# OceanBights

## The Magazine of the Catalina Marine Society

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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.

Letters to the editor should be sent via e-mail to the address below.
information@catalinamarinesociety.org



## This Issue

Another eclectic issue awaits you. We asked a previous *OceanBights* contributor to write about her experiences surviving the hurricanes that struck the U.S Virgin Islands, producing massive damage to land structures. I am sure you will find Lora's account fascinating and scary. We also have another report on dealing with invasive seaweed. Perhaps surprisingly, this seaweed may have been helped in its establishment here from the destruction of native kelp produced by West Coast hurricanes. In the sad situation that our kelp loses its battle to maintain dominance, there will always be kelp available for viewing and study in the ecology section of the California Science Center, who, by the way, are our new partners deploying thermographs (joining the Aquarium of the Pacific, Antelope Valley Desert Divers and some very dedicated individuals).

We also continue our comparison between local places to those we sometimes visit. And, interspersed, we have interesting tidbits regarding local marine topics, CMS happenings and requests for volunteers. As always, if you have comments, send them to us.■

## CMS Happenings

We have been busy. Of course, our first order of business is advancing scientific knowledge of our local ocean. To that end, our two field projects, the David Tsao Continental Thermograph Array and our Catalina Dynamic Ocean Chemistry Program (aka depth profiling) are continuing at an accelerating rate.

Our thermograph array is expanding and we have recently partnered with the California Science Center to increase the number of sites where sensors are deployed. Data are pouring in.

This year we have received significant grants to upgrade our depth-profiling instrumentation at Catalina and we are hustling to increase the deployment tempo.

However, **with the collection of data comes the moral obligation and fun to analyze it**. To this end we are happy to report that our latest work has been accepted for publication in the Proceedings of the Ninth California Island Symposium. A cornerstone of the research is the understanding of results obtained from thermograph arrays. An interesting finding is reported elsewhere in this issue.

Of course, outreach suffers when finite volunteer time is divided into field work, data analysis, research, and proposal writing. As a result, we have been unable to keep up with our intended publication schedule for *OceanBights*. Towards remedy, we look forward to engaging more volunteers in the data collection efforts.■

## Casino Kelp is looking better

As an adjacent article describes, our kelp has been beaten up by the invasive "devil weed". However, we are seeing more giant kelp and less sargassum in Avalon's Casino Dive Park. We have lamented the loss of kelp *(OceanBights, Vol. 6, #1)* at the park but now are beginning to rejoice at its return. Although we heartily applaud the efforts of the California Science Center and the Aquarium of the Pacific to enable the public to view kelp (please read the CSC article in this issue) it's best to see it in its natural habitat as epitomized by the Avalon Dive Park. May generations of divers enjoy these famous kelp forests and the 13 giant black sea bass we've recently counted beneath them.■

## Two Estuaries

Comparing and contrasting different locations is a good method for obtaining a larger understanding of the places that we love. Last issue, we compared Palau to Santa Catalina, concentrating on their ocean ecological bases, namely coral and phytoplankton, respectively. This time, we'll examine Newport Beach, specifically Newport Bay (33.61° N, 117.91° W), and contrast it to the lagoon of Venice, Italy (45.44° N, 12.31° E), which have somewhat superficial commonality. And as described below, Venice may be on our diving itineraries in the future.

The Venetian Lagoon was formed by several rivers which flowed to the Adriatic Sea from their head waters in the Alps. The Adriatic Sea is an arm of the Mediterranean Sea, and forms a semi-enclosed water body along the eastern coast of Italy. The lagoon is the largest estuary in the Mediterranean Basin.

Estuaries are fairly ephemeral as the sediment load delivered by the rivers cannot be expected to exactly match the subsidence and erosion occurring at the coast, therefore, the estuaries are either growing or shrinking. Our Venetian Lagoon is approximately 6,000 years old, and would naturally be filling with silt if extraordinary measures were not taken to preserve it.

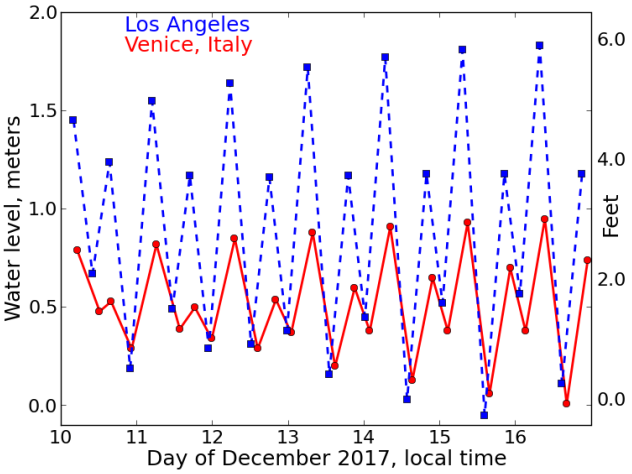
Newport Bay used to be an estuary of the Santa Ana River, which doesn't appear always to reach the ocean these days. Sediment from the Santa Ana formed a barrier or sand spit south of the river's mouth, creating Balboa Peninsula and a back-of-spit water area that became the estuary. There is some fresh-water flow into the Bay from San Diego Creek, but that must be a modern development produced by the water reclamation plant at the head of the Bay. The Bay is the largest natural wetlands remaining in Southern California.

Venice was founded by people fleeing the chaos of the collapsing Roman Empire. Invaders, taking advantage of the fall of Rome, ravaged the mainland. But mainland natives, who had probably been utilizing the lagoon for centuries, were able to isolate themselves from the marauding hordes by moving to islands located in the lagoon. They developed special construction techniques for building their homes and civic buildings in the lagoon and mudflats,

Venice and Newport. Can you tell them apart?

and used boats rather than wagons to move supplies about on the famous canals. The requirements for boats probably limited barbarian attacks.

