NOAA DIVING PROGRAM

2016 Annual Report

Cover photo: NOAA Diver Melissa Neuman inspecting an acoustic receiver, mooring weight and range test tag off of the San Diego coast for an abalone behavior study.
David Witting/NOAA

Painted wrasse and sargassum. Greg McFall, NOAA

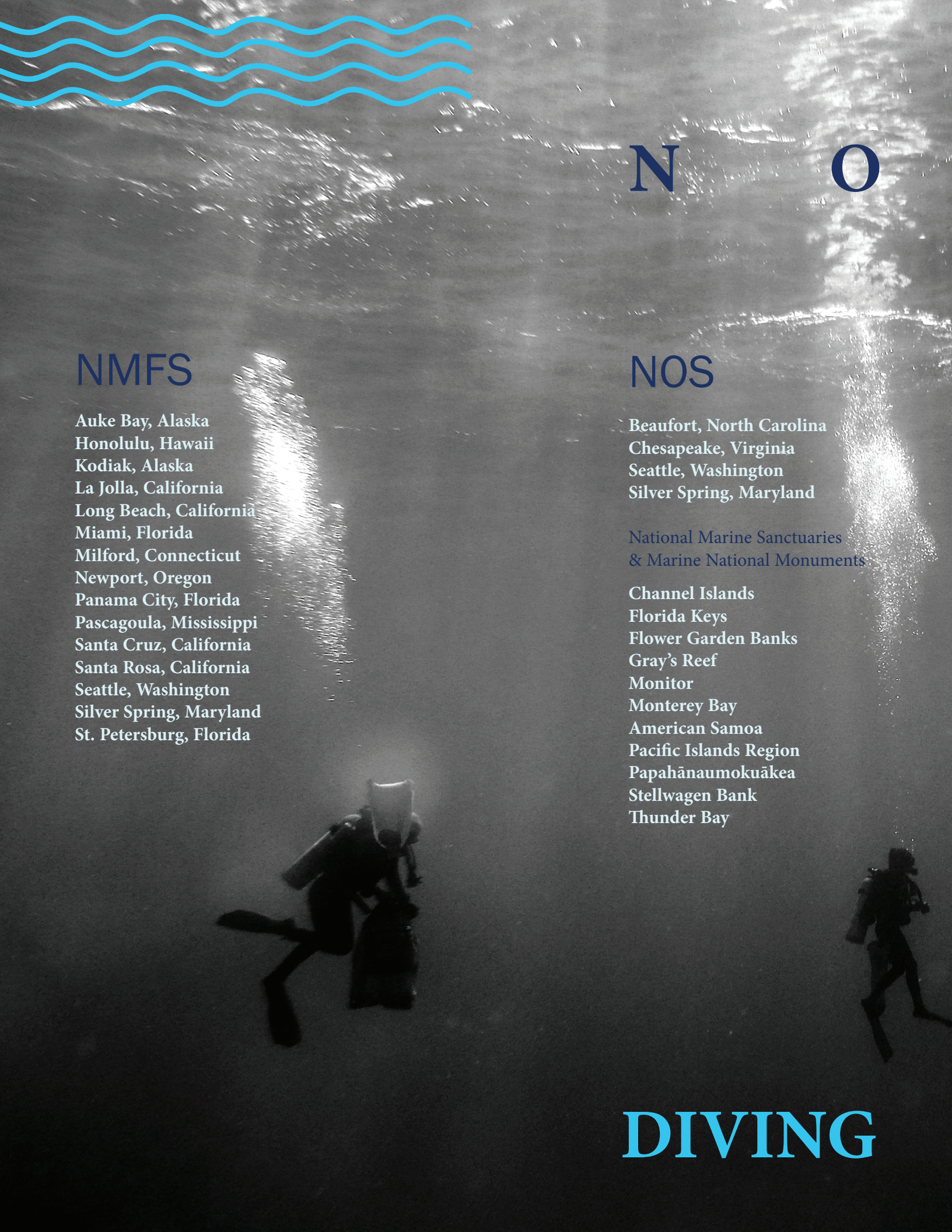
NOAA DIVING PROGRAM

The NOAA Diving Program (NDP) oversees all diving that is performed on behalf of NOAA's scientific research and operations.

The NOAA Diving Program, or NDP, is administered by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), Office of Marine and Aviation Operations (OMAO) and is headquartered at the NOAA Diving Center in Seattle, Washington. Its mission is to train, certify and equip scientists, engineers, and technicians, while promoting innovation of effective diving technologies, and safely performing underwater operations.

With 375 active divers, NOAA has the largest complement of divers of any civilian federal agency. The NOAA Diving Program establishes standards and safety procedures for conducting various types of diving in support of NOAA's mission.

The NOAA Diving Program's vision for the future is to lead the nation in the advancement of diving safety, education, training, innovation and execution of underwater operations in support of science, service and stewardship.



N O

NMFS

Auke Bay, Alaska
Honolulu, Hawaii
Kodiak, Alaska
La Jolla, California
Long Beach, California
Miami, Florida
Milford, Connecticut
Newport, Oregon
Panama City, Florida
Pascagoula, Mississippi
Santa Cruz, California
Santa Rosa, California
Seattle, Washington
Silver Spring, Maryland
St. Petersburg, Florida

NOS

Beaufort, North Carolina
Chesapeake, Virginia
Seattle, Washington
Silver Spring, Maryland

National Marine Sanctuaries
& Marine National Monuments

Channel Islands
Florida Keys
Flower Garden Banks
Gray's Reef
Monitor
Monterey Bay
American Samoa
Pacific Islands Region
Papahānaumokuākea
Stellwagen Bank
Thunder Bay

DIVING

A A

OAR

Miami, Florida

OMAO

NOAA Diving Center

Seattle, Washington

NOAA Ships*

Norfolk, Virginia (MOC-A)

Ferdinand R. Hassler
Gordon Gunter
Henry B. Bigelow
Nancy Foster
Okeanos Explorer
Oregon II
Pisces
Ronald H. Brown

Newport, Oregon (MOC-P)

Bell M. Shimada
Fairweather
Oscar Dyson
Rainier
Reuben Lasker

Honolulu, Hawaii (MOC-PI)

Hi'ialakai
Oscar Elton Sette

*Marine Operations Centers are located in the Atlantic (MOC-A), Pacific (MOC-P), and Pacific Islands (MOC-PI)

UNITS

NOAA Divers during a safety stop.
Noah Pomeroy/NOAA

2016

Program HIGHLIGHTS

Attendees at the 2015 Unit Diving Supervisor (UDS) Workshop. NOAA

The NOAA Diving Program had another busy and successful year in 2015.

