

Summary of Three Years of Accomplishments (2013-2015) for The Research Vessels *Fulmar* and *R4107* in Cordell Bank, Greater Farallones, and Monterey Bay National Marine Sanctuaries



NOAA R/V *Fulmar* anchored off the coast of Big Sur. Photo credit: Chad King, MBNMS.

NOAA's Office of National Marine Sanctuaries (ONMS) operates a fleet of small boats to support mission-critical programs in sanctuaries. The research vessels *Fulmar* and *R4107* are based in Monterey, California and are operated by the West Coast Region Office in support of Cordell Bank (CBNMS), Greater Farallones (GFNMS) and Monterey Bay (MBNMS) National Marine Sanctuaries. These two vessels serve as platforms for research, resource protection, and education and outreach missions in the area encompassed by the three central and northern California national marine sanctuaries (NMS) which covers more than 10,000 square miles. Between 2013 and 2015 the vessels spent close to 300 days at sea and successfully completed over 100 missions.

***Fulmar* and *R4107* Summary – 2013-2015**

- Support area: 10,675 square miles
- Projects supported: 51
- Missions completed: 101
- Days at sea: 297
- Research participants: 1,586
- Education and outreach participants: 341
- Number of SCUBA dives: 228
- Combined SCUBA diver bottom time: 186 hours



NOAA R/V *R4107* in Monterey Harbor. Photo credit: B. Begun, NOAA.

The three national marine sanctuaries of northern and central California are some of our nation's most spectacular marine protected areas and offer some of the best marine wildlife viewing in the world and because of this they have been dubbed the "Serengeti of the Sea". Focused along the California coastline from Pt. Arena to Cambria, the sanctuaries includes pristine shorelines, lush kelp forests, steep canyons, offshore islands, banks and seamounts, all teeming with life —from microscopic plankton to giant blue whales.

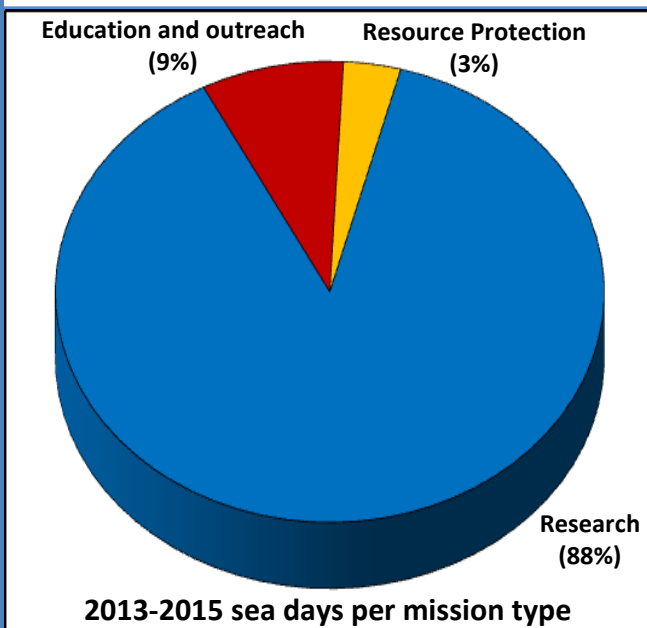
The history of California's central coast is predominantly a maritime one and hundreds of shipwrecks lie on the seafloor. It is part of the mandate of the sanctuary system to inventory and research these archaeological sites, and provide public education about them.

The *Fulmar* and *R4107* are specially designed and equipped to complete projects that fulfill the Office of National Marine Sanctuaries mission. The vessels support a wide variety of missions and provide access to offshore sites and extensive stretches of the coastline that cannot be reached by land. Resources protection and management are at the core



The three National Marine Sanctuaries of Central and Northern California are biological hot spots and have a rich maritime heritage.

of the projects supported by the vessels. During this three-year period, the majority (88%) of sea days aboard the *Fulmar* and *R4107* were dedicated to research missions. Most of the research projects were designed to provide data needed for resource managers to make informed management decisions. Each of the central California sanctuaries maintains site specific research projects that contribute to long-term monitoring data sets to meet management plan needs. Details about the research designs, methods, and results of the projects can be found on the Sanctuary Integrated Monitoring Network (SIMoN) website www.sanctuarysimon.org. While only 10% of the sea days were allocated to education and outreach missions, students, teachers and volunteers had opportunities to participate in most of the research projects at sea, and were also involved in data analysis.



RESEARCH HIGHLIGHTS

Applied California Current Ecosystem Studies

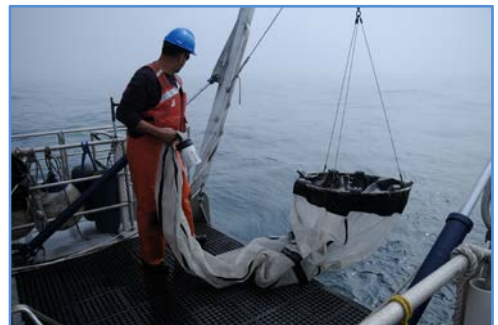
One of the most consistent, long term users of the *Fulmar* is the Applied California Current Ecosystem Studies (ACCESS), a partnership with CBNMS, GFNMS and Point Blue Conservation Science. Each year, the ACCESS team conducted three multi-day surveys to document how temporal changes in oceanographic conditions, including ocean acidification, impact marine mammal and seabird abundance and spatial distribution in the three central California national marine sanctuaries. The *Fulmar* ran predetermined, repeated transect lines along the continental shelf, conducting seabird and marine mammal surveys while the vessel's EK60 echosounder scanned for krill and other prey items in the water column. Additionally, net tows and CTDs casts were conducted at established stations to sample plankton and record oceanographic data. In 2013, ACCESS scientists tested the Whale Spotter App to log the location and species of whales in the region as part of a greater effort to reduce the threat of ships colliding with whales. In 2015, additional survey lines were established in the newly expanded area of Greater Farallones and Cordell Bank NMS. Exceptionally warm seasonal sea surface water temperatures were recorded in 2014 and 2015, the highest since the 1992 El Niño at the Farallon Islands and the highest on record this fall for the northeastern Pacific.

Oceanographic Monitoring in Monterey Bay National Marine Sanctuary

Scientists from the Monterey Bay Aquarium Research Institute (MBARI) continued to use the *Fulmar* to deploy a CTD and a rosette of water sampling bottles to collect data to support the Monterey Bay Time Series (MBTS), a long running project in its 26th year that studies the effects of natural and man-induced climate change upon ocean ecology. The data collected by this project has been instrumental in understanding the complicated and interrelated relationship between climate change, both natural and man-made, and also upon cyclical ocean conditions that can vary from year to year and from time period to time period. Since 2014, Monterey Bay has been impacted by very warm water starting with an unusually warm water mass in the northeastern Pacific water (the Blob) and El Niño in 2015.