Conceptually, Newport Beach was founded the same way, with wealthy people isolating themselves from the marauding SoCal hordes. Newport Beach, particularly the bay's islands, is a real estate development located on mudflats. These areas had to be "upgraded" and buttressed to withstand the surrounding sea. The peer requirements for large boats probably limited attacks from the middle class.




Tide comparison. Newport has larger tides than Venice

Venice is about 1,500 years old, while Newport is approximately 100 years, so there has been much more time for the Venetians to modify their environment. To maintain the defensive safety of their islands, the Venetians had to maintain them as islands, but the sediment of the rivers was filling the lagoon. Their solution was to reroute the rivers so they no longer emptied into the lagoon. In doing so, the Venetians became more dependent on the tide to remove pollution and urban wastes from the water surrounding their homes. The semi-diurnal tide dilutes the lagoon's waters and takes the wastes out to sea. Surprisingly, though Venice lies near the northern end of the Adriatic which has a nice configuration for tidal surges (think of the Bay of Fundy, the Gulf of California and Turn-again Arm near Anchorage), the tidal amplitude is not large, on the order of a meter and smaller than the amplitude at Newport (see the figure). A small tidal range is conducive to building close to the water's edge. However, with sea levels increasing and the islands subsiding, small changes in water level, such as produced by the wind, can result in substantial flooding in Venice. I know of no similar flooding in Newport. (However, there is the beginning of such flooding at Sunset Beach, but that's another article.)

By the numbers, the population of Newport Beach is 86,000, but, of course, it is embedded in a metropolitan area with a population of millions. The city of Venice has 264,000 souls, with approximately 50,000 living in what tourists would call Venice proper, the old section in the middle of the lagoon. However, the larger metropolitan area including Venice has a population of 2.6 million. So, we can expect that both areas must deal with similar urban problems, including employment, pollution and transportation.

Either naturally or by construction Venice has hundreds of islands and canals, and famously the Grand Canal, which is a major waterway through the city. By construction Newport Bay has 6 (Lido, Bay, Harbor, Collins, Linda and Balboa). Since the landscape has been altered to suit man, nature continuously alters it to suit nature. For example, canals must be continually maintained. This is a difficult process in Venice as sections to be repaired must be dammed and emptied. Because buildings line the canals without protecting seawalls, canal work must proceed cautiously. The counterpart operation in Newport is using the dredge; a large one is often seen in lower Newport Bay while a smaller one can sometimes be found on the upper bay. We know the marinas

must be continuously dredged to a depth that safely accommodates boats. And there are some areas, such as the southern end of the Grand Canal of Balboa Island that are getting awfully shallow such that sediment growth may soon hamper boat traffic through this major waterway within Balboa Island. The upper bay is dredged to provide wildlife habitat – an unnatural way to make nature I suppose.

Venice's lagoon is 550 $km^2$ (212 sqmi), while the water area of Newport Beach is 75 $km^2$ (29 sqmi), or a little over 10% of Venice's. The area ratio to me indicates that some phenomena found in Venice could be replicated in Newport, but also that some wetland-related industry supported by the European lagoon's size would not be possible in Newport Bay. These industries include fisheries and mariculture. Somewhat surprisingly (and disconcertingly) a lot of fish and other marine life are taken from the Venetian lagoon for local consumption. The Venetians have developed unique forms of weirs to trap fish and then grow them under controlled circumstances. And there are lots of recreational fishermen using rod-and-reel to snag fish on the edges of town. No doubt much of this take lands on the plates served by Venetian restaurants. The only industrial mariculture I know of in Newport Bay is the white seabass grow-out pens (see article on Hubbs, *OceanBights Vol. 3, #2* ). White sea bass are allowed to grow in enclosures to a size that is less likely to be preyed upon, and then released into the bay. They are intended to become food for recreational spearfishers. The disconcerting Venetian part is that there is no central sewer system in Venice. Raw sewage is deposited directly into the canals. Although there are obvious drawbacks to eating fish taken from this type of water, one benefit of having this large supply of nutrients is its support of the food chain in the estuary. Fortunately, this kind of nutrient supply is missing from Newport Bay.

The Venetians have emphasized job creation in their quest to have a modern life that is not completely centered on tourism. Part of their solution is the development of industrial activities on the mainland shore of the lagoon. Newport Beach has plenty of tourists, too. However, its economic activity is not centered on industry but appears to be centered on retail.

Despite being highly industrialized and a major petrochemical and cruise ship port, the large area of the Venetian lagoon supports a large biodiversity as compared to Newport Bay, as is expected from the theory of island biogeography. Foxes, martens and shrews are some of the native mammals. However, in contrast to Newport, there are no cetaceans or pinnipeds in the Venetian Lagoon. We often find sea lions and seals in Newport Bay and an article in *OceanBights (Vol. 2, #1)* described dolphin observations there. The bird population migrating through the Venetian lagoon is huge and has the new addition of flamingoes. Terns, herons, egrets and cormorants are common. Occasionally 100,000 birds have been recorded in the lagoon. Newport Back Bay is also a bird haven, see http://nathistoc.bio.uci.edu/birds/. Rare birds, such as the clapper rail, nest in the marshes of the upper Bay. And a kayak or paddle board trip often encounters a variety of unusual water fowl.

I should mention the possibility of SCUBA diving in the Venice lagoon. Recently, a

MOSE for Newport?

vibrant reef community has been found adjacent to the lagoon, along the breakwaters protecting the entrances to the lagoon from the Adriatic Sea. The reef is not composed of coral, but mostly of rubble or coralline algae. The rubble is being produced by the construction of MOSE, the set of underwater gates designed to isolate the lagoon from the sea when high tides (*acqua alta*) are expected. Some 250 species of plants and animals have been recorded in the reefs, many that are invasive to the area. Why these new species are taking hold so rapidly is not understood. But apparently, the diversity and visibility is great enough to suggest a future in SCUBA there.

