

Research Vessels *Fulmar* and *R4107* 2016 Accomplishments Summary in Cordell Bank, Greater Farallones, and Monterey Bay National Marine Sanctuaries



Divers return to the NOAA R/V *Fulmar* off the Sonoma coast. Photo credit: NOAA ONMS and CA State Parks.

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 (WCRO) 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. During 2016, the vessels spent 54 days at sea and successfully completed 23 missions.

***Fulmar* and *R4107* Summary –**

- Support area: 10,675 square miles
- Projects supported: 15
- Missions completed: 23
- Days at sea: 54
- Research participants: 297
- Education and outreach participants: 155
- Number of SCUBA dives: 48
- Combined SCUBA diver bottom time: 32 hours



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

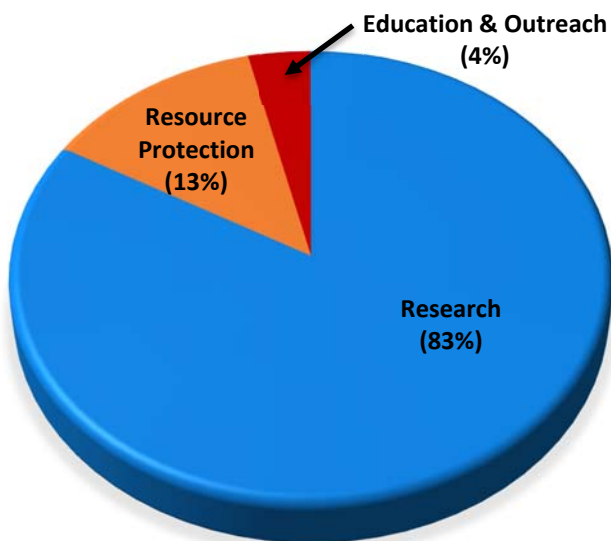
The three national marine sanctuaries of northern and central California are some of our nation's most spectacular marine protected areas and offer some of the best marine wildlife viewing in the world, and because of this, they have been dubbed the "Serengeti of the Sea". Focused along the California 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 of the projects supported by the vessels.



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



2016 SEA DAYS PER MISSION TYPE

The majority (83%) 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 monitoring projects can be found on the Sanctuary Integrated Monitoring Network (SIMoN) website www.sanctuariesimon.org. While only 4% 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. In 2016, the ACCESS team conducted two multi-day surveys to document how temporal changes in oceanographic conditions, including ocean acidification, affects marine mammal and seabird abundance and spatial distribution in the three central and northern California national marine sanctuaries. The *Fulmar* ran predetermined, repeated transect lines along the continental shelf, conducting seabird and marine mammal surveys from the flying bridge while the vessel's EK60 echosounder scanned for krill and other prey items in the water column. Additionally, net tows and CTDs casts from the back deck, at established stations, sampled plankton and recorded oceanographic data.



Common Murre in flight above the *Fulmar*. Two are carrying fish in their bills. Photo credit: Mojo cast, ONMS/Point Blue/ACCESS.



A mother humpback whale and her small calf surface to breathe.

Photo credit: Mojo Cast, ONMS/Point Blue/ACCESS.

The team noted that whale abundances were higher in 2016 than in 2015, which was an El Niño year, and among the higher years of whale abundances in the thirteen-year data set. At the same time, gelatinous zooplankton remained high in the prey samples, a trend that began in 2013. An annual report is expected in spring 2017.

ACCESS is a critical sentinel site-monitoring program for the Central and Northern California National Marine Sanctuaries that is providing timely, relevant ecosystem data for real management issues. In recent years ACCESS provided data used to:

- inform ship strike reduction efforts in the SF traffic lanes resulting in a voluntary speed reduction request to large ships
- develop a regional model to facilitate ocean acidification
- alter crab fishery closure as a result of Harmful Algal Blooms
- target and remove out-of-season crab pots to reduce wildlife impacts, such as whale entanglements
- document the ecosystem effects of the Pacific Ocean Anomalies in 2014 and 2015 including observations of rare species and absences of usual residents and changes in distribution and abundance of seabirds and marine mammals

In addition to improving understanding of sanctuary ecosystems and providing early warning of changing conditions, ACCESS provides education and outreach opportunities by mentoring graduate students, hosting NOAA Teacher-at-Sea, and collaborating with photographers and videographers to share the stories with the public.

