

## Research Vessels *Fulmar* and *R4107* 2017 Accomplishments Summary in Cordell Bank, Greater Farallones, and Monterey Bay National Marine Sanctuaries



NOAA R/V *Fulmar* about to recover her skiff during a whale disentanglement operation in Monterey Bay. Photo credit: CWRN

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 2017, the vessels spent 99 days at sea and successfully completed 32 missions.

### ***Fulmar* and *R4107* Summary –**

- Support area: 10,675 square miles
- Projects supported: 20
- Missions completed: 32
- Days at sea: 99
- Total participants: 702
- Number of SCUBA dives: 28
- Combined SCUBA diver bottom time: 19 hours



NOAA R/V *R4107* departing Monterey Harbor.  
Photo credit: J de Marignac, WCRO

## GREATER FARALLONES, CORDELL BANK, & MONTEREY BAY NATIONAL MARINE SANCTUARIES



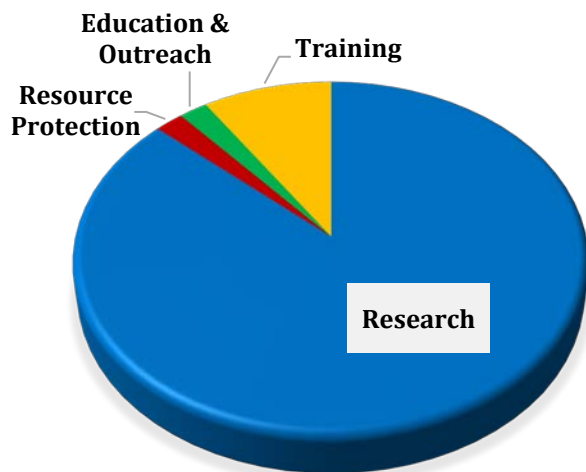
The three national marine sanctuaries of northern and central California are some of our nation's most spectacular marine protected areas and offer some of the best marine wildlife viewing in the world. Because of this, they have been dubbed the "Serengeti of the Sea". Focused along the California coastline 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 the giant blue whale.

The history of California's coast is predominantly a maritime one and hundreds of shipwrecks lie on the seafloor. It is part of the mandate of the National Marine 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. Resource 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 a biological hot spot and have a rich maritime heritage.

The majority (86%) of sea days aboard the *Fulmar* and *R4107* in 2017 were dedicated to research missions. Most of the research projects were designed to provide data needed for resource managers to make informed management decisions. The California national marine sanctuaries maintain 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.sanctuarysimon.org](http://www.sanctuarysimon.org). While only 2% 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. Safety is a top priority of the WCRO vessel operation team and safety brief and drills are incorporated in each mission. In addition nine sea days were dedicated to crew proficiency and training.



**2017 Sea Days Per Mission Type**



## RESEARCH HIGHLIGHTS

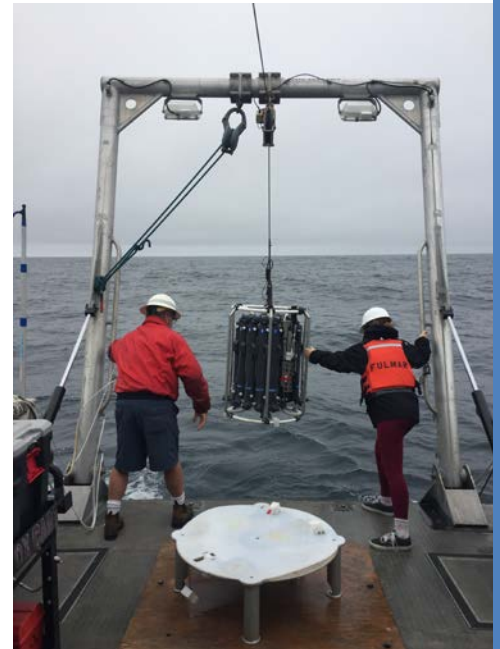
### Oceanographic state of Monterey Bay - 'The age of uncertainty'

Scientists from the Monterey Bay Aquarium Research Institute continued to use the *Fulmar* to deploy a CTD and a rosette of water sampling bottles, and using the vessel echo sounder and thermosalinograph to collect data to support the Monterey Bay Time Series (MBTS), a long running project in its 28<sup>th</sup> year that studies the effects of natural and man-induced climate change upon ocean ecology. MBTS effort focuses on monitoring physical, chemical and biological conditions with a particular attention to primary production by characterizing the origins and fate of water, nutrients and phytoplankton upwelled off Monterey.