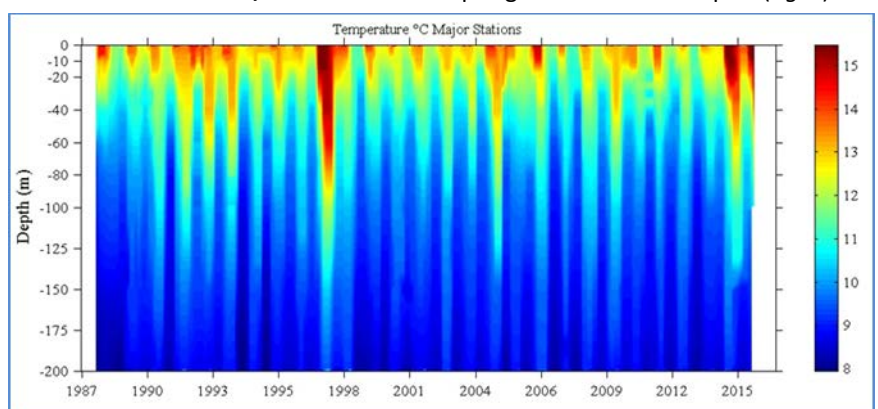
Pacific White-sided Dolphin breaching off the *Fulmar* during an ACCESS survey.



ACCESS scientist preparing to deploy a tucker trawl off the the *Fulmar*.



Krill dominated trawl samples (*left*) in Fall 2015 while large amount of gelatinous zooplankton occurred in 2014 and the 2015 Spring and Summer samples (*right*).



Sea Temperatures generated from the 26 years of data collected by the MBTS project. Temperature variations are dominated by the seasonal cycle.

Researchers from Scripps Institution of Oceanography's Coastal Data Information Program (CDIP) used the *Fulmar* to deploy and maintain wave buoys in 2013 and 2014. CDIP, an extensive network for monitoring waves and beaches along the coastlines of the United States, currently operates four buoys in the Monterey area. The buoys record and disseminate wave movement and sea surface temperature data for archiving and real time weather reports. The data has many uses such as coastal erosion surveys, sand movement, and real time weather data broadcast to the National Data Buoy Center and National Weather Service offices for maritime safety. Since its inception in 1975, CDIP has produced a vast database of publicly-accessible environmental data for use by coastal engineers and planners, scientists, mariners, and marine enthusiasts. The *Fulmar* platform is especially useful for conducting CDIP mooring maintenance because the onboard crane, large deck, and twin hull design allow for stable and safe deployment and recoveries of buoys.



The *Fulmar* recovered this CDIP wave buoy off Point Sur for maintenance. Algae and barnacle colonized the buoy. Photo credit: CDIP.

Recording Dissolved Oxygen and Sound in Cordell Bank National Marine Sanctuary



Scientists prepare to deploy an acoustic buoy while *Fulmar* crew work the crane. Photo credit: Christopher Chung, The Press Democrat.

CBNMS researchers deployed and recovered scientific moorings from the *Fulmar* between 2013 and 2015. They deployed a mooring to measure dissolved oxygen and recorded hypoxia associated with upwelling events in 2014, and a Noise Reference Station (NRS) acoustic buoy in the sanctuary to record the underwater ambient soundscape in 2015. The project is a partnership with NOAA's Pacific Marine Environmental Lab (PMEL) and adds a node to NOAA's NRS Network. The data will allow CBNMS to characterize the local soundscape, understand how ambient sound varies over time in CBNMS, and analyze how it

compares to other reference sites. CBNMS is a feeding ground for endangered whales and is near the northern San Francisco shipping lanes used by more than 1,500 large cargo ships and tankers yearly on their way to and from San Francisco Bay. Characterizing the ambient soundscape is a first step towards understanding the impact that sound has on sanctuary resources.

Tracking Top Predators in the Marine Sanctuaries

The *Fulmar* crew assisted in the recovery of a NOAA Fisheries acoustic mooring off Sea Ranch (GFNMS) that was part of an array of hydrophones that monitor the endangered southern resident killer whale population. Meanwhile, white shark researchers used the *Fulmar* to deploy and recover acoustic moorings off Año Nuevo, Tomales Bay and the Farallon Islands to track shark movements throughout central California in real-time. Two white sharks were recorded off Año Nuevo within 20 minutes of the buoy being deployed in the water. These moorings provide information critical to our understanding of the arrival of white sharks and departure into the sanctuaries as well as their residency times. Additionally, the data these units transmit are used in a number of outreach avenues, including the app SHARKNET. Therefore, servicing of the real-time receivers supported by the *Fulmar* not only advances the science of these sentinel species, but also the relationship of the public to our Sanctuary ecosystems.



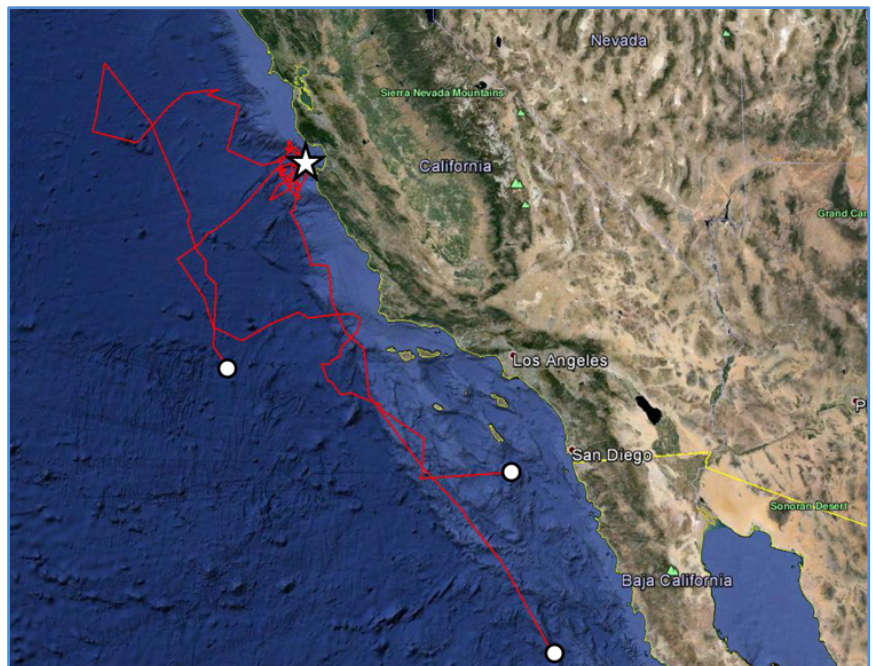
Killer whales are top predators that roam through West Coast NMS. Photo credit: Chad King, MBNMS.