Several ongoing efforts saw significant progress, and other important projects were intitiated. NOAA had another great year for diving safety, with 11,116 dives completed successfully. The few minor incidents reported were reviewed with valuable lessons learned. We continue to see increases in our metrics as is noted below in "By the Numbers" which also means that we need to remain vigilant to ensure that we're keeping our divers and our diving as safe as is possible. Here are some of the highlights of the accomplishments of 2015.

NDP Manager Greg McFall working as a rebreather Safety Diver in November, 2015. Jason Leonard/NOAA

Unit Diving Supervisor Workshop

We held a very successful UDS workshop in Seattle this past year and all but two of our UDSs were able to make it out for the event. We started the week off with Divers Alert Network (DAN) Instructor Training where the UDSs who elected to participate learned how to become instructors for First Aid, Automated External Defibrillators (AEDs), Oxygen Administration, Hazardous Marine Life Injuries, and Neurological Assessment, resulting in a DAN Diving First Aid for

Professional Divers instructor certification. NOAA Divers are required to take the first three courses initially and to recertify every two years, and are encouraged to refresh their skills frequently throughout the year. Many of our sites were having problems finding instructors in their area or paying exorbitant costs to get their divers trained. This led us to decide to have a couple of people at the NOAA Diving Center trained to become DAN Instructor Trainers so we could teach the UDSs and other key people within the program how to train their own divers. By doing this we enabled the instructors to increase their efficiency and effectiveness without increasing costs to their programs or platforms.

> "... NOAA Diving Center [staff] trained to become DAN Instructor Trainers so we could teach the UDSs and other key people within the program how to train their own divers."

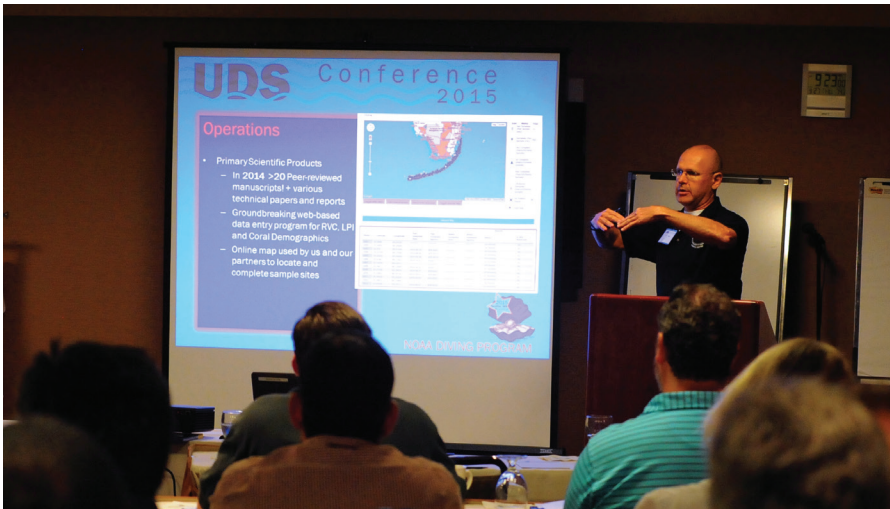
The next few days included presentations on: leadership and supervision by OMAO's Chief Learning Officer, Scott Tessmer; updates on the newly implemented modularized training program; updates on standards, policies and procedures; medical standards and problem solving scenarios; diving incident reporting procedures; and site updates and familiarization from all the UDSs.

The last official day of the workshop was spent on relevance and visioning exercises targeted at how to convey the important work performed by NOAA Divers in a manner that directly ties NOAA's mission to its mandates. The eight mandates to which NOAA Divers directly contribute are:

- Magnuson-Stevens Act
- National Marine Sanctuaries Act
- Historic Preservation Act
- Coastal Zone Management Act
- Endangered Species Act
- Marine Mammal Protection Act
- Coast and Geodetic Survey Act
- Marine Debris Research, Prevention and Reduction Act

New Regulators

While our Oceanic regulators have provided many years of great service, we recognized at some point we would need to find a replacement. Reports from NOAA diving units indicated that the Oceanics were just



Unit Diving Supervisor (UDS) Jack Javech shares information about his unit (NMFS, Southeast Fisheries Science Center, Miami, FL) during the 2015 UDS Workshop.
Nick Jeremiah/NOAA

> “[The new Mares regulators] are well tested, robust, and will serve our needs well in the years to come.”

not robust enough to endure the conditions of NOAA diving in the field. Some units reported that the exhaust tees would break of and were impossible to put back on, while others reported the regulators “breathing wet” when inverted.

We began our search by talking with the U.S. Navy’s Experimental Diving Unit (NEDU), who at the time was looking for a regulator replacement as well. Because NEDU conducts rigorous testing on all of the diving equipment they evaluate before they accept anything for use by their divers, we waited on their final report before selecting a replacement for NOAA. After completing their evaluation, NEDU had very good things to say about the Mares regulators. Of particular note, NEDU tested and aproved the Mares units for cold water use. This advantage over the Oceanic regulators as well as the general ruggedness indicated by the NEDU testing led us to select the Mares units as the new regulator for the NOAA Standardized Equipment Program (SEP).