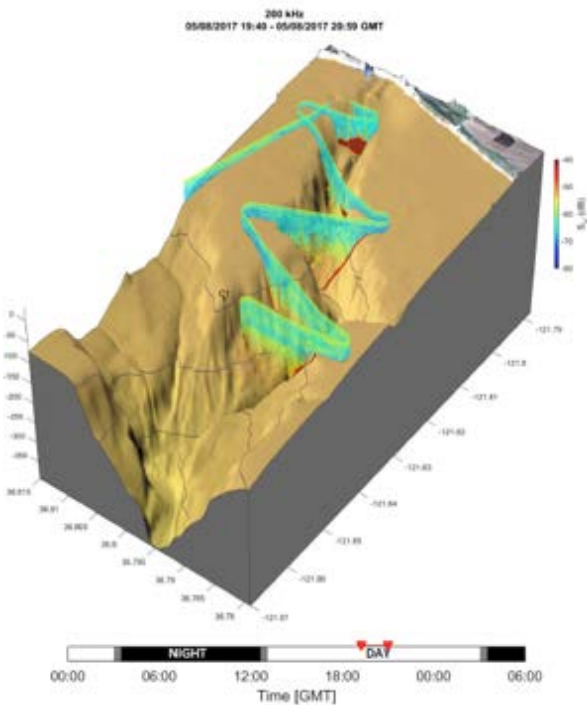
Analysis over time revealed strong associations between the non-seasonal variability of temperature, salinity and nitrate in Monterey Bay. Anomalies including El Niño Southern Oscillation, the Pacific Decadal Oscillation and the Blob were also well correlated to these factors. Over 2013-2015 'The Blob' warmed the Eastern Pacific and Monterey Bay, and during 2015-2016, El Niño did the same. In mid-2016 following El Niño, Monterey Bay returned to 'normal' climatological temperatures and the warm water fauna gradually dispersed. Still, Monterey Bay oceanography has not been normal. In late summer 2016 and spring 2017 upwelling was stronger than climatology, increasing nitrate supply and producing abundant phytoplankton, but temperatures have been average, not cooler than normal, as expected with strong upwelling. Then in spring 2017, humpback whales, and this year salmon too, again congregated off Moss Landing to feed on anchovies schooling at the head of the Monterey Submarine Canyon, even though this head-of-canyon hotspot was previously associated with anomalously warm, low productivity conditions.

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. While many consequences of these dramatic events have been described, some of the physical drivers still remain largely enigmatic - as do their connections to global warming. These large climate fluctuations alter livelihoods and economies, yet we basically do not understand their origins, drivers and how they will play out in the future.

In addition to tracking environmental change through time, the MBTS provides a contextual setting, data and infrastructure that support new ideas and process studies using Monterey Bay as a natural laboratory for sensor and platform development.



Scientists deploy a CTD rosette from the *Fulmar*. Photo Credit MBARI



Echogram of anchovies (red blob) concentrated 150 m deep at the head of the Monterey Submarine Canyon.



ACCESS scientists work together to recover a hoop net on the back deck of *Fulmar* using the A-frame and winch.

Photo credit: J. Thompson/ACCESS/Point Blue/ONMS

### Monitoring the California Current Ecosystem

In 2017, the Applied California Current Ecosystem Studies (ACCESS) project conducted on board the *Fulmar* their 48<sup>th</sup>, 49<sup>th</sup>, and 50<sup>th</sup> research cruises of the 14 year running program. The project is a collaborative partnership with Point Blue Conservation Science, Cordell Bank and Greater Farallones National Marine Sanctuaries. During May, July and September, 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, and the onboard water analysis system recorded sea surface temperature, salinity and fluorescence. Additionally, net tows and CTDs casts from the back deck, at established stations, sampled plankton and recorded oceanographic data.

