

## Research Vessels *Fulmar* and *R4107* 2018 Accomplishments Summary in Cordell Bank, Greater Farallones, and Monterey Bay National Marine Sanctuaries



NOAA R/V *Fulmar* with U.S. Coast Guard Vessel 47224 during a Search And Rescue Exercise in March 2018. Photo Credit: C.Terrell, WCRO

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 2018, the vessels spent 98 days at sea and successfully completed 41 missions.

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

- Support area: 10,675 square miles
- Projects supported: 25
- Missions completed: 41
- Days at sea: 98
- Total participants: 737
- Number of SCUBA dives: 75
- Combined SCUBA diver bottom time: 63 hours



NOAA R/V *R4107* along side NOAA Ship *Bell M Shimada* during a personnel transfer off Monterey in April 2018. Photo Credit: B. Begun, NOAA Corps

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.

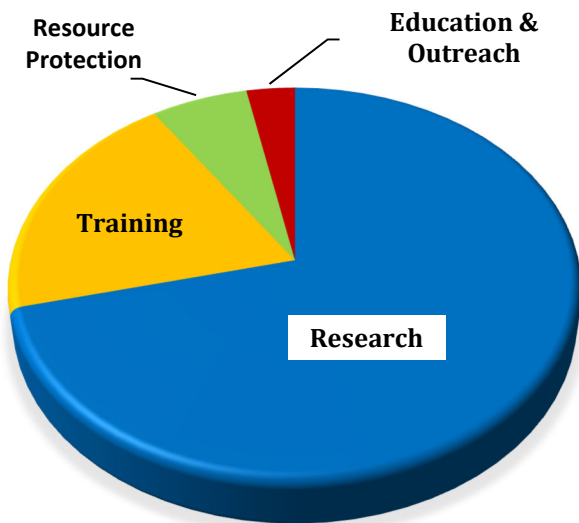
The *Fulmar* and *R4107* are specially designed and equipped to complete projects that fulfill the Office of National Marine Sanctuaries’ mission. The vessels support a wide variety of missions and provide access to offshore sites and extensive stretches of the coastline that cannot be reached by land.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

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



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

2019 Sea Days  
Per Mission Types



The majority (71%) of sea days aboard the *Fulmar* and *R4107* in 2018 were primarily 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.sanctuariesimon.org](http://www.sanctuariesimon.org). While only 3% 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. A significant proportion of the 2018 sea days (20%) were devoted for crew and mission participants training.

## RESEARCH HIGHLIGHTS

### Rapid assessment of fish population in deepwater high relief habitats

In October, a collaborative of scientists and engineers from multiple institutions, including Moss Landing Marine Laboratories (MLML), Monterey Bay Aquarium Research Institute, Marine Applied Research and Exploration, The Nature Conservancy and California State University Monterey Bay, Channel Islands NMS and the WCRO spent 24 days at sea on the *Fulmar* surveying fishes in rocky habitats using a Benthic Observation and Survey System (BOSS). The BOSS was specifically design to collect high definition video to survey fishes and macro invertebrates living in high relief habitat on the seafloor of the continental shelf and slope.

The team completed 419 visual surveys across 295 miles of coastline between Half Moon Bay in MBNMS and Anacapa Island in Channel Islands NMS. Deployment water depth ranged from 51 to 298 meters deep. The BOSS was equipped with a high-definition downward facing camera, which allowed to carefully set the tool down on rock habitat while avoiding sensitive invertebrate species such as sponges or corals. The more than 30 hours of high-definition video recorded over the course of this cruise will be processed at MLML in 2019 to obtain data on densities and mean lengths of fishes along the coast. At least 37 species were observed by the BOSS during this cruise, though this number will likely increase as detailed video analysis is conducted. This mission demonstrated that the BOSS is capable to rapidly assess fish populations at coastwide scales relevant to fisheries management. Other cruise highlights included observing large schools of Vermilion Rockfish, two Bluntnosed Sixgill Sharks behind Santa Rosa Island, and a variety of corals at Footprint State Marine Reserve. During a deployment in the Santa Barbara Channel, a group of five Humpback Whales swam around the vessel for about an hour.