Since regulators are the single most critical piece of life support equipment our divers use, we wanted to ensure that we were getting the best equipment to support the important work being done in the field. This was not a decision that we made lightly or took for granted based on the best price point. The former National Marine Fisheries Service (NMFS) Line Office Diving Officer (LODO) used to say, “one size fits none” and we realize that not everyone will be happy with the switch to the new Mares regulator. In particular, we realize that not all NOAA Divers require the improved cold water performance the Mares afford. However, we are confident that they are well tested, robust and will serve our needs well in the years to come.

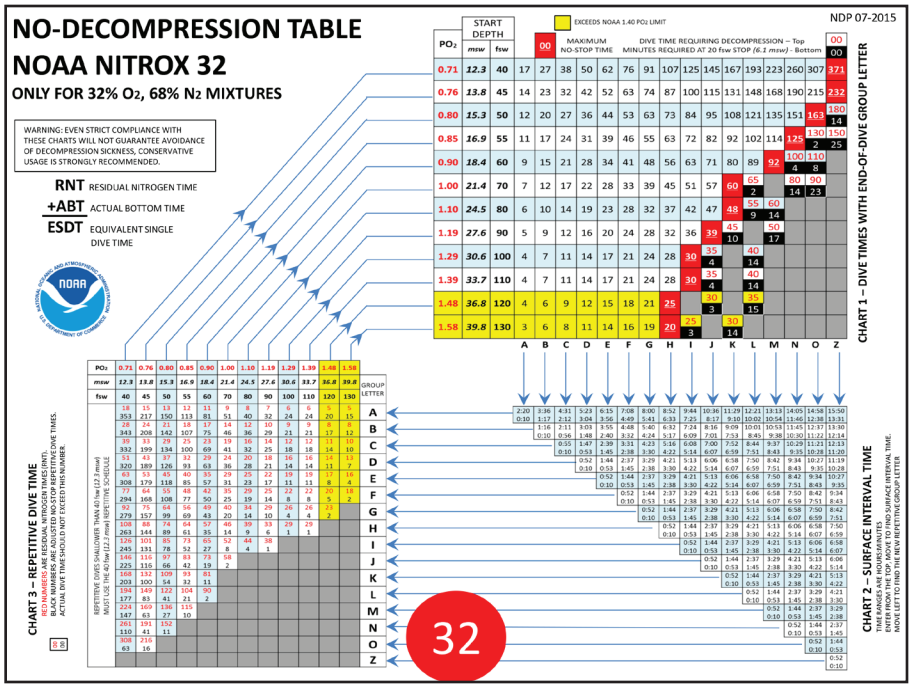
NOAA Diver students practice a beach exit in Panama city, FL. They are using the new Mares regulators.
Greg McFall/NOAA

Change in the PO_2 limit

In 2015, on the recommendation of the Diving Medical Officer (DMO), the NOAA Diving Control and Safety Board voted unanimously to reduce the maximum partial pressure of oxygen (PO_2) exposure from 1.6 ATA to 1.4 ATA. A PO_2 of 1.6 ATA has long been considered the maximum exposure to which a diver should be subjected. Because this level was set as a maximum exposure limitation, it does not leave any margin for error. The U.S. Navy, the recreational diving community, and the Divers Alert Network (DAN) all recommend a maximum PO_2 of 1.4 ATA.

Oxygen tolerance and Central Nervous System (CNS) toxicity are not

No-Decompression Table for Nitrox 32% oxygen mixture, reflecting change to a maximum PO_2 of 1.4 ATA. NOAA



well understood by the scientific community, and empirical data is hard to come by. Back in the day, the U.S. Navy would put their diver candidates in a chamber and on 100% oxygen at 60 feet (PO_2 = 2.82) to see if they would succumb to CNS toxicity; if you got CNS toxicity, you were not allowed to go to U.S. Navy Diving School. What they found over the years was that one person would get CNS toxicity one day and not on another, even though the conditions were identical. Other factors like certain medications and level of stress or exercise at depth on a high PO_2 were also thought to be contributing to CNS toxicity.

We conducted a poll of the Unit Diving Supervisors (UDSs) to see what impacts a change in PO_2 might have on operations. While a couple of sites were impacted, they were able to accommodate the change by reducing the fraction of oxygen (FO_2) in the mixtures needed to get them to their deeper sites. The NOAA Diving Control and Safety Board has developed new Nitrox tables which reflect the change in the fraction of oxygen and the depths to which they can be dived without exceeding a PO_2 of 1.4 ATA. There are 13 tables, one for each percentage between 28 and 40%. These tables include PO_2 levels for each depth and still include PO2 values up to 1.6. However all depths where PO_2 levels exceed 1.4 are highlighted in yellow and are to be avoided for planning purposes. They are only included in the event a diver exceeds the planned maximum depth. Additionally, there are four tables with dive schedules highlighted in orange (37-40%); these dives exceed the maximum PO_2 single exposure limit and should also be avoided. The new tables are available on the NOAA Diving Program website and should be printed and retained at the unit for planning and reference.

> “In 2015, the NOAA Diving Control and Safety Board voted unanimously to reduce the mazimum partial pressure of oxygen (PO_2) exposure from 1.6 ATA down to 1.4 ATA.”