ACCESS is a long term research and monitoring project that examines coastal and pelagic ecosystem health and processes in Cordell Bank and Greater Farallones and northern Monterey Bay National Marine Sanctuaries. Data is used to relate the spatial patterns of bird and mammal distribution with oceanographic conditions and prey patterns to understand seasonal and interannual changes in the pelagic ecosystem. The information is used in management decisions by NOAA and other regulatory agencies to protect resources in the sanctuaries. In recent years ACCESS data contributed:

- informing ship strike reduction efforts in the SF traffic lanes resulting in a voluntary speed reduction request to large ships
- developing a regional model to facilitate ocean acidification
- altering crab fishery closure as a result of Harmful Algal Blooms
- targeting and removal of out-of-season crab pots to reduce wildlife impacts, such as whale entanglements
- documenting 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 mammal

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.



Above - Two Buller's Shearwater fly by the *Fulmar* during ACCESS. Photo credit: R. Wallen/ACCESS/Point Blue/ONMS

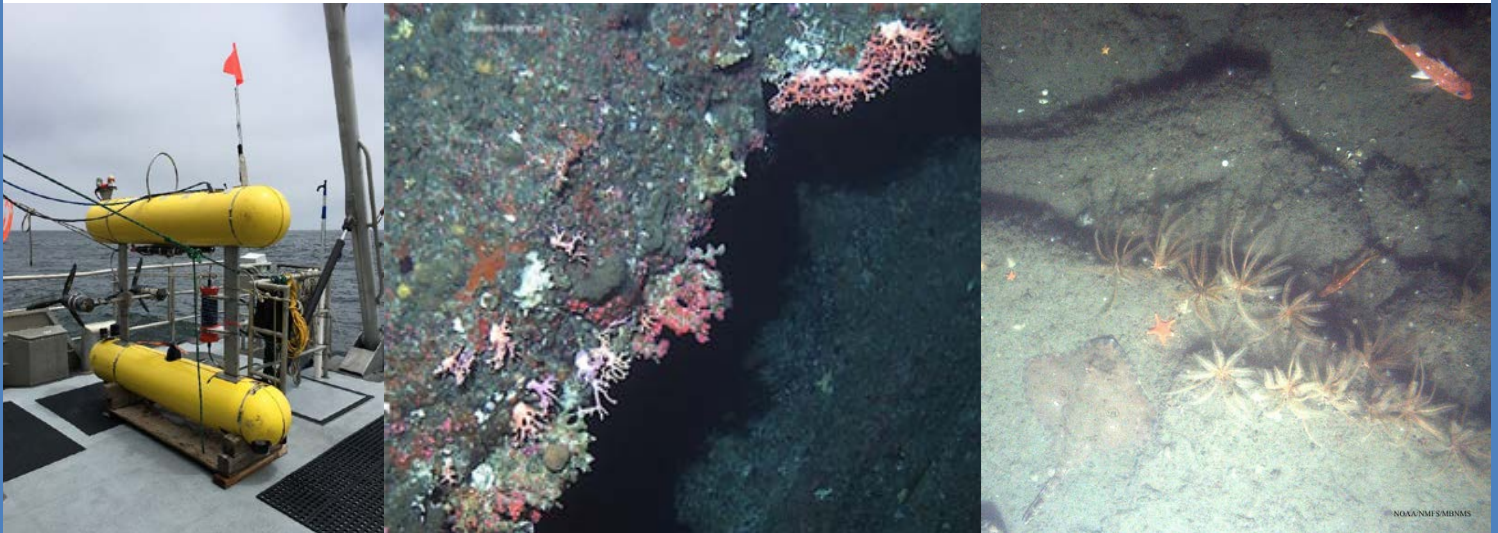
Left - Graduate students from UC Davis collected data for their research on ocean acidification and whale distribution during ACCESS cruises.