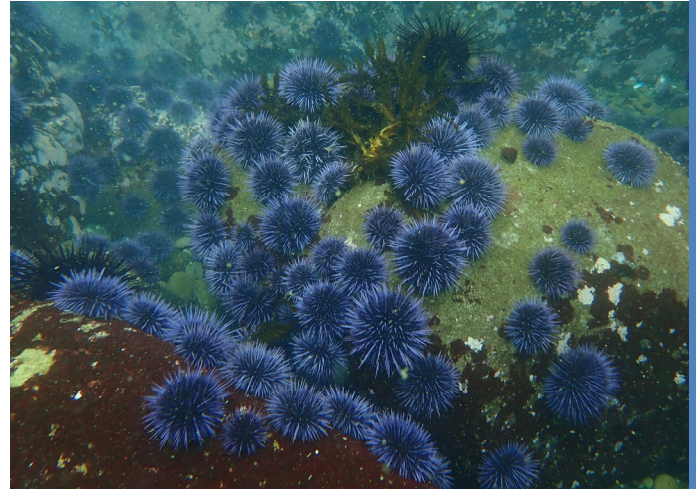
Clockwise starting left: BOSS on the back deck of the *Fulmar*, large school of Vermilion Rockfish (*Sebastes miniatus*), corals at Footprint State Marine Reserve, Vermilion Rockfish (*S. miniatus*), Bluntnosed Sixgill Shark (*Hexanchus griseus*).

### WCRO Vessels Support 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. The 13 foot inflatable skiff can deploy divers to and from shallow water sites that cannot be reached with the *Fulmar*. The inflatable is also used to access dive site close to the harbor and along Cannery Row in Monterey when the *Fulmar* is at her berth in Monterey.

#### Summary of Dive Statistics

Number of dives conducted:	75
Number of unique divers:	14
Total bottom time:	63 hours
Average bottom time:	51 minutes
Max Depth:	70 feet
Min Depth:	13 feet
Average depth:	45 feet
Enriched air Nitrox dives:	16%
Number of dive sites:	5



Purple urchins feeding on kelp, Ocean Cove.  
Photo Credit: CDWF

### Ecosystem monitoring off The Sonoma Lost Coast In Greater Farallones NMS



CDWF measured purple urchins test and gonad index on the back deck of the *Fulmar*. Photo Credit: CDWF

In July, divers from the California Department of Fish and Wildlife (CDFW) teamed with the NOAA Monterey dive unit divers to conduct a three day Rapid Assessment Survey off Fort Ross and Ocean Cove in Greater Farrallones NMS. Dive teams deployed from the *Fulmar* using her inflatable and three CDFW small boats to predetermined dive sites. NOAA divers completed 10 hours of fish survey while CDWF divers surveyed invertebrate with an emphasis on red abalone and purple urchin. Divers collected purple urchin from multiple depth strata and CDFW volunteers measured test diameter and recorded gonad index on the back deck of the *Fulmar*. This missions is part of long term research and montinotring ecosystem studies. Recent change in ocean conditions resulted in a shift from kelp forest ecosystems to purple urchin dominated systems. This shift is having major impacts important local fisheries including closing the recreational red abalone fishery, and negatively impacting the commercial red sea urchin fishery.

The loss of the kelp forest has potential future impacts to the sport fin fish fisheries. Collaborative research and monitoring effort on ecosystem assessments is a critical need for the north coast both in Sonoma and Mendocino County and elsewhere.

### SCUBA Diving survey off Big in Monterey Bay NMS

In October, Monterey Bay NMS Research team lead another 3 days SCUBA survey off the Big Sur Coast aboard the *Fulmar*. The initial goal of this mission was to survey subtidal site around the May 2017 massive landslide at Mud Creek in an effort to inform Monterey Bay NMS about what is happening at the slide site. Only one dive was completed at the toe of the slide, working from 68 ft deep to about 30 ft deep, when visibility deteriorated due to high turbidity and a plankton bloom, to an extent that diver could no longer collect data. The dive team conducted SCUBA survey at two other long term monitoring sites instead, Palo Colorado and south Wreck Beach to collect data on algae, invertebrates and fishes size, diversity and abundance.