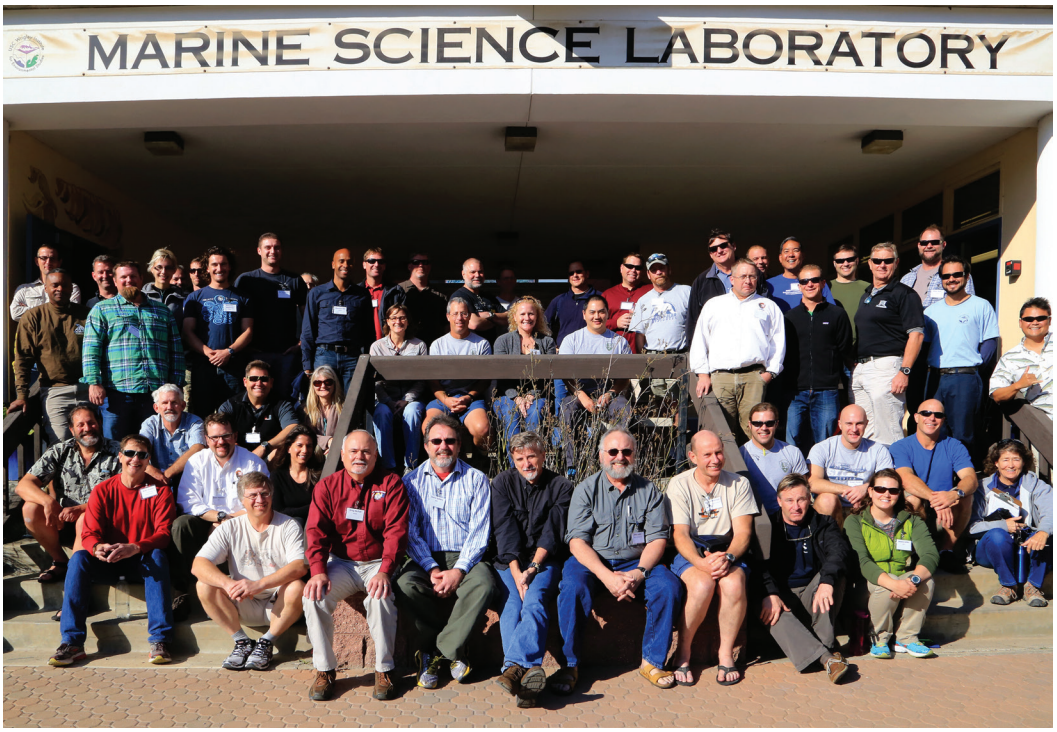
> “[Unit Diving Supervisors] are the final arbiters for all diving related decisions at the unit level, including when dives occur, how the dives are executed, and who goes in the water.”

Unit Diving Supervisor’s Manual

The UDSs hold arguably the most important positions in the NOAA Diving Program. They are the final arbiters for all diving related decisions at the unit level, including when dives occur, how the dives are executed, and who goes in the water. They are also the conduit between the NOAA Diving Control and Safety Board and the divers at the field sites, explaining policies and procedures down the chain and elevating concerns and needs up the chain.

The retooling of the NOAA Diving Program over the past 8 years has come with some attendant “growing pains” in terms of how the program is administered and what forms or pre-authorizations are required to conduct a given activity. While this administration is aimed at keeping our divers safer, it can be overwhelming at times to know when a report is due or what form needs to be sent in to document the activities that we undertake.

The current NMFS LODO Andy David spearheaded a project to coalesce all the information a UDS needs to know to administer their site. The resulting 181 page compendium is an excellent resource guide for the UDS community and Divemasters who assist them. It was approved by the NDCSB and distributed to all NOAA diving sites. UDSs have been asking for such a reference for many years and thanks to the dauntless efforts of Andy, we now have a very useful and functional tool that will be updated from time to time as necessary. Thank you to all the UDSs who do such a great job keeping our sites and our divers as safe as they can be. Keep up the excellent work!



Attendees of the CCR Best Practices Workshop at the USC Wrigley Marine Institute, co-hosted by NOAA, NPS, DAN and AAUS. NOAA

Closed Circuit Rebreathers

As NOAA continues its use of Closed Circuit Rebreathers (CCRs), we are continuing to look at and talk with other programs that are using the technology so we can better identify and implement the best practices in the field. To this end, NOAA partnered with the National Park Service (NPS), Divers Alert Network (DAN), and the American Academy of Underwater Sciences (AAUS) to co-host a CCR Best Practices Workshop at the University of Southern California (USC) Wrigley Marine Institute on Santa Catalina Island in February. Experts from across the world presented information on best practices and considerations in areas such as standards, safety, physiology, incidents and equipment evolution. The primary goals were to enhance cross-agency communication and to produce a best practices template available to the larger CCR diving community. The program involved 18 hours of structured sessions over three days - lecture, discussion, and practical - with unstructured time for additional interactions. The proceedings from this event are in review and will be published in 2016.

In our program, we have seen some growth in the use of CCRs and have reached new milestones with use of the technology. Two divers from Thunder Bay National Marine Sanctuary were trained on the use of the Innerspace Systems Corporation "Megalodon" rebreather and will begin using them in 2016 on projects in the field. Divers at both Monitor National Marine Sanctuary and Thunder Bay were able to take additional training in 2015 to increase their ability to safely dive to deeper depths. Divers from the Papahānaumokuākea Marine National Monument were able to increase their depth limit to 300 feet and are using the technology safely to characterize the mesophotic depths in the Monument, main Hawaiian islands, and National Marine Sanctuary of American Samoa.

Papahānaumokuākea rebreather divers at Hawaiian Islands Humpback Whale National Marine Sanctuary.
Louise Giuseffi/NOAA

Chair of the Board

At the 2015 NOAA Diving Control and Safety Board (NDCSB) annual meeting, Ms. Kimberly Roberson, NOS LODO and the National Centers for Coastal Ocean Science (NCCOS) UDS in Silver Spring, MD was elected the Chair of the NDCSB. While she is not the first woman to serve on the NDCSB, she is the first to serve as Chair. Kim has been diving with NOAA for almost 11 years and has over 1400 dives logged. Her unit has an excellent safety record and she is dedicated to promoting safety, efficiency and effectiveness across the Program.

"Kimberly Roberson, NOS LODO and the National Centers for Coastal Ocean Science (NCCOS) UDS in Silver Spring, MD was elected the Chair of the NDCSB."

BY THE NUMBERS:
A quick look at NOAA dives in 2015

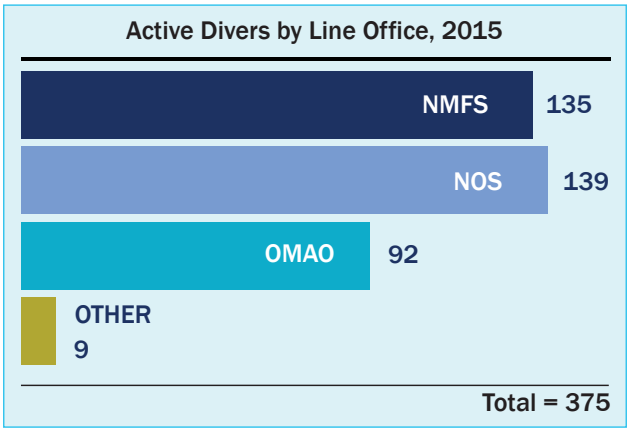


Figure A. Active divers by Line Office, 2015.