Photo credit: ACCESS/Point Blue/ONMS



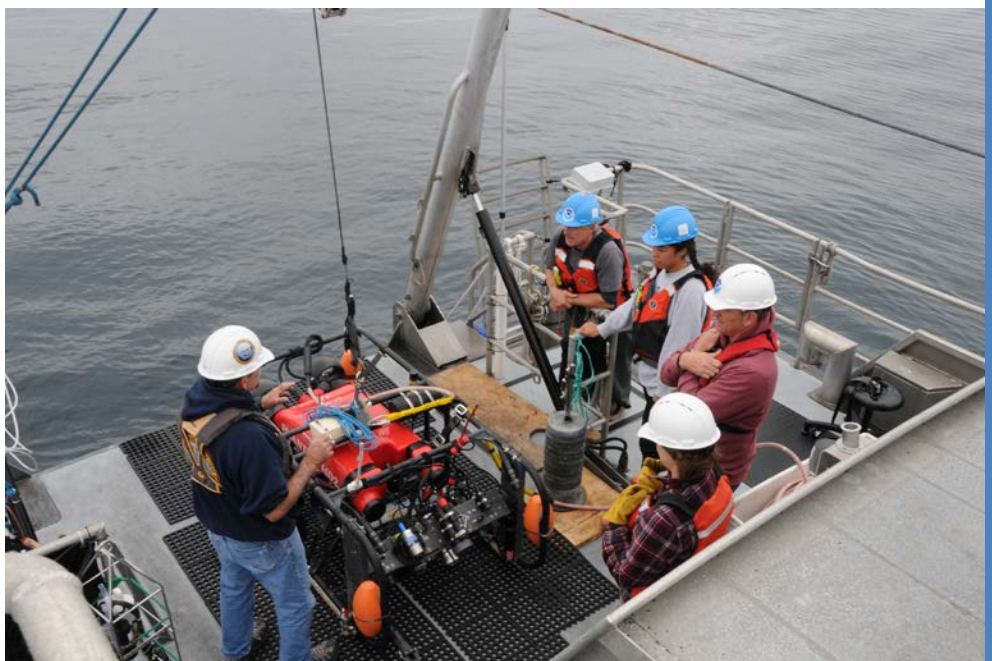
## Characterizing and Monitoring Benthic Habitat and Communities

In July, the *Fulmar* completed a visual benthic survey in Monterey Bay National Marine Sanctuary using the SeaBED, an Autonomous Underwater Vehicle (AUV) to collect baseline data and comparative data on the distribution, abundance, and condition of deep sea communities. In partnership with NOAA's Northwest Fisheries Science Center, Monterey Bay NMS surveyed a total of 26 km in federal waters, including at Point Sur, Carmel Canyon, Soquel Canyon, Ascension Canyon and Davenport Reef. The data collected will address resource protection management issues by helping determine how well various spatial management areas are protecting the resources they were implemented to protect and also help collect baseline and monitoring information. In addition, images from the AUV can be used in a variety of education and outreach products as well as in two MBNMS visitor's centers.



The SeaBED AUV is unlike other more traditional AUV, in that its twin hulls design provides greatly enhanced stability for low speed photographic survey. Photo credit: MBNMS/NWSFC

In August, the *Fulmar* completed a benthic survey using a remotely-operated vehicle (ROV) in Cordell Bank National Marine Sanctuary. The mission focused on Cordell Bank at depths between 70-120 meters to conduct quantitative surveys of benthic habitat and monitor change over time. The team completed 14 transects over 5 days of diving. The sanctuary is implementing a new long-term benthic monitoring plan to track changes to benthic communities and to understand environmental conditions in these areas.



The ROV team reviews protocols for safety before launching the vehicle. Photo credit: K. Grimmer/MBNMS

## Listening to the Underwater Soundscape



Cordell Bank NMS and PMEL researchers redeploy an acoustic mooring from the *Fulmar* after refurbishing its sensor on Cordell Bank.

Photo credit: J. Stock/CBNMS

Scientists aboard the *Fulmar* recovered, refurbished, and redeployed a Noise Reference Station (NRS) acoustic buoy on Cordell Bank in October. The buoy had been recording sound in Cordell Bank and Greater Farallones National Marine Sanctuaries for two years and the data will provide a characterization of the local soundscape, analysis of how ambient sound varies over time, and how it compares to other reference sites. The project is a partnership with NOAA's Pacific Marine Environmental Lab (PMEL), Oregon State University, and the ONMS noise team. This buoy is the 11<sup>th</sup> of 12 NRS buoys deployed by PMEL and the fourth one in a national marine sanctuary. It will be recovered again in 2019. Teachers from Marin County

School District joined the expedition as part of a workshop to learn about sound in the ocean and methods for field research.

