment of southern California abalone through extensive dive surveys using a timed-search method. Timed searches are a way to measure abalone abundance by counting abalone over a specific unit of time. This technique is used in low-density areas where transects are not feasible. On the backside of Santa Catalina Island for example, a trained diver may find 2-6 pink abalone in a one hour dive. Greens are more abundant on the front side of the island, and as many as 20 may be encountered by one diver in an hour, which is very encouraging. However, the norm is more like 2-5 green abalone per hour. The DFG has found that densities are no where near historical levels, and a re-opening of the fishery will most likely not be considered for many years. However, there is cause for optimism because there are some signs of recruitment indicated by the presence of juveniles and a wide range of adult sizes, representing many year classes.

Certain life history traits that make green abalone and other abalone species vulnerable to over-fishing will also make it difficult for them to rebound. Green abalone can attain a size of about ten inches and are 10-21 years old when they reach seven inches, which was the old minimum size for commercial harvest. They usually become sexually mature at about three inches. Like all abalone, the males and females broadcast spawn into the water column when conditions (i.e., temperature, season, water chemistry, etc.) are optimal. They may spawn every year, but successful fertilization and recruitment of newly settled abalone varies depending on the conditions. Large females will have millions of eggs; however, probably far less than one percent of the fertilized eggs will survive to adulthood. Slow growth, broadcast spawning, and low juvenile survival rates are some reasons as to why abalone populations will likely take a long time to recover.

Adult and juvenile green abalones require specific habitats for feeding and protection. Planktonic larvae will drift aimlessly with the currents until settling on appropriate rocky habitat and finally turning into a juvenile abalone. Juveniles stay hidden for about four years until finally emerging as adult abalone. During this life stage they are found under boulders or deep cracks, and are more vulnerable to predators such as octopus, fish, lobster, and crabs than adults are. Adult green abalone mostly prefer deep, dark cracks or tight ledges in thick kelp, where they are protected from predators and receive plenty of drift kelp for sustenance. Both juveniles and adults are more commonly found in depths of 5-15 feet, but can be found deeper to at least 30 feet. Even though abalone are difficult to find,

they still reside in shallow water and areas of high use where they are vulnerable to poachers, which also contributes to the low numbers of abalone in southern California. The minimum fine for possession of abalone in the moratorium area (south of San Francisco) is $15,000 under FG code section 12006.6 (a).

Withering Syndrome (WS) is an abalone disease that complicates our recovery efforts and creates additional uncertainty regarding the ability of the stocks to support a fishery. DFG studies regarding WS have shown that green abalone should be the best species for recovery in southern California. WS is a chronic wasting disease caused by intra-cellular bacteria that weakens the abalone through starvation, leading to a shrunken foot and eventual death. Abalone exhibit signs of WS with increased water temperatures, and the disease has detrimentally affected all southern California abalone species to some extent. DFG researchers have found that in lab experiments comparing green and red abalone, the higher temperatures did not result in higher infection intensities of the causative agent of the disease nor increase in clinical signs of disease in greens. The fact that green abalone seem to tolerate the disease better than other abalone species is encouraging and supports the idea that greens should be the best species for testing recovery techniques in southern California.

Our two study sites at Santa Catalina Island allow us to monitor tagged aggregated abalone in a small, defined area to determine their survival, movement, and persistence over time. We placed approximately fifty abalone into each site, which measures 10 x 10 meters and is divided into four quadrants. Two tags were affixed to the shell of each abalone using an underwater epoxy. Small, electronic tags known as PIT tags, emit a unique signal read by a specially designed underwater reader. The tag tells us which abalone we are examining in case that the second tag, a numbered stainless-steel external disc is either unreadable or worn. The sites were monitored intensively after the initial aggregation, and subsequent monitoring is still occurring monthly and will be ongoing until 2011. The monitoring for this project is being conducted by our partners, the Long Beach Aquarium of the Pacific.

Aggregation was very successful at both of the sites and the results so far are showing a high rate of survival with the majority of the abalone persisting at the sites or in proximity to the sites. The tagging operations did not appear to impact overall abalone health, and very little mortality was observed. For the first couple of weeks, most abalone persisted within the site boundaries; however, in the following weeks, many of the abalone moved outside the plots, but not very far. Other untagged abalone have moved in and out of the sites. In general, final calculations will be used to determine individual and group movements and overall survival, which will ultimately be the factors in

PIT tags enable abalone tracking for over 50 years. Image provided by D. Stein.

determining if aggregation is feasible and warranted.

Measuring success is challenging when dealing with abalone aggregation. This is due to the difficulties in determining if new recruits at a site are a result of our direct efforts or from natural recovery. Thus the determination of abalone aggregation as a successful recovery technique will take a stepwise process. The first step is to determine if the abalone in this study persists over time. If so, we can assume that our efforts are increasing the odds for successful reproduction in accordance with the Allee effect. Subsequent yearly monitoring will determine significant increases in abalone density in and around the two study sites. If there is an increase, further monitoring in the broader vicinity of the sites should help determine how successful aggregation is for increasing the abalone population in a given area. This will give us a higher confidence in using aggregation on a larger scale, and as a tool to assist us in increasing abalone populations, a primary goal of the ARMP.

An abalone tagged with epoxy. Eventually the tag will become encrusted. Image by D. Stein.

The status of the southern California abalone populations is that their numbers are low and attaining full recovery at historical fishing levels will be a gradual and challenging process for researchers and resource managers. The first step in recovery was to close the fishery, which occurred in 1997 south of San Francisco. Even in the thirteen years since the moratorium, we are observing positive signs for recovery, and divers are more often talking about abalone sightings throughout the Southern California Bight. Other means to recovery such as aggregation may eventually prove to be a useful method to facilitate reproductive success and enhance populations. We are hopeful that divers will start seeing more abalone of all species, and that these grand snails may once again be a common invertebrate on southern California reefs.

Derek Stein, Associate Biologist, and Kai Lampson, Marine Biologist, both work on the Invertebrate Project for the California Department of Fish and Game's Marine Region in Santa Barbara. ■

Annual Meeting

The CMS annual meeting will be held Sunday, April 10, 2011 at the Long Beach Aquarium of the Pacific.

Upcoming Meetings

This year's CalCOFI Conference theme will be Ocean Acidification and Hypoxia. It will be held at Scripps Institution of Oceanography in La Jolla, CA. December 6-8. More information can be obtained from *oceaninformatics.ucsd.edu/calcofi/conference/*

The American Geophysical Union meeting will be held, as usual, in San Francisco, December 13-17, 2010, with several ocean-related sessions.

Annual Meeting of the Southern California Academy of Sciences, May 6-7, 2011, California State Polytechnic University, Pomona. The symposium showcases research in all fields pertaining to Southern California.

Ocean Sciences Meeting 2012 will be held in February in Salt Lake City, Utah. This meeting, held every 2 years is the pre-eminent gathering of ocean scientists of all specialties.

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 statements, 2) submit an application that is approved by the board; and, pay the annual dues (currently $100). 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
19872 Collins Road
Canyon Country CA 91351

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