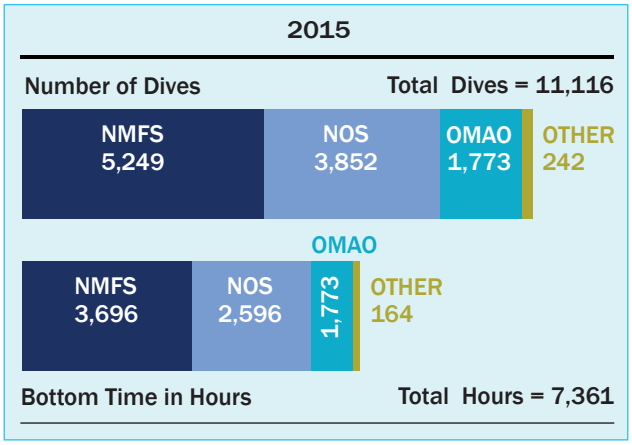


Figure B. Dives and bottom time, 2015.

The majority of dives at NOAA are conducted by the National Marine Fisheries Service (NMFS), the National Ocean Service (NOS) and the Office of Marine and Aviation Operations (OMAO). NMFS continues to lead all other Line Offices in the number of dives and total bottom time. (**Figures A** and **B**.) However, NOS lays claim to the deepest operational depths achieved at 300 fsw. The Line Office conducting the majority of OSHA-classified working dives continues to be OMAO. (**Figure C**)

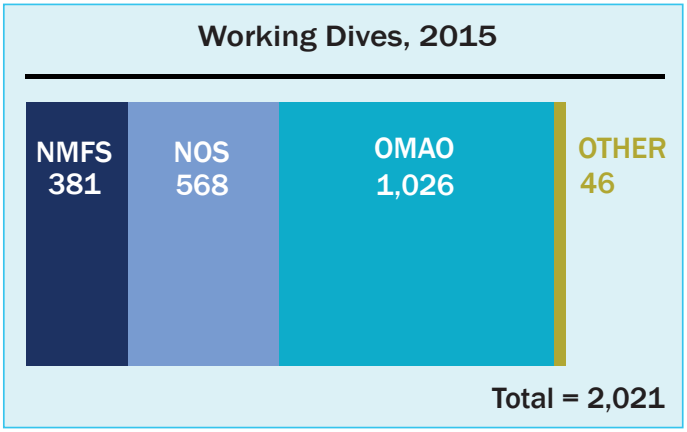


Figure C. OSHA-classified working dives, 2015.

> "We continue to show increases in all of our metrics [since 2013]"

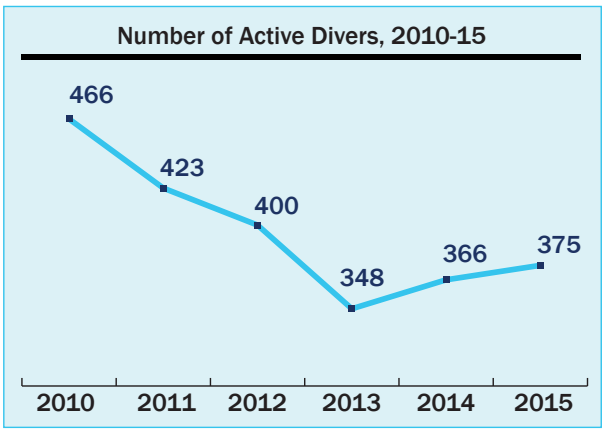


Figure D. Number of active divers, 2010-15.

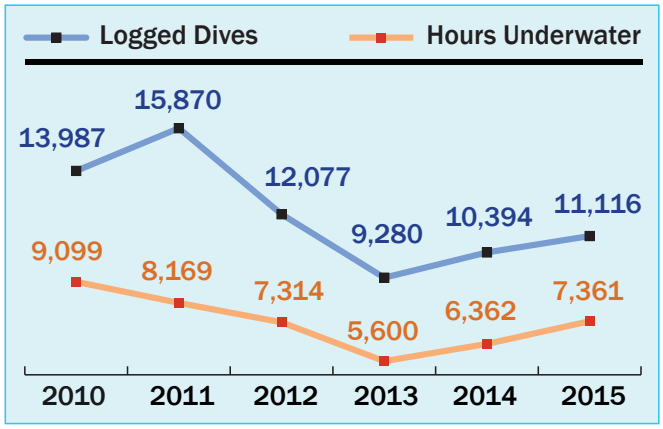


Figure E. Logged dives and time underwater, 2010-15.

The numbers for 2015 show improvement across all areas of the NOAA Diving Program. Compared with the previous year the total number of divers who were active in 2015 and logged dives was up 1% to 375 divers, while the total number enrolled in the program remained steadily above 400 divers. The number of dives logged rose 3% from the previous year to 11,116 dives. This resulted in a total bottom time of 7,361 hours which is up 8% from 2014. These numbers do not include reciprocity divers conducting dives with our program or from our vessels, and reflect only dives by NOAA employees and volunteers. When compared to the past few years, we are happy to say that we continue to show increases in all of our metrics after the drastic decline of 2011-2013. (**Figures D** and **E**) Across the program, scientific dives continue to account for two-thirds of our diving activities as shown in **Figure F**.