### Mapping Golf Balls off the Monterey Peninsula

In June, the *Fulmar's* skiff served as a dive platform for NOAA's divers to survey errant golf balls in Stillwater Cove. The distribution of 184 golf balls was recorded during 22 SCUBA dives (totaling 789 minutes of bottom time) at 10 different distinct sites. The goal of the survey was to better understand the distribution of golf balls within Stillwater Cove, and to make informed recommendations for areas of future collections effort to remediate the number of errant golf balls within the sanctuary. The Pebble Beach Golf Links officially opened in 1919 near Carmel, California. Nine of its 18 holes are along the coastline of Stillwater Cove in Carmel Bay, leaving ample opportunity for errant (and sometimes intentional) shots to propel golf balls into the ocean, or onto the beach, where they may subsequently be transported into the ocean during a high tide or storm. This issue was relatively ignored until a pair of high school students collected thousands of golf balls in short amounts of time. MBNMS estimates that over 52,000 golf balls are added to the Sanctuary every year. The balls can impact communities by altering habitats, preventing plant growth and invertebrate settlement on the seafloor. In addition, as the golf balls deteriorate, microplastics can contaminate the food web. As a result, Pebble Beach Golf Company, the Monterey Bay Aquarium and Monterey Bay National Marine Sanctuary started a cooperative effort to determine how to recover golf balls as efficiently as possible.



A cluster of golf balls found near Pescadero Rocks in Stillwater Cove recorded during a dive survey in June at a depth of 30 feet.

Photo credit: C.King/MBNMS



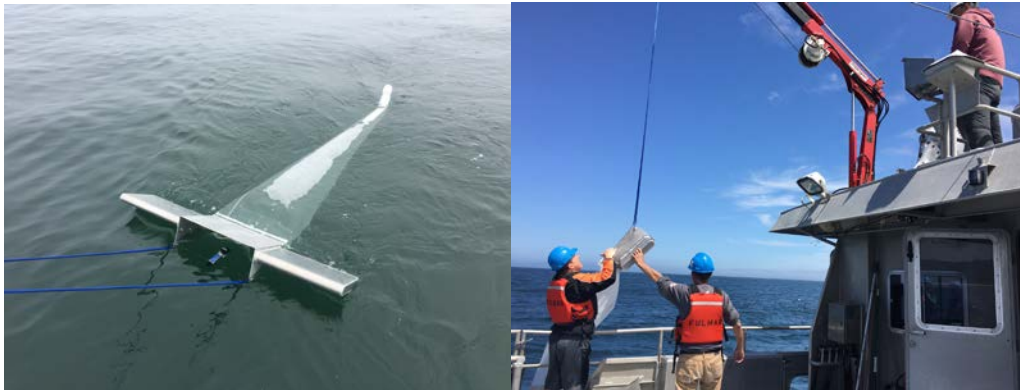
### Emerging Technologies to Sample the Sanctuaries

Scientists from NOAA Pacific Marine Environmental Laboratory used the *Fulmar* to deploy and recover a subsurface mooring, carrying an Acoustic Doppler Current Profiler (ADCP) off Half Moon Bay. The instrument on the mooring was used to compare ocean current profile data with similar data acquired by a Sailability Unmanned Sailing Vessel. Data from both platforms will be analyzed to verify that the newly developed current measurement capability of the Sailability meets NOAA standards for climate-quality measurements.

In May, Monterey Bay NMS researchers successfully used the *Fulmar* to test a Manta trawl net designed to sample for microplastics in the ocean surface layer. The R/V *Fulmar* was used as a test platform for launch and recovery of the trawl.



real time oceanographic. Photo credit: Sailability



The *Fulmar's* crane was used to deploy a Manta trawl to sample microplastic in Monterey Bay. Photo credit: MBNMS