There is another reason developing for SCUBA in Venice. Venice is in a state of unarrested decay. By appearances, Venice is a difficult place to live. The cost of maintaining historic (i.e., old) structures in a marine environment in the face of rising sea levels and subsidence must be prohibitive, and many of the old palazzos lining the Venetian Grand Canal are no longer occupied. Unless some unforeseen economic change occurs, the old palaces are doomed to succumb into the water. Then the best way to see them will be with mask, snorkel and perhaps tank.

There is perhaps a Newport Beach diving analogue to future Venetian diving; namely, diving the Newport Pier, perhaps the only pier that allows diving in California. You can dive the pilings at the end of the pier and get a feeling for what the foundations of many Venetian buildings may look like.

**Don't dive the north side of the pier so as to avoid being sea kill due to the dory boats that swiftly haul ashore there.**

Newport should pay attention to MOSE. The gates eloquently lie on the seabed, out of sight and removed from maritime traffic which moves safely overhead. However, when needed, the gates can be inflated, which causes them to tilt up, break the surface, and close the lagoon to the sea. With rising sea levels and increased storm activity, a small version of MOSE may be needed between the Wedge and Corona del Mar.■

## Mussels

Call me a worry wart, but during our mussel-hunting trip this late fall (see *OceanBights* Vol. 5, #1 for a description of a typical expedition), there were decidedly fewer mussels on the rocks, although there were still plenty. We did see recruits and we didn't do a scientific study on numbers so we can't say anything definitive. We just hope this is not a trend. We used to see sea stars eating the mussels, but no longer, and that is another sad story, *OceanBights* Vol. 5, #2.■

## CMS Organization

We welcome Andrew Solomon to the CMS Board of Directors. Andrew is currently the Dive/Boat Safety Officer at the California Science Center. ■

## SoCal Chlorophyll

CMS will present a poster describing recent work on chlorophyll dynamics in the Southern California Bight. Chlorophyll, produced by plants such as phytoplankton and seaweeds, can be an indication of ocean productivity. Chlorophyll density was estimated from the water color as seen from satellites, with greener water indicative of more chlorophyll. The seasonal changes in chlorophyll were related to temperature changes as expressed by the CMS temperature model, derived from a decade of thermograph measurements made around Santa Catalina Island, as well as measurements of nitrate made from CalCOFI cruises during the same time period. The research indicated the different dynamics between Santa Catalina and San Nicolas islands, with Catalina behaving like a textbook ➔ *see chlorophyll pg 19*

## Weeding a Seaweed: Managing *Sargassum horneri*

Mary Ann Wilson

*Sargassum horneri* is a large alga native to the shallow reefs of eastern Asia. As a key species in the Northwest Pacific ecosystem, *S. horneri* is a primary producer, a biofilter of nutrient runoff, and a traditional food source for the people who live in Japan, Korea, and China. The seaweed beds also provide a habitat for fish, sea urchins, abalones and turban-shell snails. But as an invasive in California (see *OceanBights* Vol.6, #1 ), it grows more densely than many native species, creating a canopy that blocks sunlight from other plants, including the giant kelp (*Macrocystis pyrifera*) which is native to the California coast. This may impact animals relying on the kelp to hide or for food.

For example, in 2015, local researcher and oceanographer Jon Council said in *The Catalina Islander* that sea lions "use giant kelp like duck blinds and dart out into anchovies and smelt. Without the kelp, they don't have that cover." Because of warmer-than-normal water temperatures brought on by a late-season El Nino and tremendous surge generated by Hurricane Marie in August of 2015, the kelp was devastated. While adult sea lions can adjust to changing conditions, pups are a lot slower and have to work harder to get to bait balls without kelp cover. Also, some species, such as smelt, lay their eggs in the fronds or leaves of the kelp. So for sea lion pups, the smelt are now fewer and harder to catch.

Mary Ann Wilson

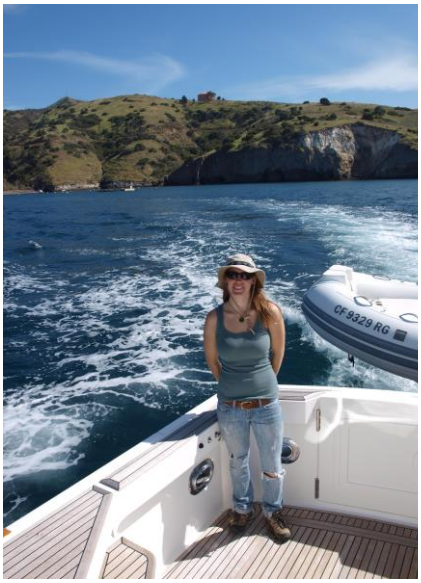
Commonly referred to as sargassum, *S. horneri* was first detected in Long Beach Harbor in 2003 - at that time the only place outside its native range. By April 2006 it was found off Santa Catalina Island north of Big Fisherman's Cove near Two Harbors and USC's Wrigley Institute. In 2009, it was also found in the marine park at Anacapa Island. It has since expanded rapidly across the Channel Islands and halfway down Baja California, and is still actively spreading. Since 2013, it has become more dominant on the reefs which have historically been covered by giant kelp.

The invasion problem is twofold. First, the seaweed grows very fast, especially in the winter and spring; and once established, eradication is impossible. Hence its nickname is "devil weed." Second, it is highly fecund as well as monecious, which means it has male and female gametes. Theoretically, a single individual can start a whole new population. It is well suited to short and long range dispersal; and if ripped off the substrate while reproductive, the buoyant plants can drift long distances on currents and drop gametes as they go. Once established, populations continue to spread locally.

Lindsay Marks, a PhD candidate at the University of California, Santa Barbara (UCSB), spearheaded recent investigations on the invasion. In May of 2017, she gave a presentation about the ecology of *S. horneri* and her attempt to remove it with the help of a giant underwater vacuum tube known as the Super Sucker.