Above: WCR staff assisting Stanford scientists tagging a blue shark.
Photo credit: Bryan Begun, NOAA.

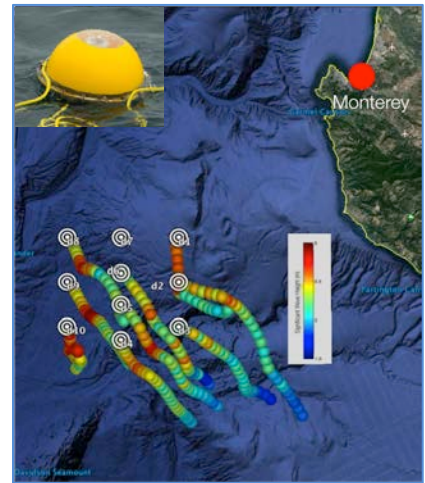
Right: Six-week tracks of three blue sharks tagged off Monterey (white star) in Fall 2015 with one shark moving as far as approximately 1,000 km to Baja California, Mexico.
Courtesy of Stanford University.

The *R4107* proved to be an ideal platform in the Fall of 2015 to tag pelagic sharks off Monterey. Researchers from Stanford University's Hopkins Marine Station, with help from *R4107* crewmembers, tagged six blue sharks with satellite tags to better understand the role that national marine sanctuaries off California play in the ecology and life history of these important apex predators while also elucidating the role that these predators play in local marine ecosystems.



Sanctuaries contribute to global Survey of Ocean Surface Water.

An array of small drifters to measure surface waves and currents were deployed and recovered from the *Fulmar* in April 2015 as part of the instrument calibration and validation of the Surface Water and Ocean Topography mission (AirSWOT). AirSWOT is an international effort led by NASA's Jet Propulsion Laboratory to be the first global survey of Earth's surface water, observe the fine details of the ocean's surface topography, and measure how water bodies change over time. The drifter data provide valuable information on surface currents and drifter dispersion, and serves as a ground truth for remote sensing observations and calibration for regional circulation models. The *Fulmar* was the ideal vessel for this operation due to its homeport near the field site, its size, and its ability to sustain high cruising speeds, which greatly reduced the time needed to complete the operations.



Drop sites (black-white) and hourly positions (colored by wave height) for the AirSWOT drifters.

Wave Gliders and Other Autonomous Vehicles Sample Monterey Bay National Marine Sanctuary



California sea lion on a Wave Glider.

The *Fulmar* has been an excellent platform for conducting launch and recovery operations for Liquid Robotics, Inc. (LRI) Wave Gliders, including training, sea trials of the Wave Glider SV3, and supporting a variety of data collection missions in Monterey Bay. Wave Gliders use wave energy for propulsion, and solar energy to charge on-board batteries for powering a variety of meteorological and oceanographic sensors. This has allowed a variety of sensors to be rapidly tested and observed, and for reporting software to be refined in comparison to oceanographic buoys in Monterey Bay. In 2013-2014, this included wave height sensors, acoustic Doppler current profilers, weather stations, and water speed sensors. High resolution cameras bound for the Arctic and a comparison of hydrocarbon detecting fluorometers were also tested. Towed sensors tested from the *Fulmar* included mini-magnetometers for detecting magnetic variance, which can be used for marine archaeology, wreck detection, and geophysical surveys. Another towed sensor, for Maritime Domain Awareness, used the *Fulmar* as a real-time acoustic source. This Wave Glider system could provide low cost surveillance of remote marine protected areas in the future.

The *Fulmar's* seaworthiness, speed, operational range, and ability to mobilize quickly with little notice were essential in recovering a Wave Glider that malfunctioned and headed offshore in December 2015. Taking advantage of a small weather window the *Fulmar* crew and LRI engineer steamed 108 nautical miles off Monterey for this critical rescue mission.

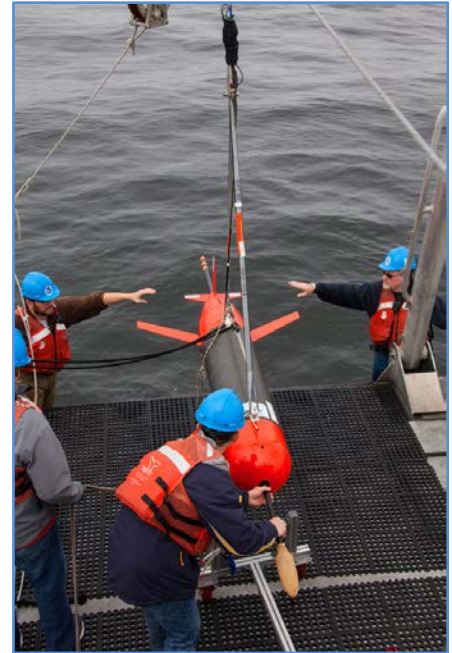


LRI Engineers practicing Wave Glider deployment with the *Fulmar* crew.

Partnership with Monterey's Naval Postgraduate School

A strong partner and user of the *Fulmar* and *R4107* is the Monterey based Naval Postgraduate School (NPS). NPS researchers, professors and graduate students completed 28 missions (53 days at sea) on the *Fulmar* and *R4107* between 2013 and 2015. These missions supported research projects for a variety of oceanography classes and the development and testing of equipment. NPS researchers used a variety of automated underwater vehicles to study environmental effects on sound propagation underwater including developing techniques to monitor marine mammals.

The *Fulmar* was used to develop performance curves of towed submersibles needed to support thesis works on non-traditional detection methods and an array of buoys to establish an at-sea wireless network. These performance curves were critical for controlling the depth of the submersible tow-body in later experiments, providing essential data in support of the students' hypotheses. The NPS nearshore and wave processes class used the *Fulmar* and *R4107* to deploy and recover drifter buoys that collected wave and current data at various nearshore locations in Monterey Bay.



NPS researchers initiating deployment of a littoral gliders.

In 2013, NPS scientists deployed underwater gliders from the *Fulmar* to record in-situ environmental and acoustic data to track sound generating targets, such as marine craft and marine mammals (e.g. whale calls) in the Monterey Bay area. In 2014, they deployed multiple gliders simultaneously to triangulate the sound source location. In 2015, they successfully tested acoustic communications, networking hardware and software integrated in the glider for near-real-time environmental data extraction via the *Fulmar* and Wave Gliders. NPS also compared sensors they developed for the Wave Glider to collect near surface meteorological and oceanographic data with a traditional Marine-Air-Sea-Flux System buoy. In February 2015, the *Fulmar* was used as an acoustic platform to transmit low-level acoustic signals that validated model predictions of transmission loss to a mobile deep receiver in a California coastal environment.