Fish-eating anemone (*Urticina piscivora*).  
Photo Credit: CDWF

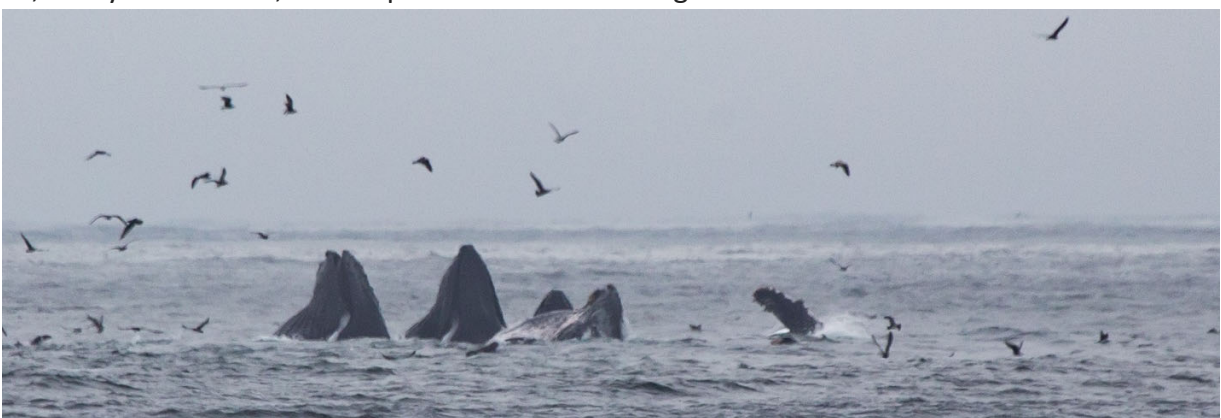
### Monitoring the California Current Ecosystem

The Applied California Current Ecosystem Studies (ACCESS) project completed two cruises on the *Fulmar* in May and September. Now in its fifteenth year, the project is a collaboration between Cordell Bank and Greater Farallones NMS and Point Blue Conservation Science to monitor ocean ecosystem health off the coast of San Francisco. The project measures oceanographic parameters, prey availability, and predator distribution and abundance on pre-determined transect lines three or four times a year using the *Fulmar* and NOAA ships. In May the spring upwelling conditions made for rough seas but good ocean productivity indicated by abundant plankton and whales. The September cruise had exceptionally calm seas but foggy conditions that made observations challenging. Highlights included lunge feeding humpback and blue whales concentrated near the shelf break, where they normally occur. Seabird sightings included resident post-breeding season Common murrelets, Cassin's auklets, Rhinoceros auklets and transient various species of shearwater, fulmar, phalaropes, and numerous storm-petrels. The scientists were joined by funders, media, advisory council members, and John Armor, ONMS Director and NOS Acting Deputy Director. The collaborative ACCESS project works to understand status and trends of sanctuary resources, ecosystem health, and response to climate change.



Above - A Laysan Albatros (*Phoebastria immutabilis*) flew by the *Fulmar* during ACCESS. Photo Credit: *Fulmar* crew, WCRO

Below - Humpback whales lunge feeding.  
Photo Credit: R.Anderson, ACCESS/NOAA/Point Blue





Cordell Bank NMS protects a vibrant invertebrate and rockfish community.

Photo: Robert Lee/BAUE

### Monitoring Oxygen Level in Cordell Bank NMS

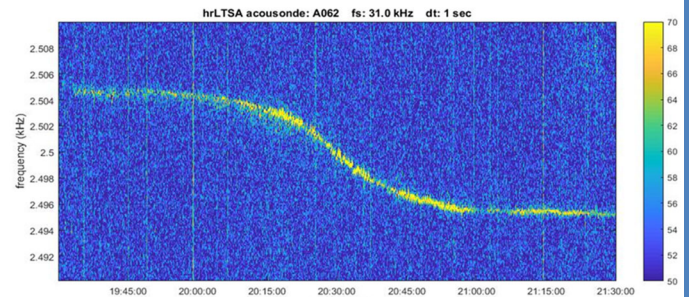
In July, Scientists from University of California Davis Bodega Marine Laboratory and WCRO used the *Fulmar* to recover and deployed oceanographic sensors from two light weight moorings. These moorings are part of continued hypoxia, or low level of oxygen, monitoring at Cordell Bank, which began in 2014. This work is essential to understanding patterns of low oxygen in the ocean and the effects it has on marine wildlife – important information for effectively protecting ocean ecosystems. Hypoxia in the ocean can be the result of natural processes and of human activity, particularly climate change. Long-term ocean monitoring indicates oxygen in the ocean has declined since the 20<sup>th</sup> century and hypoxic zones have proliferated around the world. Marine animals that do not typically experience low oxygen concentrations may not be well-adapted to survive, therefore low oxygen concentrations can result in behavioral changes, stress, or mortality. If long-term, large-scale low oxygen conditions were to occur in Cordell Bank NMS, it could be devastating to the abundant marine life there. This work will help scientists and sanctuary managers understand how the biodiversity at Cordell Bank may be impacted by hypoxia and could inform improved conservation management of the sanctuary.