Listening for White Sharks off Piedras Blancas

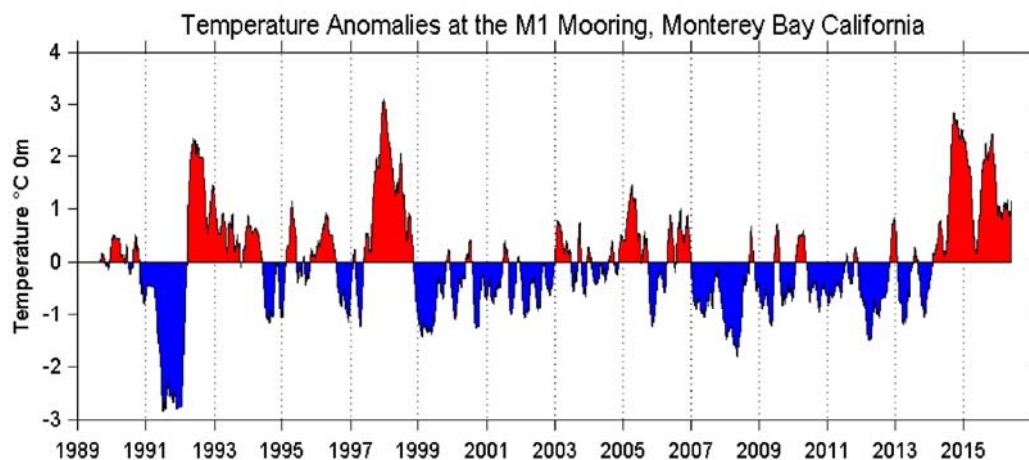
In March, researchers from Stanford's Hopkins Marine Station used the *Fulmar* to retrieve an acoustic mooring off Point Piedras Blancas. The acoustic buoy detected tagged white sharks and transmitted their location to researchers in real-time. The goal of their research is to track the movements, residency and behaviors of white sharks throughout National Marine Sanctuaries in central California. Additionally, this data is used for public outreach and education through the "Shark Net" application for iPhones and iPads.



The *Fulmar* recovers an acoustic mooring as part of a project that tracks white sharks in national marine sanctuaries. Photo credit: ONMS.

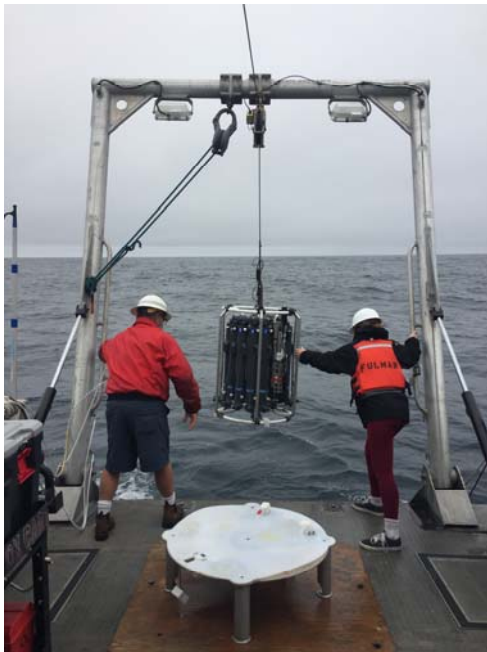
Oceanographic Monitoring in Monterey Bay National Marine Sanctuary

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 27th year that focuses on primary production at the base of the Monterey Bay's food chain to study 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.



Dramatic Blob-associated warming began in late 2013 and was comparable in magnitude to that of the 1997-98 ENSO. El Nino

In fall 2013 a new and poorly understood phenomenon entered Monterey Bay. In association with the California drought, surface waters across the north Pacific warmed, producing a basin-scale layer of warm surface water now known as northeast Pacific 'Blob'. During 2013, 2014 and 2015, this warm and nearly oligotrophic Blob water pushed into outer Monterey Bay, compressing the productive upwelling habitat to shore and leaving narrow, nearshore refugia for blooming phytoplankton, large schools of forage fish, and their predators. As a dramatic consequence, feeding humpback whales were visible near-continuously from shore off Moss Landing, apparently targeting deep daytime schools of anchovies over the head of the Monterey Submarine Canyon.