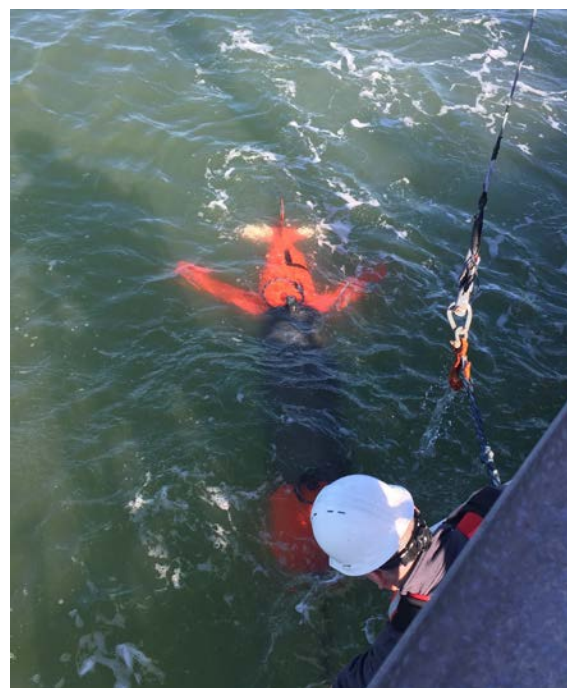
In November Liquid Robotics, a Boeing Company, launched a Wave Glider from the *Fulmar* in Monterey Bay. The vehicle was equipped with an inertial measurement units to study how the Wave Glider and its instruments operate in extreme seas. The Wave Glider is a semi-autonomous platform that uses wave energy for propulsion and solar power for the onboard electronics and sensors. Data collected depend on the particular sensor configuration of each vehicle. In general, most data are transmitted via satellite in near real time. Currently, Wave Gliders are primarily being used for research, resource protection, and education missions. Data collected under the current sanctuary research permit include basic meteorological and oceanographic parameters in offshore locations of the sanctuary that may be difficult to collect otherwise for long duration during winter months. The *Fulmar* is a stable vessel to safely launch and recover oceanographic equipment, especially in the winter months when weather windows are small and transits may be longer to get into an area clear of fishing gear.



Liquid Robotics technicians conduct last minute Wave Glider checks on the back of the *Fulmar* back deck during transit to the deployment site.

Photo credit: J de Marignac/WCRO

In February Scientists from the Physics Department of the Naval Postgraduate School (NPS) deployed and recovered unmanned underwater vehicles, including two Liquid Robotics' Wave Gliders from the *Fulmar* to collect in-situ environmental and acoustic data in the Monterey Bay area, and communicate acoustically through autonomous surface systems. Collected data will be use to track sound generating targets. In September, Wave Gliders with Teledyne-Benthos directional acoustic modems (DATs) integrated into a tow-fish pulled behind the Wave Gliders. This portion of the test was designed to evaluate the accuracy of the new DAT modem technology. In addition, acoustic probe data was collected, which provides information on the environment through which the acoustic signal propagated. Eventually the goal is to be able to use acoustical signature to track ships and marine mammals in real time.



NPS researchers initiating deployment of an autonomous glider from the *Fulmar*.  
Photo credit: J de Maignac/WCRO

### RESOURCE PROTECTION HIGHLIGHTS



Brant Cormorant on a boundary buoy for the Monterey MPWC zone.  
Photo credit: S.Kathy/MBNMS

#### **Buoy Maintenance and Inspection**

Monterey Bay NMS Resource Protection staff continued to use *R4107* to inspect the 13 buoys array in Monterey Bay that marks marine boundary lines for a motorized personal watercraft (MPWC) zone within the sanctuary. The mission also accomplished three ancillary goals: 1) area familiarization for three Bay Net volunteers on-board, 2) vigilance for any regulatory violation activity, and 3) and a "show of the NOAA flag" nearshore of the Sports Fest Monterey event at Monterey Harbor. During the cruise, the mission team and boat crew opportunistically collected marine debris from sanctuary waters.



A drone hovers aboe the *Fulmar* during a California Whale Rescue Network training. Photo credit: CWRN



## Entangled Whale Rescue

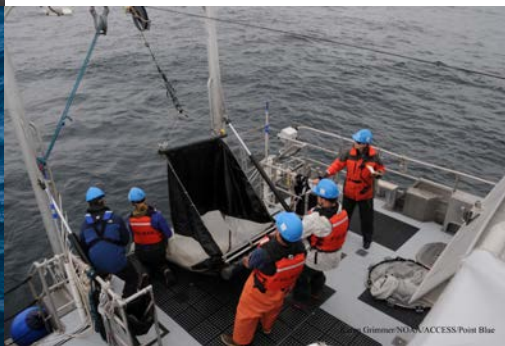
Entangled whale reports have been on the rise off the California coast peaking in 2016 with over 60 reports, a five-fold increase compared to prior years. The *Fulmar's* size, speed and small skiff make it a platform of choice for entanglement evaluation and disentanglement operation. The West Coast Regional Vessel Operations Team continue to increase its ability to respond to entanglements by undergoing specialized training and developing protocols with experts from other national marine sanctuaries, NOAA Fisheries Stranding Network, and the California Whale Rescue Network. During joint training sessions, the *Fulmar* crew led a workshop on navigation including hands on exercises on a variety of search patterns that could be used to relocate an entangled whale. The crew also provided training in small boat handling and basic survival skill at sea.