### Partnering with the Naval Postgraduate School to study Monterey Bay NMS.

In 2018, Researchers from the Naval Postgraduate School continued to use the *Fulmar* and *R4107* to conduct science and education missions that studied oceanographic and physical properties of the Monterey Bay NMS. In addition to providing an opportunity to conduct real-world laboratory science, the collected data supports graduate students class projects and theses.

### Support for NPS Tactical Oceanography Class

In February, the NPS Tactical Oceanography class conducted a two-day field experiment in central Monterey Bay operating from the *R4107*. Each day, three NPS acoustic receivers were deploying from drifting buoys in the vicinity of MBARI's MARS hydrophone at Smooth Ridge. Mobile acoustic sources were deployed each day generating low-level acoustic tones as they transited across the Sanctuary. The students used the data to develop projects for the class focused on acoustic propagation. One group focused on tracking the mobile source based on Doppler-shifted acoustic signals received on the buoys and MARS hydrophone. Another group measured the performance of the simple passive sonar system of distributed hydrophones. The capabilities of the *R4107* was key to the success of the experiment. Her speed and ability to easily operate in the outer sanctuary allowed an experiment design that could be executed in one day, allowing students to test fundamental principles of a passive sonar system, a key objective of the class.

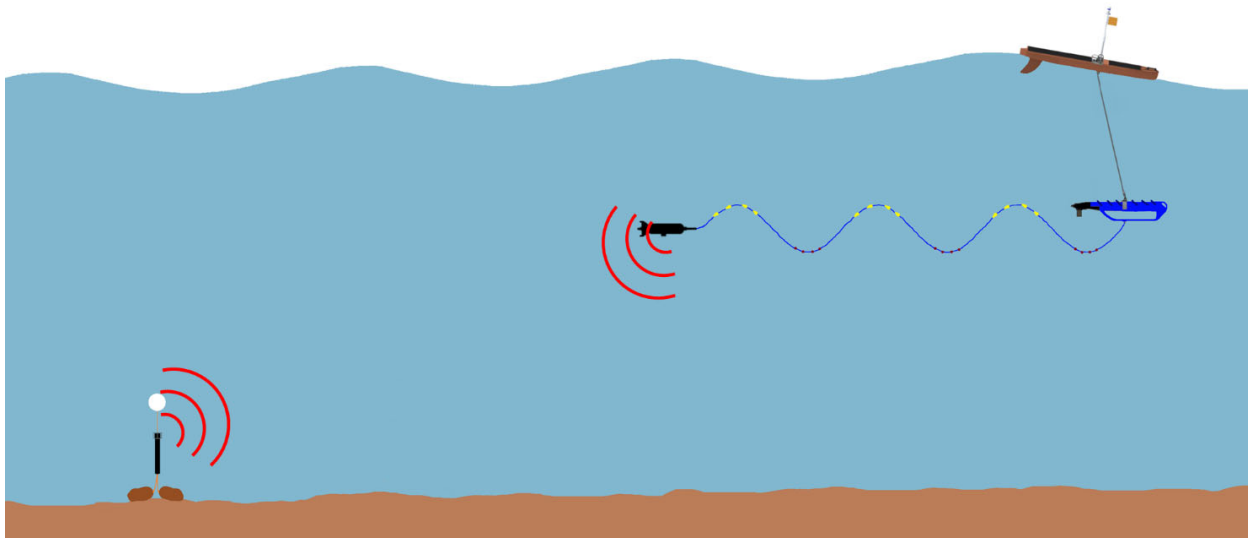


Doppler-shifted acoustic data collected on a drifting buoy is used to reconstruct the path taken by a mobile sound source.

In July, the class deployed drifting buoys from the *Fulmar*, a mobile source, and transmitted a low-level signal from a dipped source off the vessel to collect acoustic data to demonstrate the principles of active sonar tracking of a mobile source.