MBARI Scientists recover a CTD and Rosette from the Fulmar back deck.
Photo credit: MBARI.



Pelagic red crab washed ashore on the Monterey Peninsula in fall 2015 and again in spring 2016, apparently in association with El Niño. Photo Credit: MBARI.

In 2015-2016, a newly-recognized form of El Niño - El Niño Modoki - that has been increasing in frequency over the past two decades, was recorded. Under El Niño Modoki, the western and central equatorial Pacific did warm dramatically, but the warming failed to penetrate east of the Galapagos to Peru, and so was unable to reflect off the continents and propagate up the coast to California. The impact of the 2015-2016 El Niño winter were muted due to this lack of a strong ocean connection.

These events and their consequences have been documented by cruises on the *Fulmar* and other research platforms, and MBARI, along with the rest of the oceanographic community, are still working out their relationships. In 2015 the Blob dominated Monterey Bay late until fall when El Niño took over. While relationships between these phenomena remain uncertain, both brought warm, low nutrient and phytoplankton biomass and production conditions.



Humpback whale hot spot - During 2013, 2014 and 2015, feeding humpback whales congregated over the head of the Monterey Submarine Canyon whales were a near-daily sight from Moss Landing. Photo Credit: A.Gonzales.

Partnership with Monterey's Naval Postgraduate School

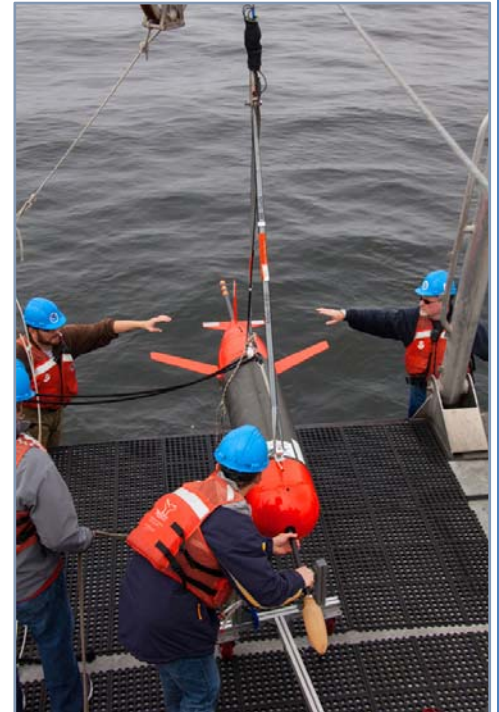
A regular partner and user of the *Fulmar* and *R4107* is the Monterey based Naval Postgraduate School (NPS). In 2016 NPS researchers, professors and graduate students completed 7 missions (20 days at sea) on the *Fulmar*. These missions supported research projects for a variety of oceanography classes 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.

Autonomous Gliders

Scientists from the Physics Department used the *Fulmar* to deploy and recover autonomous gliders for environmental monitoring. The purpose of this project was to collect in-situ environmental and acoustic data from autonomous underwater gliders in the Monterey Bay area, and communicate acoustically through autonomous surface systems. Post-processing of data were to allow for tracking of sound generating targets, such as marine craft and marine mammals. Eventually the goal is to be able to use acoustical signature to track ships and marine mammals in real time.

Descriptive Physical Oceanography

In support of the Descriptive Physical Oceanography class activities, Student deployed a Slocum glider and conducted CTD cast from the *Fulmar* along a transect to sample deep and shallow water environments in Monterey Bay.



NPS researchers initiating deployment of an autonomous glider from the *Fulmar*.



NPS graduate student launches an EMATT from the *Fulmar* back deck. Photo credit: J. de Marniac, WCRO.