To find out how its stages of growth and relative biomass compared to native species in the same area, Marks and her team have been sampling the native algal community at Isthmus Reef, located on the front side of Catalina Island, every three months since 2014. What they found was an inverse seasonal pattern between the native kelp and the invasive algae—the native species have higher biomass in the summer

and fall, and as they later decline, *S. horneri* increases. "You could look at this sargassum as just filling an empty niche," Marks said, "or taking advantage of this opportunity where the native species may be underutilizing their limited resources like space and light."



Researcher Lindsay Marks

To find out whether marine protected areas (MPAs) can resist invasion, she collaborated with researchers Jenn Caselle and Katie Davis at UCSB to study it at Anacapa Island where there are three marine protected areas: the no-take old reserve established in 1978; the new state marine conservation area (SMCA) established in 2003 which allows fishing of spiny lobster; and, the new no-take reserve established in 2004.

In the old reserve, there is a much larger number of predators like lobsters than in the unprotected areas on the backside of the island. Because of the higher number of lobsters, there are fewer sea urchins which are lobsters' preferred prey. Sea urchins eat algae, so there's a lot more kelp in the protected areas. Conversely, fewer predators live outside the protected areas, which results in many more herbivorous urchins and less native kelp.

The researchers suspected that this biological difference in communities might also be responsible for the differences in the *S. horneri* biomass. Since the invasive alga is very opportunistic and prospers in places where native algae do not, they surmised that perhaps there would be less *S. horneri* in areas with healthy robust kelp communities and more of the sargassum in degraded areas.

As expected, Marks and her team did not find a lot of *S. horneri* in the old reserve. They think this was because the sargassum was experiencing more intense competition and shading from native algae and therefore had fewer resources available. However, on the backside of Anacapa where fishing is allowed, they saw very little of *S. horneri* as well. These sites were characterized by "urchin barrens" where enormous numbers of sea urchins graze all available algae, including both kelp and sargassum. While this is an alternative scenario for resistance to invasion by sargassum, it is certainly a less desirable state of the ecosystem.

In the newer MPAs established in 2003 and 2004, there were much higher levels of *S. horneri*. The researchers surmised that urchins will eat anything if hungry enough, but given the choice they prefer the taste of kelp over *S. horneri*. A follow-up project Marks called "Algae Buffets" bore out these expectations. Given a choice between samples of giant kelp, southern sea palm (*Eisenia arborea*), and *S. horneri*, the urchins favored the two common native kelps. The reason? *S. horneri* is a fucoid alga, and these typically have chemical defenses against herbivories, so it probably doesn't taste very good.

Thus MPAs may be able to resist invasion only if they're more established, with mature kelp forest communities and more predators controlling herbivore populations. "It will be interesting to see as these newer MPAs continue to mature, whether or not sargassum will impede that progress," Marks said.

In an attempt to weed the seaweed, Marks used an underwater vacuum device called a Super Sucker as part of a National Oceanographic and Atmospheric Agency (NOAA) Fisheries pilot project. The gentle vacuum transports algae from divers to the surface where it can be sorted for bycatch and bagged for disposal. A similar device has already been used on coral reefs around the island of

Oahu in Hawaii to reduce invasive algae there.

In February of 2015, Marks—along with Adam Obaza of NOAA Fisheries, Sam Ginther, a graduate student at Cal State Northridge, and a group of volunteer research divers—cleared fourteen 60 $m^2$ areas of *S. horneri* on the leeward side of Catalina Island. Since it was too difficult to remove tiny recruits from seaweed beds, they chose February when the alga was biggest but also the least dense, and also before it was reproductive.

So understanding the life cycle of *S. horneri* is paramount to launching a successful removal. While native algae are perennial, meaning they live through multiple reproductive cycles, *S. horneri* is an annual species. It's much more abundant in the summer time, sometimes reaching 1000's of individuals per meter squared, due to the peak in recruits. As the season progresses from fall to spring, it becomes much less abundant. But in terms of biomass, recruits contribute very little in the summer. That changes in the winter and spring, when there's a huge boom of biomass.

In all they removed more than four tons of material in three days. They returned in September 2015, when they expected to find the greatest number of new recruits based on their seasonality data. Initially, they had reduced recruitment by about 50% in the removal plots compared to control plots.

Thanks to the Kenneth T. and Eileen L. Norris Foundation for their support of our Catalina Dynamic Ocean Chemistry program.

Sounds impressive, but unfortunately that 50% reduction turned into a 25% reduction as those populations matured and grew up. Marks was disappointed. "We sort of sped up the self-thinning process but all we really did was slow population growth," she said.

Marks surmised that the warmer waters deterred the growth of native kelp, which had essentially disappeared from the region where they were working on the leeward side of Catalina near **Wrigley, which meant the native species were unable to colonize the spaces on the reef we created by clearing sargassum. She thought they would have seen less of it the following year** if native kelp had been able to reclaim those spaces.

Dr. Bill Bushing, a marine biologist who was one of the first to discover sargassum on Santa Catalina Island, observed that there was very little of it during August and September of 2009, at which time the water was cooler than the previous five years when sargassum became a problem. "Possible reasons may include the limited light reaching the subtidal rocky reefs due to the thick native kelp canopy, or the cooler water temperatures directly affecting the growth of sargassum," he wrote in *California Diver* in 2014.

Native kelp and the invasive alga share a similar temperature range of what they can survive in—10° to 25°C (50 to 77°F) for *S. horneri* and 5° to 20° C (42° to 72°F) for giant kelp. But Marks said that it was possible that in the upper threshold the sargassum might have a little bit of a leg up. In the last few years, we've had unusually warm water in southern California and native kelps have all but disappeared from the leeward side of Catalina while sargassum has continued to thrive.➔ *see sargassum pg. 10.*

## CMS at AoP Diver Day

CMS will be at the **Aquarium of the Pacific Diver Day**, Saturday, March 10, 2018. Certified divers have free entrance into the Aquarium on Diver Day.