## Environmental Sensing and Networking with Autonomous Platforms

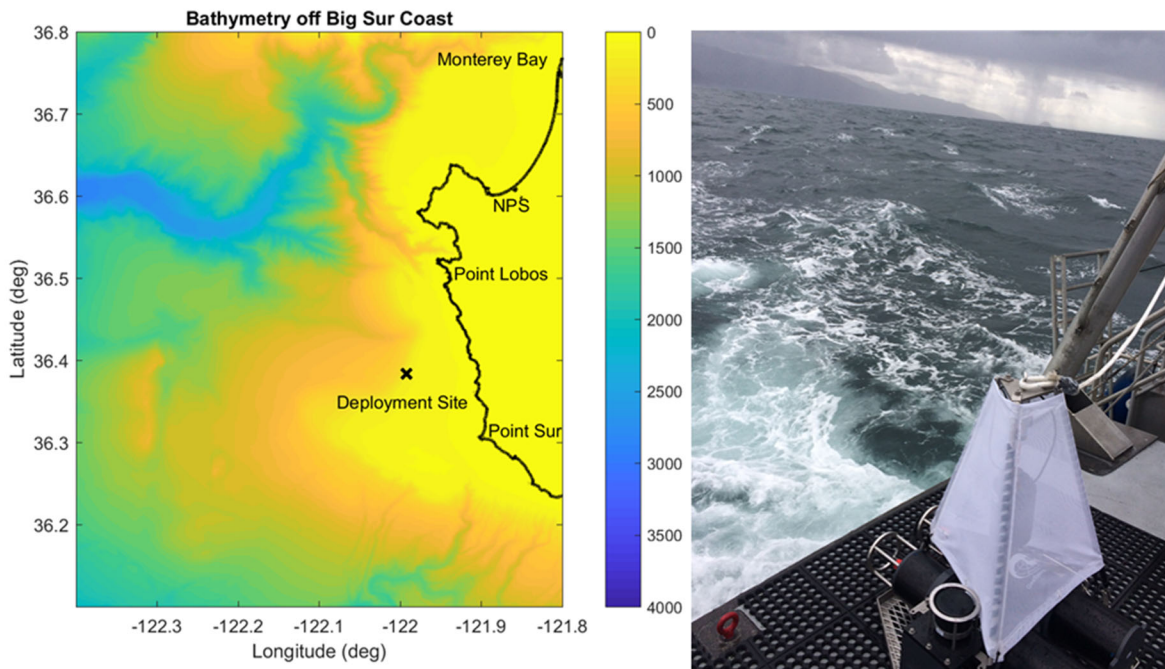
In April, the NPS Physics Department tested and evaluated Directional Acoustic Modems ability to localize submerged assets. This was the second such test of its kind (the first occurred in 2017), and focused on evaluating the performance of directional acoustic modems deployed from autonomous surface vehicles known as Wave Gliders. An echo repeater modem was placed near the seafloor to emulate a submerged asset. Tests were conducted over 3 days during daylight hours comprised of having the Wave Gliders run patterns in the vicinity of the echo repeater while transmitting signals to determine range and bearing between the assets. The results of this test identified several deficiencies in the systems, which we hope to address in 2019. Details of the analysis can be found in the NPS thesis by LT Leander van Schriek of the Royal Dutch Navy (June, 2018).



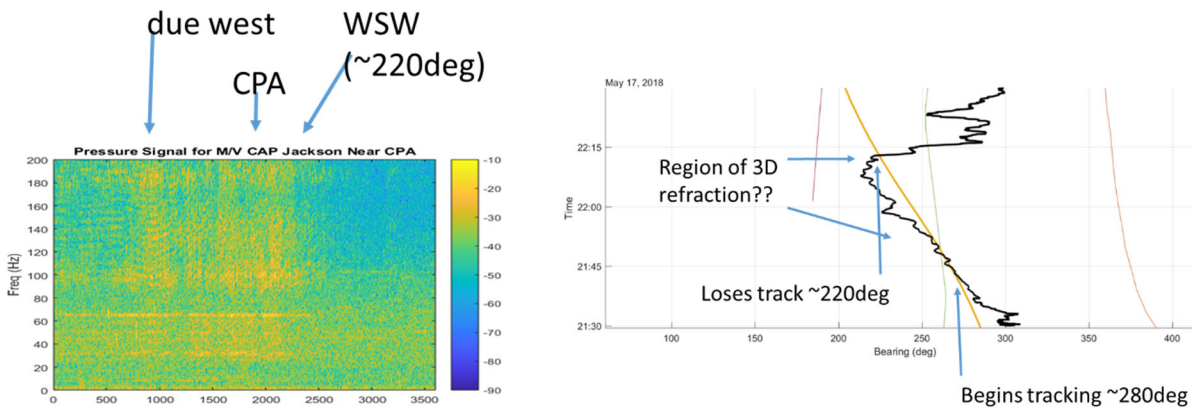
Depiction of assets used in test and evaluation of directional acoustic modems. An echo-repeater was moored with biodegradable burlap sandbags. Comms testing was accomplished using Wave Glider vehicles towing directional acoustic modems in tow-bodies.