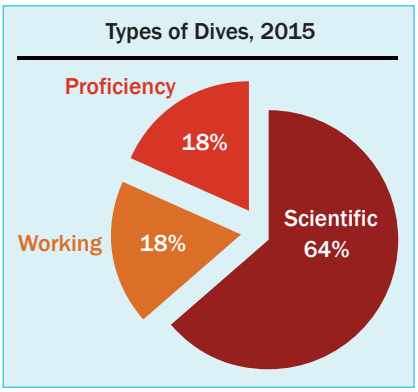


Figure F. Types of dives, 2015.

The NOAA Diving Program continues its exceptional safety record with no significant injuries or accidents involving NOAA Divers.

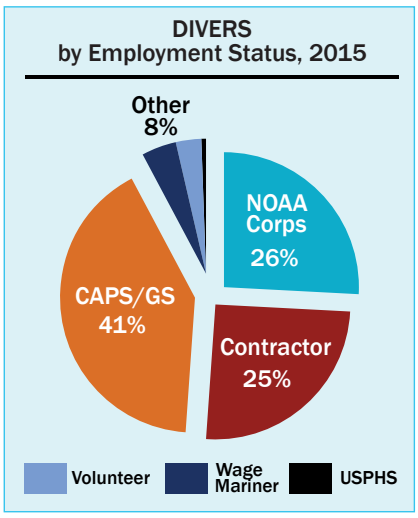


Figure G. Divers by employment status, 2015.

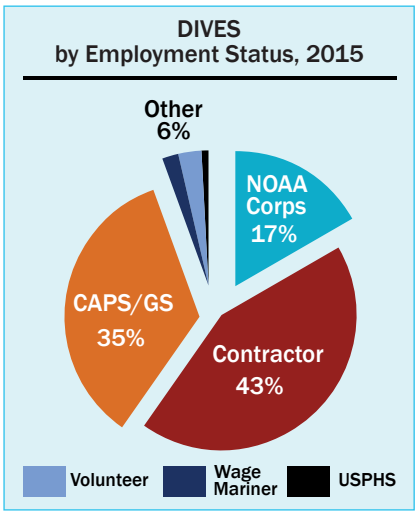


Figure H. Dives by employment status , 2015.

Diving Center

A group of NOAA Diver students and NDC staff pose for a picture during the September 2015 Class at a diving site in West Seattle. NOAA

The NOAA Diving Center (NDC) in Seattle, WA, is responsible for training and certifying NOAA divers.

The majority of dives conducted by NDC involve instructional training for the NOAA Diver courses. This year we continued our new modular training format and have found it to work very well. Many of our students who are experienced recreational divers choose to skip the introductory week of Module 1 and show up during the second week for Module 2. We are also seeing more and more experienced scientific divers coming to the one-week Module 3 course to gain additional skills and experience. This year we trained 51 divers and 17 Divemasters using this new approach. Feedback from the students, ships, and science programs has been very positive and we plan to continue to develop and improve these modular courses. More information on our modular training format can be found in the NOAA Diving Program website.

In addition to training divers, NDC helps the NOAA Diving Program to support field operations with equipment, personnel, and expertise. The NOAA Ship *Hi'ialakai*, for example, uses NDC personnel and a hyperbaric chamber from the NOAA Diving Program for their remote, arduous, and technical diving operations. With this NDC support, scientists working from the *Hi'ialakai* pushed their diving depths down to 300 feet this year and discovered several new species along the way.

> "This year we trained 51 divers and 17 Divemasters using [our new modular training format]."

The training tower at the NOAA Diving Center. NOAA

From left to right: NOAA Divers Tommy Abbas, Bob Stone, Brad Weinlaeder, and Zach Hileman (NDC) during their last day of diving at Little Port Walter, Alaska. Brigitte Malessa/NOAA

NDC staff also participated in eradication efforts on invasive crown-of-thorns sea stars in the National Marine Sanctuary of American Samoa and helped install piping and reinforce pilings at the Alaska Fisheries Science Center's Auke Bay Laboratories in Little Port Walter, Alaska.

In 2015, we also embarked on a three-year project to renovate the office and training facilities at NDC. Phase 1 was completed in early spring and expanded the second floor office space to accommodate all our training and support staff on one floor. This enabled the expansion of the existing first floor training room so that it will now be able to handle a full class of 20 students. The second phase of this project started this past winter and will add windows, skylights, a new front entrance, carpet, and paint. If you haven't stopped by the NOAA Diving Center in a while you should. You will be amazed at the extra space and much improved training environment.

One of our favorite Diving Center outreach programs is the NOAA Science Camp which is held each summer at the Western Regional Center in Seattle, WA. Science Camp strives to take complex scientific concepts and present them in innovative and interesting ways to engage campers and demonstrate that science can be fun. This year we had about 60 students participate in the interactive sessions at the Diving Center. During these sessions campers learned about diving for NOAA, tried on diving gear, communicated with divers in our training tank, and conducted simulated dives in the hyperbaric chamber.

Unfortunately, in summer 2015 we had to say goodbye to one of our staff members, Jim Bostick, who took a job with the Department of Defense to assist them with their diving operations in Europe. Jim's service and support at NDC and on the *Hi'ialakai* as their primary hyperbaric chamber operator and Divemaster will be sorely missed as will his great sense of humor and boundless energy. Thanks to Jim for many years of service and best wishes to him on his new adventures.

> "Jim [Bostick]'s service and support of NDC and on the *Hi'ialakai* as their primary hyperbaric chamber operator and Divemaster will be sorely missed . . ."

Jim Bostick. NOAA

Medicine

Students participating in the NOAA/UHMS training course Physicians Training in Diving Medicine. Greg McFall/NOAA

The primary responsibility of the NOAA Diving Medicine office is to monitor the health and wellbeing of all NOAA divers.

As part of this responsibility, the Diving Medical Officers (DMOs) staff the 24-hour NOAA diving emergency hotline to provide medical advice and assist during any NOAA Diving emergencies. All calls for diving related medical emergencies are answered by the DMO on-call. LT Gary Montgomery joined CDR Joel Dulaigh as a second DMO in 2015. Prior to joining the NOAA team, LT Montgomery was assigned to the Federal Correction Center, Bastrop, TX with the Federal Bureau of Prisons where he provided care to federal detainees. After joining the NOAA Diving Program, LT Montgomery attended the U.S. Navy Recognition and Treatment of Diving Casualties course, the Undersea and Hyperbaric Medicine Society (UHMS) annual scientific meeting, NOAA diver training, and the NOAA/UHMS Physicians Training in Diving Medicine. Now, after almost a full year of training, LT Montgomery is ready to assist NOAA Divers as we move forward into the future of NOAA Diving.