Members of the California Whale Rescue Network practice getting in and out the *Fulmar's* skiff. Photo credit: CWRN

A significant number of the 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, both spatial and temporal, between humpback whales and crab pot distribution. Because of the increased number of whale entanglements in commercial crab pots in the Monterey Bay area, the *Fulmar* conducted a special survey following the ACCESS protocol in May to collect data, model the co-occurrence of large whales and crab pots, and identify baleen whale hot spots in an effort to decrease the risk of entanglement of large whales in central California.

The team included Point Blue Conservation Science, Greater Farallones and Monterey Bay national marine sanctuaries, and was supported by The Nature Conservancy, the Ocean Protection Council and the Dungeness Crab Fishing Gear Working Group. The goal of the working group is to provide guidance and recommendations to the California Dungeness crab fishing industry, about how to avoid or minimize whale entanglements and identify measures or experiments that can be developed or implemented by the fishing community to address the entanglement issue.



Sightings of marine mammal, seabird, vessel, marine debris and crab pot are recorded from the *Fulmar's* flying bridge; and Tucker trawl samples krill and other zooplankton at 3 depths (above the seafloor, in the mid water close to surface).

Photo credit: K. Grimmer/MBNMS (*Fulmar* fly bridge and back deck) and P.Chetirkin/ONMS (Blackfooted Albatros and humpback whale)

## EDUCATION AND OUTREACH HIGHLIGHTS

### Supporting Oceanography Students

The use of the *Fulmar* and *R4107* in January and July provided students from the Naval Postgraduate School a unique opportunity to conduct real-world laboratory science in pursuit of their graduate education. Students from the Tactical Oceanography collected oceanographic and acoustic data sets in the middle of Monterey Bay NMS to analyze for class projects and learn about how environmental factors affect acoustic propagation and sensor performance. Students were able to successfully execute complex experiments in a couple of days and work with imperfect noisy data sets to derive results that help them learn and apply Navy-relevant principles in underwater acoustics.

### U.S. Senator Experiences Sanctuary

In April, Senator Gary Peters from Michigan spend a day on the *Fulmar* to experience Monterey Bay National Marine Sanctuary first hand. He completed two SCUBA dives in nearshore kelp forests off Cannery Row and Pacific Grove. Following the dives, the *Fulmar* headed out over the Monterey Submarine Canyon where a group of about 20 orcas was feeding on the remnants of a gray whale while seabirds swarmed the area looking for scraps. On the trip back to Monterey Harbor, the group spotted several humpback whales, including one individual engaging in vigorous tail slapping - perhaps 100 tail slaps in a 15 minute period. Senator Peters was genuinely inspired by this showcase day in the Serengeti of the Sea. Outreach to a member of Congress, including in this case the ranking member of the Ocean's Subcommittee on the Senate Commerce Committee, helps demonstrate the power of the conservation successes national marine sanctuaries can have in coastal communities across America.



Graduate students launched a mobile acoustic source known as EMATT (*top*) and deploying a drifting buoy with a GPS tracker and an acoustic receiver that records the EMATT signals (*bottom*).

Photo credit: NPS



*Above* - Mother and calf orcas

Photo credit: P. Chetirkin/ONMS

*Below* - December sunset in the smoke of the Thomas wildfire in Santa Barbara county during the *Fulmar* transit to the Ventura Harbor Boatyard.

Photo credit: C. Terrell/WCRO

## 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 and central California sanctuaries. The *Fulmar* crew has been essential to the success of ONMS mission. Investments in vessel operators and crew by the West Coast Regional Office Vessel Operations Team, enabled the vessels to be ready to respond with minimal notice for a wide variety of missions. The emphasis on training, safety, customer service and preventive maintenance contribute to make the *Fulmar* and *R4107* operation team, a model among the NOAA Small Boat Program. The *Fulmar* continue to be an icon for sanctuary research.