NPS graduate students conducting CTD casts from the *Fulmar*.

In July 2015, the *Fulmar* was used to test new sensors developed to conduct real-time passive acoustic monitoring of marine mammals using a REMUS-600 autonomous underwater vehicle (AUV). This 10-day experiment was successfully completed in a variety of weather conditions with the expert support of the *Fulmar* crew to launch and recover the AUV each day and assist in identifying locations of marine mammals of interest. Data were used for numerous class projects in Tactical Oceanography.

In October 2015, the *Fulmar* supported the NPS Descriptive Oceanography course field studies. Students were able to learn about oceanographic sensing in different environments. Using a variety of sensors deployed from the *Fulmar*, deep water and shallow water CTD profiles were recorded and the students were able to launch and recover a Slocum glider.

Deepwater Exploration in West Coast National Marine Sanctuaries

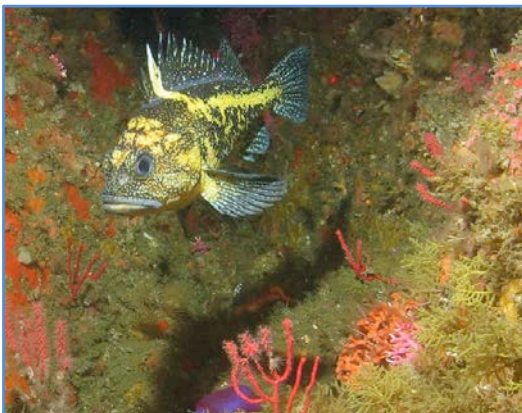
Remotely Operated Vehicles (ROVs) and a variety of underwater video camera systems are valuable tools to explore, characterize and monitor deep seafloor habitats, communities and shipwrecks that cannot be reached by SCUBA divers. The *Fulmar* is an effective platform of choice to support small to mid-size ROV operations, including the Sanctuary-owned Phantom ROV. The *Fulmar's* spacious back deck and laboratory areas can accommodate the equipment and personnel necessary to operate an ROV. Its low clearance, A-Frame, cable winch and crane are well suited to deploy and recover gear safely. The *Fulmar's* sophisticated navigation systems, ability to maintain positions and follow track lines at low speed are essential for successful ROV operations.



The Phantom ROV on board the *Fulmar* off the Farallon Islands.

Photo credit: Bob Schwemmer, ONMS.

Deepwater Characterization in Monterey Bay National Marine Sanctuary



The Institute for Applied Marine Ecology at California State University Monterey Bay conducted the seventh year of sampling deepwater habitats within MBNMS in July of 2013. This cruise specifically targeted some of the Sanctuary's Ecologically Significant Areas in order to better understand the communities within this new designation. During the eight-day cruise, the *Fulmar* surveyed five areas using the ROV *Beagle* and recorded 31 hours of video and 5,284 still photos at depths ranging from 14m to 533m. A total of 27,934 individual fish were counted and, when possible, identified to one of 43 different species observed. Video imagery analysis is currently being conducted on selected invertebrates and habitats observed during the cruise.

Cordell Bank Benthic Surveys Completed

CBNMS led a successful research mission on the *Fulmar* using the Sanctuary-owned Phantom ROV in August 2014. The team surveyed the invertebrate community on the shallowest parts of the bank. In seven days of field operations, the team completed 17 transects, collected over 2,000 still images, and nearly 20 hours of video. The data collected is used to characterize the sanctuary and provide information for monitoring. CBNMS plans to continue ROV operations on Cordell Bank in 2016.

China rockfish hovering over red gorgonian coral (*top*), wolf-eel in a brachiopod field (*middle*), and Yellow-eye rockfish hovering over crinoids (*bottom*). Photo credit: MBNMS/CSUMB/MARE.

Surveying the Expansion Area

During September 2014, a second survey was conducted with the Phantom ROV on the then-proposed expansion areas of CBNMS and GFNMS, characterizing areas near Bodega Canyon and an area to the north of the canyon named “The Football”. Sanctuary researchers teamed with scientists from NOAA’s National Centers for Coastal Ocean Science, United States Geological Survey, and California Academy of Sciences to explore features up to 300 meters depth. The team completed 20 transects in each of the target areas over six days of ROV dives. Highlights included records of hundreds of skate egg cases on the sea floor and in bundles on the rocks surrounding a catshark nursery area. The team also discovered a new species of deep-sea coral from the *Leptogorgia* genus at approximately 600 feet deep. The deliverable will be a site characterization report due 2016, including maps, observations, images, and counts of animals at these sites. In addition, a wealth of still images and high definition video for use in education and outreach was captured.

Testing a new tool to study the seafloor

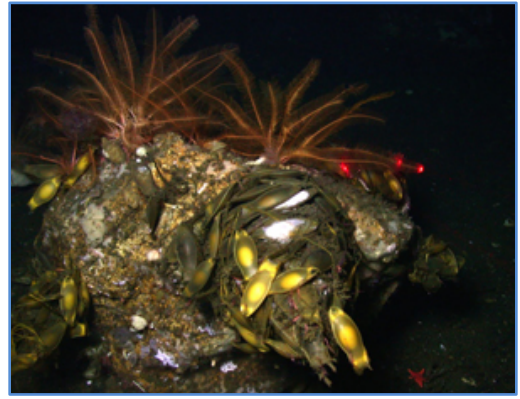
Scientists from the NOAA’s Northwest Fisheries Science Center and Office of Science and Technology successfully tested a Lagrangian camera float from the *Fulmar* to assess fish and invertebrate abundance and distribution in CBNMS. The float consisted of a drifting bottom-following high definition camera that maintained a specified altitude above the seafloor. The float was equipped with a tracking beacon enabling scientists aboard the *Fulmar* to geo-reference the recorded imagery. The float collected a series of images on Cordell Bank that can be used to assess invertebrate and fish abundance.



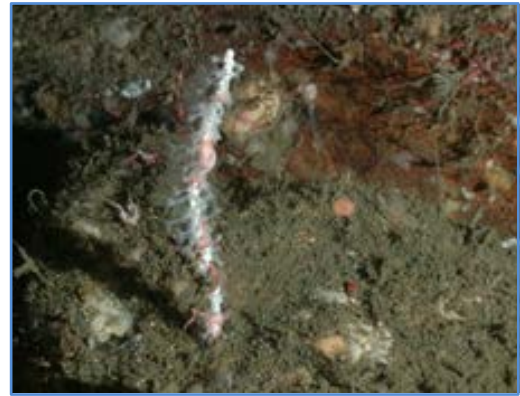
The BATFish on the Deck of the R4107.