We have manned a display for Diver Day for many years and use the opportunity to reconnect with the diving community, see old friends, describe our projects to interested people, and recruit volunteers.

## 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 David Tsao Thermograph Array that is currently under development. For more details, contact Karen at karen@catalinamarinesociety.org or Craig at craig@catalinamarinesociety.org.

Please come by our table and say hello. We could use the company.■

*Sargassum* ➔ Two hurricanes in 2014, Marie in August and Odile in September, may have also deterred the growth of native kelp. While Marks was hesitant to comment on the role of those particular hurricanes, she suggested that any loss of native kelp would facilitate the sargassum invasion. "It's well known that invasions do better in more disturbed habitat," she said. "So maybe this former water event has removed what we would think would be primary competitors of sargassum – the larger species of algae like kelp. And that frees up additional resources like space and light for the invasive species."

To investigate whether increased wave disturbance facilitates the invasion of *S. horneri*, Marks has been turning herself into "Hurricane Lindsay"—ripping out the bigger species of algae, and then allowing the invasion to occur in order to see what grows back in its place. She hopes to understand what is excluded, and whether or not sargassum does better in these areas where the natives have been compromised.

For the Super Sucker's next phase of abatement and management, NOAA has handed it to Los Angeles Waterkeeper. Their target is Palos Verdes, specifically Malaga Cove where the sargassum is patchy in distribution (compared to Catalina where it has become ubiquitous in some areas), and the kelp populations are more established. "The idea is that after removals, there'll be enough of the native species to recolonize the space that's been created, create a foothold, and then prevent the invasive algae from becoming abundant there," Marks said. "So hopefully LA Waterkeeper will have more success working in places that are not so heavily invaded."

Though it seems like Catalina has been abandoned, Marks thinks the situation there is neither hopeless nor permanent. "I think the kelp will come back," she said. "It's not un-

Adam Obaza, Hannah Ake, and Katie Nichols at Malaga Cove. Credit: Ian Jacobson

common for there to be a few years of low abundance, especially following major, El Niños, but it's cyclical. I think kelp may have a harder time coming back in areas where sargassum is really dense, but I think it will eventually. In the last year or so I've started seeing new kelp plants growing back here and there."

Los Angeles Waterkeeper launched their Invasive Species Campaign in early 2016, treating invasive species as a form of biological pollution. As the proliferation of *S. horneri* continued, its widespread distribution threatened potential lasting ecological consequences to native habitats. LAW decided to dedicate the resources of their dive program to address the current invasion with the hope of developing practical removal methods, establish a more informed dive community, and aid in the development of recommendations that will address future non-native introductions.

Their pilot study, headed by Dive Program Manager Ian Jacobson, began in September 2016. Five volunteer divers removed more than 100 lb. *S. horneri* in two days in an area next to a healthy kelp forest, which is the reference site. There is one *S. horneri* reference site which is untouched, and two experimental sites, one of which sargassum has been removed once, and another in which sargassum will have been removed a second time by February 2018. The reason for the double removal plot is to find out if regular maintenance is more effective.

Jacobson started seeing new sargassum recruits in late September 2017, but it won't be until May of next year before they have data. Jacobson will be looking at whether the removals reduce density over time. If successful, they will develop a strategy to control and abate the sargassum, as well as protect kelp forests in certain areas. For example, say a small sargassum population is found in a harbor and gets caught in boat hulls or anchors, and is then introduced in a new area. "If we can effectively control both populations in a very coordinated way, then that could be one buffer to potential expansion and potential distribution to novel areas," he said.

Neither Jacobson nor Marks is even thinking about eradication. "Management, control, abatement— those are the terms we're using," Jacobson said. "And it's premature to say how effective any strategy is, because our studies aren't complete yet. Call me next year at this time."

I plan to take him up on his offer, so stay tuned. In the meantime—if you're a certified diver, you can help track the spread of marine invasive species by reporting sightings of *S. horneri* and a new one not discussed here, the edible seaweed *Undaria Pinnatifida*. If you come across either of these species, take a close-up photograph so you can upload your observation to MarineInvasives.org or use the I-Naturalist app. Include the name of the species, its location, how many you saw, the water depth, life stage, and habitat. Make sure you don't remove the invasive algae since it spreads easily. And before you leave the dive site, check your gear and anchor, and remove any hitchhiking seaweed.

MarineInvasives.org has information on both invasive species and a map of all the places where these species have been recorded. iNaturalist is a user-friendly app you can download on your phone and also use on your computer. After you upload your pictures and observations, fellow iNaturalist contributors can verify your species ID and provide ➔ *see weed, pg 18*

## Volunteer for our Depth-Profiling Program

Can you deploy a 7-lb instrument from a boat or kayak? CMS has an active program to measure ocean chemistry around Santa Catalina Island and we could use your help. Contact us for more information.

## Hurricane Irma: Record-Breaking But Not Spirit-Breaking

Lora Johansen

All windows to the apartment are boarded, all doors are closed. The air is stagnant. My roommate Kristen and I sit on my bed, sweating. A single candle is the only light. I read a book and Kristen distracts herself by playing with her kitten. Underneath the wind's incessant, deafening howl, we hear sudden noises: crash, bang, boom! With each explosion we involuntarily imagine the resulting wreckage. Crack! Maybe our massive mango tree just crashed through our neighbor's roof. We sit this way for hours, listening to the destruction of hurricane Irma. There is nothing else to do.