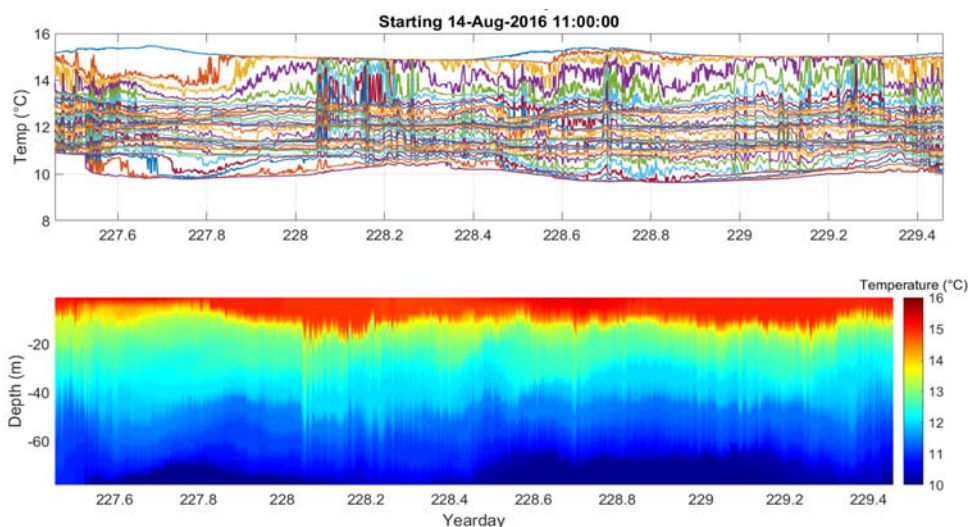
Tactical Oceanography

Students from Tactical Oceanography classes conducted field experiments aboard the *Fulmar* in March and July. In March, they launched two mobile acoustic sources (EMATT) from the inner Monterey Bay on straight-line courses that passed directly over the MBARI MARS Cabled Observatory site where an omni-directional hydrophone is located at a depth of 891m. One mobile source was set on a trajectory that remained over deeper water following a course over the Monterey Canyon and continuing outside the MBNMS boundaries. The other mobile source was launched over the shelf area of the bay then continued over the shelf break, over the MARS site and continuing until it crossed MBNMS boundary. In July, they launched two additional EMATTs off the coast of the Monterey Peninsula north of Point Pinos following the 100m bathymetry contour until it moved over deeper waters at Carmel Canyon and continued along a southwesterly track to outside the MBNMS boundary while a moored array of acoustic receivers recorded the signals as the source tracked over both shallow and deep water environments. CTD casts were conducted to

assess the propagation conditions through modeling. The students developed projects that focused on measurements of acoustic transmission loss in shallow and deepwater environments including ambient noise trends in deep water, comparison of predicted and actual detection range of the mobile sources in the two environments, propagation in the surface sonic layer, and characterizing ambient noise trends near the mooring site.

Effects of internal waves on shallow water acoustics

Three arrays of temperature sensors were deployed from the *Fulmar* in southern Monterey Bay for a two-week period in August. The objective of the test was to capture the variability of internal wave field that enter the bay from the deep water and to examine how this field may impact acoustic propagation in the shallow water environment in support of a student master's thesis. The results showed that sound transmitted either across or perpendicular to the internal wave fronts have important refractive effects that modify transmission loss, particularly if the sound is propagated parallel to the internal wave fronts. These results were similar and supported other studies conducted in southern California investigating internal wave impacts on shallow-water sound propagation.



The complicated internal wave field over a 2-day period derived from an array of temperature sensors deployed in southern Monterey Bay from the *Fulmar*.

Directional noise from an array of buoy-based acoustic receivers

In support of a study on the use of gliders to measure directional ambient noise, three drifting buoys with acoustic receivers were deployed from the *Fulmar* in September. The drifting buoys were used as surrogate gliders that have the capability to drift at depth. The buoys locations were tracked by GPS and signals from the *Fulmar* were transmitted from known locations. A time-delay-of-arrival method will be used to determine the effectiveness of localizing the "ground-truth" signals. Once these data are shown to be sufficiently accurate, other directional sounds of opportunity (e.g., marine mammal vocalizations) will be analyzed as well.