BATFish Testing

Engineers from Marine Applied Research & Exploration (MARE) tested their BATFish, a hydro-dynamic tow-sled. Sea-trials were conducted from the *R4107* outside Monterey harbor to evaluate its bottom following capability. When it is possible to use the *R4107* instead of the *Fulmar*, significant cost savings are possible due to the *R4107*'s lower operating cost. Due to the small size and weight of the BATFish, and quick mobilization aboard, most of the time was spent underwater performing the actual sea trials.



Catshark egg nest, with its yellow egg cases.



New species of white coral, found north of Bodega Canyon.



Fish eating anemone.

Surveying the 'Underwater Museum' off GFNMS and the Golden Gate in San Francisco

The sanctuary maritime heritage program with the assistance of CBNMS, GFNMS, the West Coast Regional office and other partners led the first archaeological ROV survey of maritime heritage in September 2014 and 2015. The team explored eight sites using the Phantom ROV during the 2014 five-day expedition, discovered four new shipwrecks that included the 380-foot tramp steamer *SS Selja* that was lost in a collision with the *SS Beaver* off Point Reyes in 1910, and a 100-year old tug boat off Southeast Farallon Island dubbed the "mystery wreck."

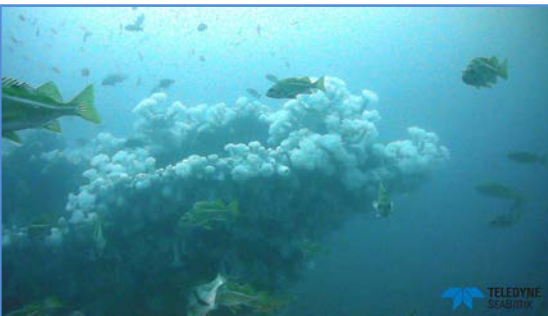


"Mystery tug" bow. Octopus, Canary rockfish and sea anemones inhabit the shipwreck.



Ituna as a luxury steam yacht, circa 1892.

Image credit: Robert Schwemmer, ONMS.



Images of shipwreck's bow provided positive identification of *Ituna*.

Photo Credit: NOAA – Teledyne Seabotix.

The science team also conducted ROV and autonomous underwater vehicle (AUV) surveys on shipwrecks discovered during the 2014 expedition. Teledyne SeaBotix, Inc. provided a pilot to operate the SeaBotix ROV and an AUV to collect high definition video footage, still images and side scan sonar data for analysis during the 2015 expedition.

These surveys provide a foundation for an inventory and enhanced public awareness about the historic resources located in Greater Farallones NMS.

Three additional shipwrecks were discovered during the 2015 eight-day expedition. The major discovery was the steam trawler *Ituna* lost 95 years ago. At 170 feet in length, it was the largest steam trawler fishing out of San Francisco and one of the first to utilize the Otter trawl system in the Pacific. *Ituna* was initially built as a luxury steam yacht in 1886 and was converted to a first-class passenger-cargo steamer before being transformed into a trawler. She sank in 1920 during a storm en route from San Francisco to Oregon. While 12 of its 14 crewmen escaped, two went down with the vessel when it sank in a matter of minutes. The shipwreck was found sitting upright on the seafloor and was easily identified by its iron clipper bow and ecliptic stern rising off the seafloor. Two additional discoveries included a 167 foot fuel barge and a commercial fishing trawler lost in more recent years.



Teledyne SeaBotix engineer deploying an AUV to conduct side scan sonar survey of *Ituna*.