In May, NPS evaluated the performance of Directional Acoustic Sensor off Big Sur Coast. In this test, a stand-alone, passive, directional acoustic sensor (produced by GeoSpectrum Technologies, Inc.) was placed on the seafloor off the Big Sur coast in about 150m of water near the edge of the shelf break. The goal of this test was to evaluate the performance of this directional acoustic sensing system in detecting passing merchant ships and tracking their bearings relative to the system during transit. In addition to the system deployment, numerous CTD casts were conducted in the area using the *Fulmar's* A-frame winch.

This test proved reasonably successful, and NPS is planning a similar test in 2019. One of the most interesting features observed was the degree to which the underwater ridge extending out from Pt. Sur created a shield from acoustic energy propagating to the system at bearings more southerly than about 220deg. There is also preliminary evidence of 3D refraction of the acoustic energy from the edge of the ridge. As a result, our next test will attempt to place the system on top of the underwater ridge to avoid such shadowing and 3D refraction. A more detailed presentation of results was provided at the Nov, 2018 meeting of the Acoustical Society of America meeting. In addition to bearing estimates, acoustic propagation models have been employed to estimate the source levels of such passing merchant vessels. This work is on-going and will be the focus of the thesis by LT Steve Seda of the US Navy.



Deployment location for GeoSpectrum system (left) and GeoSpectrum system prior to deployment (right).



Spectrogram of acoustic data collected during passage of M/V CAP Jackson(left) and comparison of estimated bearing (black line) with AIS-derived bearing data (orange line, right).

### Autonomous glider operational test

In July 2018, the *R4107* was used to deploy and recover a NPS Slocum glider for a 1-week long test. The purpose of the experiment was to test controlling the glider using a new remote piloting system installed at NPS. The test was 100% successful and the capabilities of the *R4107* were instrumental to the success. Her speed enabled the team to get to the deepwater site quickly, and the ample deck space and the boom made easy work of launching and recovering the glider.

### Listening to the Sanctuary

In November, NPS deployed three passive acoustic recorder moorings from the *Fulmar* to kickoff the Monterey portion of a joint NOAA/Navy managed project that will characterize the soundscape of National Marine Sanctuaries. One day was used to deploy a High-frequency Acoustic Recording Package (HARP) at Sur Ridge. The second day was used to deploy two Sound Trap ST500 moorings, one near Soquel Canyon and the other near Point Pinos. All recorders are expected to be in the water for 6 months when they will be replaced. The range and speed of the *Fulmar* made each day very successful, completing work in far less time than expected.



## RESOURCE PROTECTION HIGHLIGHTS

### Observing the Squid Fishery off Monterey

In April and May, Monterey Bay NMS staff conducted a series of six missions from the *R4107* to observe and document interactions between the California squid fleet and marine mammals following a report of entangled Risso's dolphins. Squids spawn in nearshore waters of Monterey Bay, and Risso's dolphins and California Sea Lion forage on them. During all the missions, the squid fleet was following best practices and releasing marine mammals as needed from their nets. No dolphins were observed in the nets although they sometimes occurred in the area. Juvenile and mature sea lions moved in and out of the nets. The juvenile animals seemed more easily caught as the seines closed and one had to be prodded with a boat hook to swim out.



Fishing vessel hauling her catch close to shore off Pacific Grove. Photo credit: MBNMS

## EDUCATION AND OUTREACH HIGHLIGHTS

### Get In Your Sanctuary

In July, Monterey Bay National MMS kicked off special events for 2018 "Get Into Your Sanctuary" activities by hosting military veterans on the *Fulmar*. Approximately 30 veterans from around Monterey Bay joined for a day of wildlife watching, marine science and education about national marine sanctuaries and the resources they protect. Congressman Jimmy Panetta, a distinguished veterans, participated to the event and praised ONMS for providing special opportunities for veterans to get out and get in national marine sanctuaries. Highlights included tremendous amounts and diversity of wildlife, in particular lunge-feeding humpback whales. Get Into Your Sanctuary activities occurs nation-wide to promote the values national marine sanctuaries provide the nation, and encourage all Americans to get out and in a national marine sanctuary.