CDR Joel Dulaigh (left) and LT Gary Montgomery. Aitana de la Jara/NOAA

The primary goal of adding another diving medical officer is to increase customer service by decreasing the turnaround time for diver physical exams and annual medical histories. Now, with two medical officers

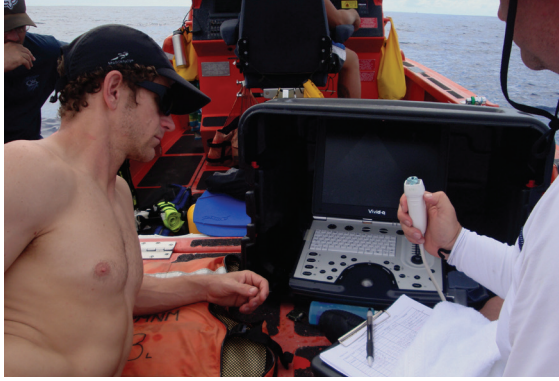
on duty able to monitor messages, responses to the field are being sent promptly. The increase in staff also provides the opportunity to expand the services already provided. While officers at NOAA Diving Medicine currently conduct physical exams for divers, wage mariners, NOAA Corps Officers or other personnel assigned to NOAA vessels to meet standards for sailing on NOAA vessels, CDR Dulaigh and LT Montgomery are now exploring ways to streamline the process to obtain lab tests and x-rays to provide a better experience to their customers.

The DMOs are Basic Life Support instructors through the American Heart Association and can provide CPR training upon request. They are also Diver's Alert Network (DAN) instructors, providing training up to, and including, Diving First Aid for Professional Divers. One or both of the DMOs is on site and available during all NOAA Diver and Divemaster courses to provide instruction and medical support to students and staff. One of the specialty courses coordinated by the DMOs is the Diving Medical Technician course. In 2015, 12 students participated in this course. It was taught in cooperation with the NOAA Ship *Hi'ialakai* using the recompression chamber on board the ship and the classrooms at the Inouye Regional Center in Honolulu, HI.

The flagship course of NOAA Diving Medicine is the annual NOAA/UHMS Physicians Training in Diving Medicine. This course is co-directed by CDR Joel Dulaigh and Dr. Jim Holm, Medical Director of Hyperbaric Medicine at Virginia Mason Medical Center and current President of UHMS. In 2015, the course was attended by 33 physicians, Physician Assistants, and Nurse Practitioners from around the globe. Attendees included individuals from hyperbaric medicine fellowship programs at several major universities across the country, as well as several foreign national students.

Another role that NOAA Diving Medicine has taken on is resupplying first aid kits for the field and providing new oxygen, AED, or first aid kits to units that need them. In cooperation with Lisa Glover in the Standardized Equipment Program (SEP), we also developed a combined oxygen/AED kit as an alternative to the standard oxygen kit. This kit is targeted to small boat diving operations where space is limited.

In September 2015, the NOAA Diving Program partnered with Dr. Neal Pollock of Divers Alert Network (DAN) and Duke University Medical Center in support of his research on venous gas emboli (VGE), or bubbles, in the post deep dive diver. During a research mission aboard NOAA Ship *Hi'ialakai*, over 1,000 cardiac scans were performed to study the effects of various depth, time, and decompression protocols on bubble development. Some divers performed various light exercises during their decompression with the theory that this would decrease the post-dive bubble load. We hope to continue this partnership with more medical studies in the future.

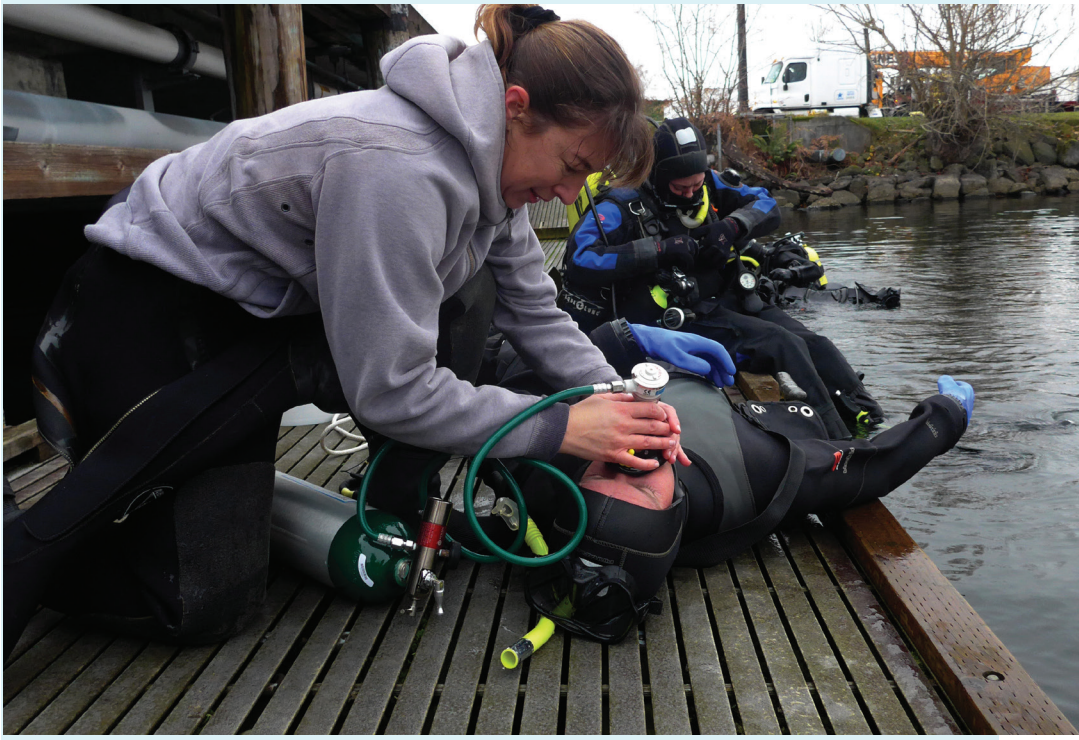


A NOAA Diver prepares for a cardiac scan immediately following the conclusion of a deep dive. NOAA