On September 8th, 2017, hurricane Irma hit the U.S. Virgin Islands. It was the strongest hurricane in the Atlantic, and the second longest and second largest hurricane in recorded history. The storm sustained record-breaking winds, over 185 miles per hour, causing destruction of many Caribbean islands. On St. Thomas, downed trees and utility lines covered the roads or leaned at dangerous angles, creating an impenetrable spider web of debris. The lush, green vegetation that once covered the islands was stripped, leaving it naked and brown –a difference that was even evident from satellite photos. Thousands of buildings were destroyed; few evaded damage. Many residents experienced blown out windows, water and debris-covered floors and trees crashing through walls. Others were lucky to escape with their lives as their roof and walls were torn clean off. Appliances, furniture, and belongings were ripped out by the storm until nothing but the foundation remained. Kurt Vincent, a resident of St. Thomas for 7 years, fell victim to this scenario. He described how he and his two roommates huddled between a door and a mattress, the only structure available, while they waited for a break in the storm to run to safety. "We just kept saying it's going to be okay, were going to be okay". Luckily, he and his roommates made it to safety by jumping through a blown-out window of a neighbor's house. The next day, Kurt walked around the neighborhood, stocking his backpack with what few of his belongings he could find.


Lora Johansen. Lora has a permit to work with endangered turtles.

Vincent wasn't the only one out on the streets the morning after Irma. Many community members took to the post-apocalyptic streets the morning after Irma and went immediately to work clearing debris by hand, chopping trees and utility poles with chainsaws, securing sandbags and tarps, helping people trapped or in need of medical attention, even cutting power lines to make the road accessible. Soon, community efforts became more than just homeowners clearing the streets and patching up houses. My Brother's Workshop Café, a local non-profit, prepared and distributed over 30,000 free meals since hurricane Irma. Other local organizations like 340 Boxing Federation and the Family Resource Center acquired and distributed trailers full of relief supplies. National relief organizations like American Red Cross, Salvation Army, Americorp, and United Way also came to the rescue. However, the most unexpected help came from the private sector. Donors sent private jets down with supplies, flew out evacuees, and more. Imani Daniel, CEO of Virgin Islands Relief Logistics, says that "allies in the

states are really what keep the islands going".

The University of the Virgin Islands' Center for Marine and Environmental Science building was destroyed.

Despite relief efforts and the resiliency of the islanders, it may still be a long road to recovery. The islands still rely heavily on these relief efforts. St. Thomas is currently at about one third of its capacity for electricity. All three U.S. Virgin Islands are still without a fully-functional hospital. Some hotels are rumored to be closed until 2019, which could be a death sentence in the islands' tourism-driven economy. Although the future looks difficult for the VI, some of the other Caribbean islands are in a much worse state. Barbuda suffered so much damage that it was deemed "uninhabitable" and over a thousand people were evacuated to Antigua, a nearby island with less damage. Unfortunately, Irma was not the only Category 5 hurricane this year. Record breaking hurricanes have become the new normal. Less than two weeks after Irma, Category 5 hurricane, Maria, hit the Caribbean, destroyed the few islands that remained functional and broke records by dumping 24–36 inches of rain on Puerto Rico in one day. Less than one year before "Irmaria", as they are collectively referred to by the locals, Matthew destroyed parts of the Antilles and the continental U.S., breaking records as the the lowest latitude Atlantic Category 5 hurricane, and helping three U.S. cities break storm tide records. Although some people may write off these record-breaking storms as a coincidence, peer-reviewed scientific articles dating back to the early 2000s show that Categories 4-5 hurricanes have increased in both number and proportion over the last few decades. **Several articles predicted this trend to continue, if not increase, due to global climate change.** In 2006, the

➔*see Irma pg 18.*


After 94 days without power on St. Thomas, residents plead the Water and Power Association (WAPA, as the locals know it) to restore power to their homes so they can at least have running water. Signs like this, usually made from hurricane debris, are a common sight on the island's main road.

## A Kelp Forest inside a Science Center

Jennifer Lawrence and Chuck Kopczak, PhD

Just two Metro stops from downtown Los Angeles, the California Science Center hosts more than 2.4 million guests a year. One of its most popular exhibition galleries, *Ecosystems*, immerses guests in environments that house almost 250 species of plants and animals side-by-side with hands-on interactive exhibits. This innovative learning environment effectively conveys the principles of ecology and creates more responsible stewards of the environment through scientific understanding. *Ecosystems* is a logical extension of the California Science Center's *World of Life* gallery that opened in 1998. Where *World of Life* focuses on the processes necessary to sustain individual organisms, *Ecosystems* explores the relationships between individual organisms, species, and their environment—and how those relationships shape the world.

When developing the concepts for *Ecosystems*, the most important criterion that influenced its final form was the revelation that live animals, interactive exhibits and immersive environments could be successfully combined in the same exhibit spaces. Curator of Life Sciences Chuck Kopczak recalls, "Early in the development process, the designers had concerns that the live animals would be such a draw that guests would run right past the interactive exhibits to get to the animals." But working through


Jennifer Lawrence
Credit: Andrew Solomon

Chuck Kopczak

the process with exhibit designers, architects, living collections specialists and internal staff, and then evaluating the plan in focus groups and through other formative evaluation methods helped staff at the California Science Center determine that the shared-space approach would be workable and successful. By incorporating the best ideas and concepts from all three types of exhibits, *Ecosystems* presents the science of ecology in a new and meaningful way.

The **Kelp Forest** gallery within *Ecosystems* is the heart of the whole exhibition, introducing guests to a local ecosystem that most of them have never been able to visit firsthand in the wild. By giving guests the opportunity to experience a kelp forest up close and in person right inside the Science Center—which offers FREE general admission — Science Center staff hope to nurture an appreciation of—and a desire to conserve—these complex, diverse ecosystems right off the Southern California coast.

The main message of the Kelp Forest gallery is that ecosystems help create and maintain species diversity. The Kelp Forest's main 188,000-gallon, walk-through aquarium showcases biodiversity by serving as home to over 1,000 marine organisms, including two giant sea bass, two shark species, Garibaldi, moray eels, a sparkling school of sardines and many more fascinating creatures from just off the coast of Los Angeles. Twice-daily dive shows give guests the chance to interact with a diver in the tank, who calls their attention to some of the wonders found in-

side, much to the delight of the audience.