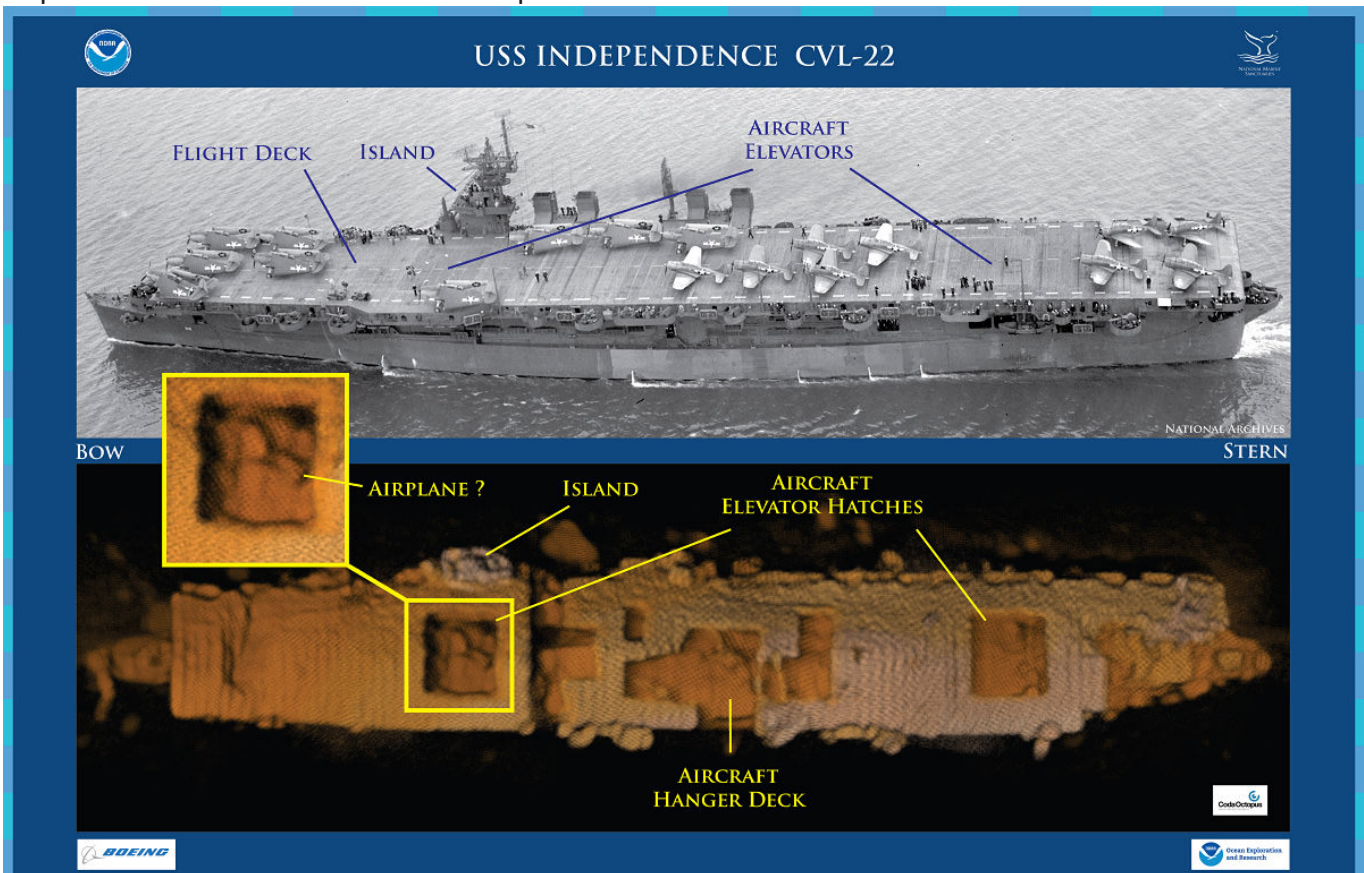
Photo credit: Denise Jaffke, NOAA

Survey of Sunken Aircraft Carrier

Seventy years after its service in World War II, NOAA's ONMS and NOAA's Office of Exploration and Research (OE&R), working with private industry partners, the Boeing Company and Coda Octopus, confirmed the location and condition of the aircraft carrier *USS Independence* in 2,600 feet of water at the northern end of MBNMS. She was the lead ship of her class of light aircraft carriers that were critical during the American naval offensive in the Pacific during WWII, and later one of the more than 90 vessels assembled as a target fleet for Bikini Atoll atomic bomb tests in 1946. After returning to the United States, the blast-damaged carrier was scuttled by the Navy in 1951. In March 2015, the *Fulmar* served as the escort vessel and support platform for the Boeing's AUV *Echo Ranger*, integrated with Coda Octopus' Echoscope 3-D sonar during a three week expedition led by ONMS Maritime Heritage Program. This was a complex mission that required the *Fulmar* to serve as a tow vessel for the 18-foot long, 10,000 pound *Echo Ranger* from port to deployment area, and then serve as support vessel while the *Echo Ranger* conducted its mission. Mechanical failures aboard the *Echo Ranger*, entanglement with crab pot lines, and harsh weather all tested the crew during the three week project, which required continuous 36 hour offshore operations.



The *Fulmar*'s skiff assisting with AUV *Echo Ranger* sea trials in Pillar Point harbor, the *USS Independence* mission staging area. Photo credit: Bryan Begun, NOAA.



Features on an historic photo of *USS Independence* are captured in a three-dimensional sonar image of the shipwreck. Resting upright in 2600 feet of water, the aircraft carrier's hull and flight deck are clearly visible, with what appears to be a plane in the carrier's hangar bay. Image credit: Robert Schwemmer, ONMS.

The R4107 and Fulmar Support Dive Operations

The *R4107* effectively can deploy of small dive teams during day trips out of Monterey. The *Fulmar* has even greater dive support capabilities, with an on-board Nitrox compressor, a deployable skiff, significant range, and berthing accommodations for up to ten divers working in remote sections of the coast for up to five days at a time.

Summary of *Fulmar* Dive Statistics from 2013 to 2015

	2013	2014	2015
Number of dives conducted	152	14	88
Number of unique divers	14	4	12
Total bottom time	121 hr	13 hr	54 hr
Average bottom time	48 min	54 min	50 min
Average depth	59 ft +/- 17 sd	35 ft +/- 18 sd	51 ft +/- 15 sd
Enriched air Nitrox dives	86%	100%	84%
Number of dive sites	27	4	9

Research Diving in Monterey Bay National Marine Sanctuary

MBNMS divers and partners continued the nearshore characterization and monitoring effort of the Big Sur coast aboard the *Fulmar* in 2013 and 2015. The goal of the project is to increase first-hand knowledge of the marine resources and habitats along the coastline, particularly kelp forests. This long-term project provides data to directly inform sanctuary



NOAA diver on transect surveying fish, invertebrates and algae.

Photo credit: Chad King, MBNMS.



NOAA diver surfacing off Lucia on the Big Sur Coast. Photo credit: Chad King, MBNMS.

management actions and permitting processes. The work of MBNMS scientific divers in this area has

established the sanctuary as a leader in ecosystem-based management of resources along the Big Sur coast. Surveys of fishes, invertebrates, and algae provided species richness data that complement those collected by the University of California Santa Cruz's Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and allow comparisons among subtidal sites along the coast.

In 2014, MBNMS and PISCO divers also concluded a three-year subtidal monitoring effort at the Alder Creek land slide, which closed scenic Highway 1 in Big Sur for two months. These surveys will guide the design and implementation of a study that will assess the impact of the slide and subsequent engineering performed at the site. The study was funded by the California Department of Transportation as part of their coastal development permit from the California Coastal Commission.



NOAA diver preparing to dive from the skiff while the *Fulmar* is waiting outside the kelp bed. Photo credit: Chad King, MBNMS.



Wolf-eel peaking out of a hole.

Photo credit: Steve Lonhart, MBNMS.



Kelp forests provide habitat, shelter and food for many fish and invertebrate species. Photo credit: Steve Lonhart, MBNMS.

In December of 2013, MBNMS divers assisted a team from the California Academy of Sciences, Steinhart Aquarium, collecting rocks and marine invertebrate off the coast of Big Sur during a multi-day expedition aboard the *Fulmar*. In the summer of 2014 the aquarium opened a new 2,000-gallon temperate reef exhibit called "Rocky Reefs". The Academy has had a long-standing and important partnership with national marine sanctuaries. Many of their exhibits are focused on highlighting the importance of national marine sanctuaries.

In December 2013, MBNMS divers conducted a detailed survey of a seaplane wreck site they discovered in September. The plane made an emergency ocean landing and then sank in September 2012. The divers recovered items and information that positively identified the aircraft, which initiated the salvage of the wreckage that was paid for by the plane owner's insurance. This action is part of ongoing MBNMS efforts to remove marine debris from the sanctuary.



A divers' survey positively identified a plane wreck off the Big Sur Coast. Photo credit: Steve Lonhart, MBNMS.



A blood star afflicted with the sea star wasting disease. Photo credit: Chad King, MBNMS.

In 2014, MBNMS divers conducted surveys off the *R4107* to assess density data on sea stars that were affected by or had survived a wasting disease that is sweeping through the intertidal and nearshore subtidal, from Canada to Baja. The sea star wasting disease appears sporadically, causing mass mortality of affected sea stars. The disease is little understood and no identifiable cause for these events has been found, although it seems to be associated with raised water temperatures and a sea star-associated densovirus.