Non-acoustic Detection Experiment

In support of another thesis research on non-traditional detection methods, two one-day cruises were conducted in southern Monterey Bay in November to evaluate the performance of an experimental towed temperature array to detect signals generated by a submerged tow-body. The *Fulmar* was used to control the depth and speed of the tow-body while a small RHIB was used to tow the array of temperature sensors mimicking the performance of an unmanned surface vessel. CTD were also conducted from the *Fulmar* to evaluate the strength of the temperature gradient near the planned tow depth (15m). Data analysis is ongoing but initial results appear promising.

Dive Operations

The *R4107* can deploy 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

Number of dives conducted	48
Number of unique divers	8
Total bottom time	32 hr
Average bottom time	40 min
Average depth	36 ft +/- 11 sd
Enriched air Nitrox dives	85%
Number of dive sites	6



NOAA diver Deborah Marx dives into the water from the research vessel *Fulmar* under the supervision of NOAA divemaster Matt Lawrence, off of Gerstle Cove.

Photo credit: B. Frank, Special to The Chronicle.

Sonoma Coast Doghole Ports



The doghole port project team documented underwater remains of the Redwood coast lumber industry including this anchor in Fort Ross State Historic Park. Photo credit: (NOAA ONMS & CA State Parks).

A multi-agency team lead by NOAA Office of National Marine Sanctuaries Maritime Heritage Program and California State Park completed eight days of land survey and five days of underwater survey in August 2016 along the north coast of GFNMS. The underwater survey team dove off the *Fulmar* and conducted operations at four doghole ports (Fort Ross, Gerstle Cove, Fisk Mill Cove and Duncan's Landing). Divers located submerged infrastructure at two locations, Fort Ross and Gerstle Cove. Additionally, divers visited the steamship *Pomona* shipwreck to document its condition and made exploratory dives to locate the schooner *J. Eppinger*, bark *Windermere*, and steamship *Whitelaw*. While the remains of those three shipwrecks were not found, the team confirmed the location, from reports by recreational divers, of the ship *Joseph S. Spinney*.



ONMS Maritime Heritage Program archeologist Matt Lawrence evaluates conditions before a dive at the wreck site of the *Joseph S. Spinney*. Photo credit: NOAA ONMS & CA State Parks.



Fort Ross doghole port, late 19th century. Photo credit: Fort Ross Conservancy.

Doghole ports were once the center of maritime activity along the northern California coast and the evidence of that confluence of land and sea networks can be seen in the archaeological remains of lumber chutes and lost vessels. These sites now lie within GFNMS and several California State Parks. Archaeologists, historians and resource managers are working together to document and interpret these remains to better understand our past and connect present day communities to their heritage. Surveys are being combined with archival research and oral history to document the larger lumber industry landscape that linked the redwood forests to the world. The economic and social effects of the lumber industry were vast and served as an important source of employment, building materials and stimulated settlement in areas overlooked by other industries.

The project team included participants from Office of National Marine Sanctuaries West Coast Region and Maritime Heritage Program, Greater Farallones National Marine Sanctuary, California State Parks, Fort Ross Conservancy, Greater Farallones Association, National Park Service's San Francisco Maritime National Historical Park, Sonoma State University, and Cal Trans.



NOAA Corps Lieutenant Bryan Begun searches for remains of the lumber chute mooring anchors off Gerstle Cove in Salt Point State Park. Photo credit: NOAA ONMS & CA State Parks.

RESOURCE PROTECTION HIGHLIGHTS

Entangled Whale Response

NOAA recorded 68 reports of entangled whales off the California coast in 2016, 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's* size, speed and small skiff make it, along with its sister ship in Santa Barbara, the *Shearwater*, a platform of choice for whale disentanglement operations. The *R4107* is a solid platform for reconnaissance missions to evaluate the conditions of potentially entangled whales. The West Coast Region 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.

The WCRO vessel team continued to provide crucial support of the West Coast Entangled Response Network. As entangled whale reports have hit all-time record highs each of the previous three years, the Sanctuary and crew of *Fulmar* and *R4107* have stepped up to provide training opportunities and response support. Trainings have included testing a UAS for entanglement analysis, Personnel Qualifications Standards for responders, training of Sanctuary personnel, response strategies, telemetry deployment from *Fulmar* and its skiff, and use of the specialized tools.