Guests gather in the tunnel through the Kelp Forest main aquarium. © 2017 Pete Eckert.

Often a diver will call out a nest of eggs being guarded by a parent fish, as several species have successfully reproduced in the tank. Senior Aquarist Cora Webber remarks, "One of the things I am proudest of is that our Kelp Forest is one of the most diverse mixed-species exhibits around. We have more species of fish and growing algae than many aquariums in the country—species found in the wild from two feet to 100 feet deep, all thriving together in our tank. In the next few years, we'll be working on some exciting new projects in aquatic research." Fish species including garibaldi have laid eggs, several rockfish species have spawned, and some perch species have given live birth. In fact, staff modified the sex ratio of perch in the tank to slow down the fishes' reproduction. In addition, green, red and brown algae species like *Macrocystis pyrifera* and *Egregia menziesii* have released spores, settled, and begun to grow.

On occasion, Science Center guests observe staff taking measurements and placing *Macrocystis pyrifera* from the ocean into the tank, as the California Science Center works to be the first aquarium not directly connected to the ocean to successfully grow and display live giant kelp. To make the aquarium hospitable to giant kelp, it's designed to provide all the elements that growing kelp need to stay healthy—sunlight, wave motion, and chilly, nutrient-rich water. The aquarium is open to the sky at the top, which helps provide much of the sunlight that kelp needs, but the area above the tank also features large sun-tracking mirrors called heliostats to direct sunlight toward the kelp as needed. A surge generator provides the wave motion necessary for healthy kelp growth. As an added bonus, the surge generator makes the aquarium display

A CSC dive show presenter flashes a thumbs-up to guests. Photo by Leroy Hamilton.

Curator Chuck Kopczak introduces guests to a sea star in the Curator's Lab. © 2017 Pete Eckert

more lively for guests, as the kelp sways with the waves and, on the top deck, the water rises and falls several feet in guests' view. To ensure water quality, a full life-support systems staff and a well-equipped water laboratory staff work in concert, conducting daily water quality checks and analyses to maintain a proper environment for all the tank's marine life, including kelp.

Guests to the Kelp Forest also explore the diversity of kelp forest animals up close in a special section of smaller aquariums. One of the kelp forest diversity tanks recently hosted red abalone farmed by the California Department of Fish and Wildlife (CDFW) as part of a project to conserve and protect abalone off the California coast. Guests can also find out about the kelp forest food web through a collection of aquariums that shows animals, plants and algae as interconnected sources and consumers of food. For example, one tank gives guests the opportunity to view Kellet's whelks scavenging with their proboscises, and another features a wide variety of sea plants and algae that convert sunlight into sugars, which are then available for consumption by other members in the food web. The Kelp Forest gallery also contains the Curator's Lab, where species such as brine shrimp and rotifers are grown as food for the animals. Staff members also conduct scientific studies in the lab to help advance the field. One such study is an upcoming project with USC in which Science Center staff and scientists will work to optimize growing kelp in a laboratory environment. The results of the study will hopefully help scientists at USC advance the development of kelp as a biofuel. And on the top deck of the aquarium in an exhibition area called the Rocky Shore, guests can learn about how animals adapt to the harsh environments of the intertidal area, where settlers like barnacles and sea stars get beaten by waves, soaked in water, and baked in the sun. The Rocky Shore area features a touch tank for meet-and-greets with intertidal animals like anemones, urchins, sea cucumbers, limpets, snails, and more.

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or google Amazon Smile. Tell other CMS supporters.

Handling the care of the Kelp Forest gallery and the species within it requires a small army of aquarists and divers. The Science Center currently has 57 divers on board, and 47 of them are volunteers. The volunteer dive team handles much of the daily maintenance of the Kelp Forest, including feeding the animals, and conducts some of our most fascinating public demonstrations. The dive team also plays a huge role in helping to ensure the animals' health. Because divers are most closely and consistently in contact with the animals in the tank, the divers can observe the animals' normal behavior and report anomalies or injuries to husbandry staff.

Chris Liebl, a high-time diver with over 700 dives around the world, has volunteered at the Science Center for over five years, and he has this to say about his experience here. "I dove all over the world, but this gives me my fix. I get to dive every week, and I feel like I'm doing something good. When I see the kids come in, it's something special. One child in a wheelchair who had no control of his muscles was looking straight up. As he sat in the tunnel, I swam over him—into his line of sight—and he started waving non-stop! That's why I come here… I love it." He finds his animal care duties exciting, too. "I got to be shark wrangler this morning to back up the vet. I learn so much here! I never know what I'm going to get to do. This is a great gig."

All dive volunteers at the Science Center receive several types of training: hazmat, fill station, fish identification, animal feeding, and tank cleaning and care. Full facemask training, a prerequisite to becoming a dive show presenter, is also offered at the Science

## *Ecosystems*: Mission and Math

*Ecosystems* was designed to strengthen the Science Center's ability to serve all members of the community with science learning experiences and programs not available anywhere else in the region or state. The addition of *Ecosystems* has also successfully brought about the following significant impacts on the Science Center's mission and services:

- Completes a vital piece of the Science Center's 25-year Master Plan by creating a learning experience that presents an ecosystems view of earth
- Approximately doubles the Science Center's permanent exhibit gallery and program space, enabling us to serve up to two million visitors per year, including over 370,000 school children and youth groups
- Provides increased employment and volunteer opportunities for community residents and others
- Expands education and conservation programmatic capacities, particularly in the area of ecological science learning for students, families and educators
- Adds 250 new species to their living collections
- Helps guests understand the concept/definition of an ecosystem
- Introduces guests to real ecosystems, especially to the locally prominent and globally rare ecosystem, the kelp forest
- Informs guests about the diversity of life on Earth, and encourage environmental stewardship
- Inspires science learning in accordance with the Science Center mission statement.