Greater Farallones National Marine Sanctuary Dive Expedition

In an effort to characterize the newly expanded area of GFNMS, sanctuary divers explored three areas: Del Mar State Marine Reserve, Gerstle Cove and Pt. Arena Cove. Divers recorded high numbers of abalone and sea urchins at all three sites and high densities of kelp and rockfishes in Del Mar Reserve. The *Fulmar* spent one night at anchor in Pt. Arena Cove and shuttled personnel to and from shore using the vessel's skiff, which was a critical mission component to assess the feasibility of using the infrastructure of Pt. Arena Cove for possible future transfers of scientific or other personnel. It was found that Pt. Arena Cove offers limited ship-shore transfer capabilities and safe harboring due to its susceptibility to foul weather.



Photo credit: Chad King, MBNMS.

Testing the Puma Unmanned Aircraft

In September 2014, the West Coast Region Office funded a three day mission on the *R4107* to assess the capability of the Puma™ All Environment small unmanned aircraft system (UAS) for detecting various targets on the ocean's surface, including marine mammals and other large marine organisms. The Puma UAS is a waterproof aircraft, light enough to be launched by hand from the *R4107*, and includes a camera that can broadcast live images to a base station. MBNMS researchers and the UAS team completed four flights and although primary targets (leatherback turtles and their jellyfish prey) were never observed, a total of eight Humpback whales and one ocean sunfish were recorded. The UAS proved adequate in detecting objects as small as one meter across from altitudes as low as 60 meters and large animals, such as whales, at its maximum flight altitude of 300 meters. Although this system may cost less than traditional aerial surveys, it lacked a high-definition camera, and is not yet suited for rigorous data collection due to the inability to calculate total area covered, preventing density estimates. In its current configuration, this system may be better suited for reconnaissance applications within national marine sanctuaries, although future configurations of the UAS could remedy its current deficiencies.



Ocean sunfish was one of the Species that could be identified from the UAS.

RESOURCE PROTECTION HIGHLIGHTS



LT Dave Gothan launching the Puma UAS.
Photo credit: M4 Consulting.

Puma Unmanned Aircrafts Demonstration

In September 2014, the *Fulmar* hosted 12 representatives from various state, federal, and local agencies and political and legal offices around the San Francisco Bay Area. In addition, staff from West Coast National Marine Sanctuaries participated along with pilots from the NOAA Unmanned Aerial Systems Center for Excellence. The PUMA UAS was successfully launched and demonstrated for a period of roughly 2-3 hours in Drakes Bay, just outside the boundaries of the Point Reyes National Seashore. A video feed was broadcasted from the PUMA to an on-board projector where guests could observe the aerial footage being captured by the UAS. The demonstration exercise provided a valuable experience for

various stakeholders interested in monitoring, enforcement, and research and management activities within the sanctuary and MPAs to come together and brainstorm potential uses for the PUMA.

Ship-Whale Interactions

In 2013, a graduate student from Moss Landing Marine Laboratories conducted two marine mammal surveys on the *Fulmar* while the vessel was transiting between Monterey and San Francisco as a portion of her master's thesis, conducting a risk assessment of ship-whale interaction. Her goal was to identify any high-risk areas in the vessel traffic zones between San Francisco and Los Angeles where ship-whale interactions may occur. Her findings will assist managers to make better decisions to the benefit of whales and the shipping industry.

Entangled Whale Rescue

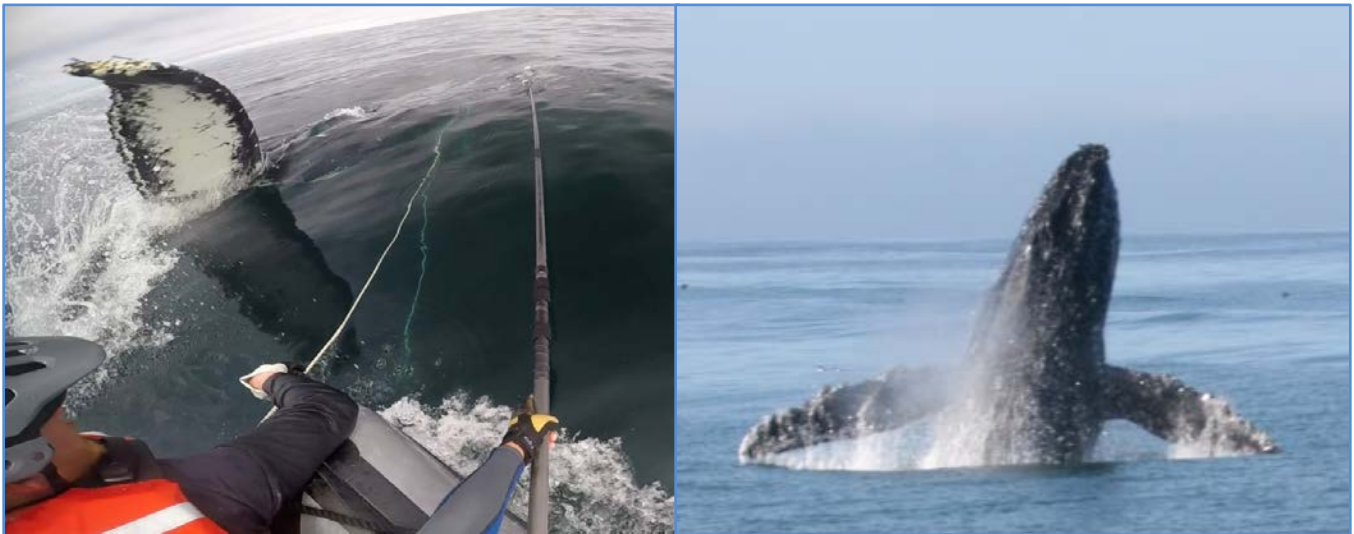
NOAA received over 60 reports of entangled whales off the California coast in 2015, a five-fold increase compared to recent years. The majority of these reports were of humpback whales entangled in crab pot lines. The increase may be partially explained by better reporting, but there is also an increase in whale population size and a greater overlap, spatial and temporal, between humpback whales and crab pot distribution.

The *Fulmar* participated in an intense three-day rescue operation to free an entangled juvenile humpback whale over the 2015 July 4th holiday that took the *Fulmar* crew and highly trained experts from Monterey Bay to Big Sur and to the Farallones Islands. The *Fulmar* was also involved in setting free a humpback whale that was entangled in the line of a scientific mooring off Monterey Bay in October 2014.



The whale disentanglement Team is getting a Nantucket sleigh ride on the *Fulmar*'s skiff. MMHSRP Permit #18786.