Practicing throwing a grapple hook from the *Fulmar*. Regular training exercises are keys to successful whale disentanglement operations. Photo credit: NOAA/CWR.



The disentanglement team approaches an entangled humpback whale with the *Fulmar's* skiff.

Photo credit: NOAA/CWR.

When available the *Fulmar* participated in responses. One response was notable for several reasons. It demonstrated good integration between the response team and sanctuary personnel, the network's equipment (including an inflatable), and search strategies. The mission was to find a particular blue whale that had been reported entangled and test its reaction to "kegging" and the small response boat. The whale was found and we are told it was the first time that anyone had experienced the "Nantucket Sleigh Ride" on a blue whale. A Nantucket Sleigh Ride is when the small boat attaches to the working line of the entanglement and is dragged around by the whale. This technique enable the rescue team to

approach an entangled whale to evaluate its behavior and the entanglement, and can be used to deploy a tracking device that can facilitate the relocation of the whale. In addition during that

response, an entangled humpback whale was seen and documented and the support team on *Fulmar* found a second entangled blue whale. The results of that mission demonstrated how well the *Fulmar*, sanctuary personnel, and other official responders worked together.

Going forward, a tool cache for *Fulmar* and *R4107* is being acquired as sanctuary personnel advance in the network with the goal of being able to deploy telemetry quickly and independently as a functional entanglement response team.



MBNMS resource protection staff depart for a patrol aboard the *R4107*. Photo credit: J. de Marignac, WCRO.

Buoy Maintenance and Inspections

MBNMS resource protection staff continued to use *R4107* and *Fulmar* to inspect the buoy array in Monterey Bay that marks marine boundary lines for motorized personal watercraft zones within the sanctuary. The resource protection team also conducted patrols to investigate compliance with MBNMS regulations by ocean users, specifically regulations concerning disturbance of marine mammals and seabirds. The *Fulmar's* skiff supported dive operations to inspect underwater water pipes off Cannery Row in Monterey.

EDUCATION AND OUTREACH HIGHLIGHTS

Congressional Outreach

The *Fulmar* crew successfully demonstrated the operational capacity of the research vessel to congressional staff visiting the Monterey area. The *Fulmar* is an ideal platform for decision makers and their staff to observe sanctuary resources, such as humpback whales, sea lions and otters, and learn about resource protection challenges, such as algal blooms and unusual warm water events, and their impact on wildlife. These type of missions create a more informed constituency of MBNMS by demonstrating its core missions in resource protection, research and outreach in the environment MBNMS strives to protect.

MBNMS Staff Area Familiarisation & Team Building

MBNMS conducted an all-staff team building activity at sea on the *Fulmar*. The mission was designed to familiarize sanctuary staff with the natural resources they are charged to protect by enhancing their understanding of the sanctuary managed areas and awareness of current ocean activities within MBNMS.



Pre-departure safety briefing for the MBNMS staff on the *Fulmar*. Photo credit: C. King, MBNMS.



MBNMS Staff had the opportunity to go on the *Fulmar* to learn about the resources they are helping to protect. Photo credit: C. King, MBNMS.

VALUABLE REGIONAL ASSETS

At the end of 2015 the *R4107* inoperable due to a critical mechanical failure. Under the leadership of a newly-assigned NOAA Corps officer, WCRO staff developed and implemented a plan to restore and repair the vessel with a minimal budget and recycling parts its sister ship, the *R4106*, no longer needed. After an extended period in the yard, the *R4107* was back on line by the beginning of the summer and mission ready.

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. Since 2015, additional full time crew and a NOAA Corps officer complemented the West Coast Regional Office Vessel Operations Team, enabling the vessels to be ready to respond with minimal notice. In addition, the NOAA fleet inspector commented that the vessels have never looked better. The *Fulmar* is an icon for sanctuary research in northern and central California.



Captain Chris Eubank keeps a watchful eye on operations from the *Fulmar* aft control station on the fly bridge. Photo credit: J de Marignac, WCRO.