Center. All divers with an interest are encouraged to become dive show presenters. Once a year, the Science Center offers a scientific diver training course to active dive team members who are qualified candidates. After successfully completing the course, divers travel out into the Pacific to conduct collection dives for invertebrates, algae, and fish for the Kelp Forest. They can also help with an important part of the Science Center mission—conservation. The Science Center partners with Reef Check California, a nonprofit organization that utilizes volunteers to conduct citizen science surveys in California's rocky reef ecosystems. As part of the project, Science Center scientific divers conduct annual surveys of local dive sites off the coast of Los Angeles. The goal of these surveys is to provide data for marine resource managers and to build a conservation constituency among California divers. The California Science Center has also partnered with Catalina Marine Society's Thermograph Array Project. Scientific divers help with the management of three local sites by retrieving and replacing the sensors at each site twice a year. The thermograph data is used to describe large temperature variations, including seasonal warming and internal tidal waves. In short, the California Science Center is committed to making a difference by inspiring science learning, and also by encouraging and participating in conservation efforts outside their walls. If you'd like to learn more about what the Science Center is doing, please visit their website at www.californiasciencecenter.org. Or even better, visit *Ecosystems*! If you're interested, consider joining their team as a volunteer diver—they can always use more hands. And fins! ■

**Upcoming Events**

Diver Day, March 10, 2018

AoP Citizen Science Symposium, March 24, 2018

SCUBA Show, June 23-24, 2018

*Jennifer Lawrence is Senior Exhibit Developer for the California Science Center and Chuck Kopczak is Curator of Life Sciences there. Other staff also contributed to this article.*

*Weed* ➔ useful feedback. LA Waterkeeper has trained 30 LAW divers how to identify sargassum, report it using iNaturalist, and conduct monitoring surveys for the Pilot Project. And rather than give your GPS location, you can just drop a pin on a map.

Also, LA Waterkeeper has been giving presentations to local clubs since 2016 so contact them if you're interested.

As Marks said, "It's a slow process, we're building momentum, we're moving in the right direction." So get involved and help the effort to weed this seaweed.■

*Mary Ann is a regular contributor to* ***OceanBights****.*

*Irma* ➔ National Oceanic and Atmospheric Administration (NOAA) said that "the strongest hurricanes in the present climate may be upstaged by even more intense hurricanes over the next century as the earth's climate is warmed by increasing levels of greenhouse gases in the atmosphere". By trapping extra heat into the earth's atmosphere, increasing greenhouse gases indirectly cause ocean warming and high levels of ocean evaporation, fuel for hurricanes.

Unfortunately, Caribbean residents who witness these record-breaking hurricanes see this effect first-hand. "There are quite a few deniers of climate change here [in the Virgin Islands]" Daniel says, "but it's become much harder to deny after the experiences we just had". Even though Irmaria broke records, property, and infrastructure, it did not break the spirit of the Virgin Islanders. The immediate and overwhelming response from the community has been one of support, passion, and hope. Social network sites, articles, and websites on the hurricanes feature the tag #VIStrong and

when locals speak of the future, the message is clear and unified: We will recover and we will emerge stronger than ever before.■

*Lora Johansen is a second-year graduate student at the University of the Virgin Islands, St. Thomas, studying the movements of juvenile hawksbill sea turtles under Dr. Paul Jobsis. She relocated to California after hurricane Irma to finish her thesis remotely. After her master's degree is complete, Lora hopes to find a job in research, animal husbandry, or animal rehabilitation.*

## Santa Ana Winds

We have all been impacted somewhat by the recent wild fires driven by Santa Ana winds. Besides the terrible loss of lives and homes, those of us out of harm's way are reminded of the tragedy via the fast winds, ash in the air, disrupted traffic, missed appointments etc. But what are the effects of these large winds on the local ocean? Actually, learning more about the effects of Santa Ana winds is one of the goals of the David Tsao Continental Thermograph Array.

**There has been conjecture and some supporting evidence that Santa Ana winds contribute to the delivery of nutrients** to the local ocean. They blow out to sea the surface water and that is replaced by deeper, nutrient-rich water. The California Science Center has a neat interactive exhibit that shows this process in a small tank. And, we all know that the ocean next to the mainland becomes calmer and colder when Santa Ana's are blowing. Indeed, the winds make for excellent beach diving with great visibility and easy entry and exit, with the only downside being the added chill. (Not for the normal leeside of Santa Catalina, though, where the Santa Ana winds generate dangerous onshore surf). Satellite observations performed by the Jet Propulsion Laboratory for a case study have found upwelling and a phytoplankton bloom corresponding to a Santa Ana event. Santa Anas typically occur when the ocean is nutrient poor, making this delivery of nutrients particularly important.

With our thermograph array in place, we hope to catch Santa Ana winds in action, measuring the temperature change occurring at the times of the events and inferring how much deep water is brought to the surface.

If the inferred nutrient transport is large enough, we would look for a phytoplankton bloom using satellite data as described elsewhere in this issue. To my knowledge, there is no anecdotal evidence from either divers or fishermen that these blooms are associated with Santa Ana winds.■

**Student researchers wanted!**

Want to distinguish yourself for job and school applications and learn useful skills? Consider engaging in a research project for CMS. We can tailor a project to meet your schedule and abilities.

*Chlorophyll* ➔description of temperate seas, while chlorophyll is generated around San Nicolas year round. Understanding why the two islands exhibit such disparate behavior may provide a key to better understanding oceans in general, and particularly our own local ocean, the Southern California Bight.■

**Upcoming Meetings**

2018 Ocean Sciences Meeting, 11-16 February, Portland, Oregon.

Southern California Academy of Sciences, May 4, 2018, Cal Poly, Pomona.

Ocean Optics XXIV, October 7-12, 2018, Dubrovnik, Croatia

# 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