Veterans sampling plankton during the get In your Sanctuary kickoff cruise aboard the *Fulmar*. Photo credit: MBNMS



Humpback whales and seabirds feeding in front of the *Fulmar* during "Get in Your Sanctuary" cruise in Monterey Bay. Photo credit: J. Frediani

### **High School Students Tour the *Fulmar***

In March 29, WCRO hosted 16 students from the Carmel High School AP Spanish class dockside aboard the *Fulmar*. Students were introduced to national marine sanctuaries and current marine conservation issues, learned about conducting research at sea, and had the opportunity to pilot a Remotely Operated Vehicle (ROV) in Monterey harbor. The field trip was designed to expose students to marine sciences and conservation, a significant facet of the Monterey Bay area community. The instructor required each student to rely on the new ONMS Spanish-language web offering for research on sanctuaries. Each student wrote an essay based on their experience on the *Fulmar* or an issue they read about on the ONMS website.

### **PERSONNEL PROFICIENCY AND TRAINING**

Personnel qualifications and readiness is essential to the safety and success of WCRO vessel operations. WCRO dedicated 19 sea days for crew proficiency and training with partners. In addition to conducting emergency and safety exercise, training also included skills development for wave gliders and whale disentanglement operations.

#### **Entangled Whale Response preparedness**

Entangled whale reports haven 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 operations. The WCRO operations team continued 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 two one-day joint training sessions in March and June, members of the WCRO personnel practiced simulated whale approaches, vessels and trailing lines handling, buoy attachments and radio tracking. The *Fulmar* towed a line with floats to simulate and entangled whale, and the training participants practiced approaching and grabbing the line from small skiff using a variety of techniques and tools. After having securing control of the line, participants practiced managing a line under tension and attaching a telemetry buoy.



Practicing line handling during a simulated entangled whale training.  
Photo credit: ONMS

Re-sighting an entangled whale is a challenge for a rescue team, and one of the main goals of the training was provide skills to Monterey-based sanctuary personnel that will eventually enable them to attach a telemetry buoy on an entangled whale. The telemetry buoy allows rescuers to track a whale's movement using radio frequency and satellites signals, and provide valuable additional time to assemble a team of experts to attempt to set the whale free.

Although WCRO vessels did not respond to an actual entanglement in 2018, a member of the team participated in two disentanglement operations in Monterey Bay out of Moss Landing and Santa cruise on others California Whale Rescue Network vessels.

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## Multi Agency Emergency Response Training

In March the *Fulmar* and *R4107* participated to a multi-agency Search and Rescue exercise in the Monterey Bay led by U.S. Coast Guard Station Monterey. The objective was to simulate a large passenger vessel collision and evaluate local response efforts. Other participants included Monterey Fire Department, Monterey County Emergency Communications, Monterey County Sheriffs Aero Squadron, Monterey Harbor Office and USCG Auxiliaries. In November the *Fulmar* acted as a vessel in distress during US. Coast coxswain tow training during rough weather conditions off Point Pinos at the southern edge of Monterey Bay.

## Cutting Edge Technologies to Sample the Sanctuaries

In December, WCRO vessel operation team members participated in a two days hands on training on new deployment and recovery procedures for SV3 Wave Gliders. The first training day conducted at Liquid Robotics (LRI) headquarters in Sunnyvale, CA, focused on vehicle familiarization and pre-launch procedures. During the second day, a series of launches and recoveries were conducted at sea using the *Fulmar's* crane and A frame, and a newly developed LRI RAPID stand deployment system. The training provided proof of concept, test data to support RAPID stand standard operation procedure refinement, and operational photo and video for use in future training materials development. 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.

## 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, enable 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.



*Fulmar* crew about to receive rescue equipment from US Coast Guard during a search and rescue exercise

Photo credit: j.de Marignac, WCRO



Getting ready to launch a Wave Glider using the *Fulmar* A Frame.

Photo credit: j.de Marignac, WCRO