The *Fulmar*'s size, speed and small skiff make it a platform of choice for this type of operation. The *R4107* was involved in two reconnaissance missions to evaluate the conditions of potentially entangled whales in 2015. The West Coast Regional Vessel Operations Team is undergoing training and developing protocols with experts from other national marine sanctuaries, NOAA Fisheries Stranding Network, and the California Whale Rescue Network to be better prepared to respond to future whale entanglements.



After a long and tedious approach and evaluation, whale disentanglement experts prepare to make a cut with a sharp blade mounted on a carbon fiber pole to set the whale free. MMHSRP Permit #18786 (*left*). Breaching humpback whale (*right*).

Buoy Maintenance and Inspection

MBNMS Resource Protection staff continued to use *R4107* and *Fulmar* to inspect the buoy array in Monterey Bay that marks marine boundary lines for a motorized personal watercraft zone within the sanctuary.

EDUCATION AND OUTREACH HIGHLIGHTS



A state of the art camera mounted on the the *Fulmar* broadcasted humpack whales lunge feeding LIVE to millions of viewers during Big Blue Live.

Big Blue LIVE Brings Monterey Bay National Marine Sanctuary Success Story to Millions

Working with the BBC, PBS, and the Monterey Bay Aquarium, the *Fulmar* served as a platform for a series of nine live, hour-long broadcasts that brought together scientists, filmmakers, photographers and other experts to film and photograph marine life that feed in MBNMS. Species captured on film and video included whales, sea lions, dolphins, elephant seals, sea otters, white sharks, shearwaters, brown pelicans and even the elusive blue whale. The *R1407* assisted in spotting and tracking wildlife notably helping to locate and track a blue whale so that a helicopter-mounted camera could bring live images of the whale to worldwide viewers once the broadcast began. Big Blue LIVE told the story of conservation success experienced in MBNMS. The live shows aired on the BBC in the United Kingdom and on PBS in the United States and reached a television audience of more than 15 million - even more participated via live streaming and social media.



Monterey Bay wildlife put on a show for Big Blue Live.



The *Fulmar* was transformed into a TV studio for Big Blue Live.

B-WET Explores Monterey Bay

NOAA's Bay Watershed Education and Training (B-WET) program sponsored a cruise on the *Fulmar* to provide B-WET staff and selected local stakeholders including grantees, teachers, and partners first-hand experience of the natural and historical resources that make Monterey Bay so special. B-WET supports locally-relevant, experiential watershed education for K-12 students and related professional development for teachers by funding projects that emphasize meaningful watershed educational experiences: sustained, hands-on, place-based field activities that are aligned with academic learning standards and respond to regional education and environmental priorities. In partnership with NOAA, these locally-focused grantees ensure that classrooms and communities learn more about their watersheds; build the knowledge and skills needed to make well-informed environmental choices; and protect and restore the nation's ocean, coastal, and Great Lakes resources.



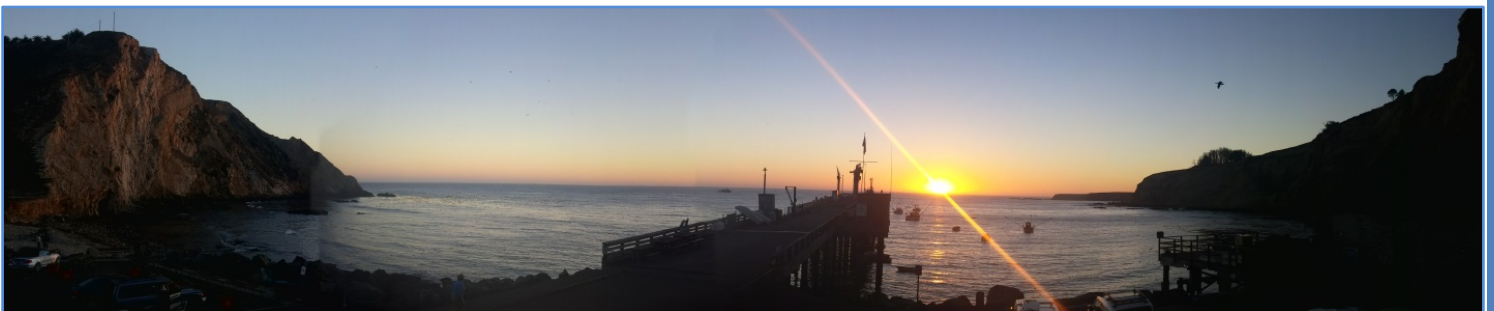
The California sea otter is perhaps the most iconic Monterey Bay inhabitant.

ONMS Helps Host First Monterey Beach Sportsfest

The West Coast Regional Office and MBNMS helped host the first Monterey Beach Sportsfest on October 4-5, 2014. This inaugural ocean sports and wellness festival offered ocean and beach activities, such as water polo, distance swims, swim-run competitions, and beach volleyball, as well as education about personal and ocean wellness. The fact that participants were swimming, paddling and playing in a national marine sanctuary was a prominent aspect of the outreach activities. ONMS provided the *R4107* to assist in laying out courses and buoys for the swim competitions and to serve as a platform for event organizers to direct offshore activities. Nearly 500 athletes participated in the various events.



The *R4107* help set the swim course and provided a rest area for water polo player during Monterey Beach Sportsfest.



The *Fulmar* anchored overnight in Pt. Arena Cove during the 2015 Greater Farallones NMS dive Expedition. Photo credit: Bryan Begun, NOAA.

Volunteers at Sea

An education cruise for MBNMS volunteers conducted in 2013 aboard the *Fulmar* afforded 58 volunteers the chance to observe seabirds, whales, dolphins and other marine mammals in their pelagic habitats. This cruise greatly enhanced the training of volunteers so they in turn could offer enhanced interpretations to visitors. After the cruise, volunteers sent images and emails thanking the sanctuary for their continued support of the volunteer programs. The volunteers appreciated the experience of being on a research vessel and out on the sanctuary. These volunteers contribute close to 7,500 hours a year (a \$150,000 value) to MBNMS.



Sanctuary volunteers had the opportunity to go on the *Fulmar* to learn about the resources they are helping to protect.

VALUABLE REGIONAL ASSETS

The *Fulmar* and *R4107* were vital to maintaining important long-term monitoring projects with partners in addition to forging alliances to meet the needs of new partners and new outreach opportunities for the three northern-central California sanctuaries. The *Fulmar* crew has been essential to the success of ONMS mission. In 2015, two full time operators and a NOAA Corps officer joined the West Coast Regional Office Vessel Operations Team, enabling the vessels to be ready to respond with minimal notice. The *Fulmar* is an icon for sanctuary research in northern-central California.