"In September 2015, the NOAA Diving Program partnered with Dr. Neal Pollock . . . in support of his research on venous gas emboli (VGE). . . Over 1,000 cardiac scans were performed"

The new combined oxygen/AED kit.
Aitana de la Jara/NOAA

Safety



NOAA Diver LCDR Nicky VerPlanck provides oxygen to a victim during a mock DUSA conducted at the NOAA Diving Center in Seattle, WA. Aitana de la Jara/NOAA

Four years of the Diving Unit Safety Assessment (DUSA) program are now complete. Inspectors completed sixteen reviews at twelve diving units and four ships on the west coast, Alaska, and Hawaii in 2015.

DUSA inspectors recorded an average of six findings per diving unit, up slightly from five per diving unit in 2012 to 2014. Despite this, Unit Diving Supervisors seemed more prepared, diver drills and rescues more efficient, and dive lockers more shipshape. Top findings continued to include: expired medications in the first aid kits, out of date AED components (pads or batteries), lockers with poor ventilation or inadequate space, and corrosion on diving gear. The top finding from the first three years, divers not completing required training, disappeared from the 2015 top ten list so we're seeing improvements with this critical aspect of the program.

Four near miss incidents were reported this year. The divers and dive leaders involved in these incidents should be commended for both taking actions during the incidents and implementing corrective actions to ensure that they don't happen again.

Acting Diving Safety Officer Roger Mays.
Greg McFall/NOAA

- One dive team fortunately avoided injury when a tug showed up at the dive site unannounced while the divers were in the water. The divers were diving in a channel, and they knew an operation was scheduled to be held in the area but the tug arrived early and they were not communicating on the same VHF frequency. The divers were recalled as soon as the topside support saw the tug coming towards them. The divers heard and saw the tug's approach and stayed on the bottom until such time as the tug departed and it was safe to surface.

- Another reported incident reminds us that existing medical conditions may compound the effects of heat and other stresses we encounter during diving. A diver with an undisclosed medical-related diving restriction was feeling nauseous after returning from a dive and his symptoms were similar to those of decompression sickness. While it was determined that the diver had succumbed to seasickness, it is important that divers disclose to the on-site Divemaster if they have medical diving restrictions or issues that may affect either their safety or the safety of the team.

- A third report revealed that two divers drifted downstream of their anchored support vessel after they missed the ascent line coming up. The lead diver failed to alert the boat operator that a second buddy pair entered the water, so the boat crew did not notice the first buddy pair surface behind the vessel. The boat operator had to remain on station until the second team surfaced before heading downstream to pick up the first pair of divers.

- Finally, two divers making a proficiency dive in Alaska experienced a situation where a drysuit inflator got stuck in the open position. The diver disconnected the drysuit supply hose which is the correct protocol but was already over-buoyant; this happened in shallow water and no one was injured.

While none of these incidents resulted in severe injuries, property damage, or significant loss of trust, they remind us that accidents and incidents can happen at any time. The common link is our human tendency to under-evaluate risk, or to overlook the clues that what we are preparing to do might not work out the way we planned.

The NOAA Diving Program reviewed these near misses and took corrective actions at the sites to prevent other similar occurrences. The NOAA Diving Program is committed to adapting, improving, and producing formal operational risk management strategies that should provide some assistance to diving units in preventing near misses and accidents.

> "The top finding from the first three years [of DUSA reports], divers not completing required training, disappeared from the 2015 top ten list."

Potter's angel fish, Gardner Pinnacles. Greg McFall, NOAA

NMFS

Andrew David
Line Office Diving Officer

National Marine Fisheries Service (NMFS)

Fifteen diving units within the National Marine Fisheries Service (NMFS) had an active year in 2015. A new unit was added in Newport, OR. The Newport unit divers were previously part of the Seattle, WA unit but they were split into a separate unit based upon their increased operations. Diving units are supported in all regions of the country but the highest operational tempo continues to remain in the Pacific Islands and Southeast Fisheries Science Centers. NMFS continues to log more dives and accrue more bottom time than the other line and staff offices within NOAA. They have 135 divers logging dives (six fewer divers than in 2014) and represent 36% of the total number of NOAA divers. The vast majority of NMFS dives were scientific (81.1%) compared to working (7.3%) or proficiency (11.6%). Enriched air, or nitrox, was used more frequently than air as a breathing mixture (59.1% vs. 40.9%).

Direct observation and sample collection, habitat restoration, collection of telemetry data, ship husbandry, public outreach and safety/training were the dominant categories of activities conducted this year. Their level of training remains high and is exemplified by diving skills training, rescue drills, fitness tests and checkout dives for new equipment and techniques. Once again, 2015 was a year without any significant diving injuries to Fisheries divers. The Program's decision to reduce the maximum partial pressure limit for oxygen (PO2) exposure will further reduce the likelihood of oxygen toxicity accidents, while the addition of a Light Decompression diving mode will counterbalance any degradation in operational capacity from the PO2 change. The first in-house rebreather training program in the NDP was begun this year by Ray Boland, the Deputy Line Office Diving Officer and Unit Diving Supervisor (UDS) for the Honolulu unit. Ray will be training NOAA divers on the AP Inspiration closed circuit rebreather.

The triennial UDS Workshop was held in Seattle, WA in March 2015. Attendance was exceptional with UDSs from all active Fisheries units participating. Lodging costs were covered by Fisheries Headquarters; this was a considerable help to units on tight travel budgets. Significant

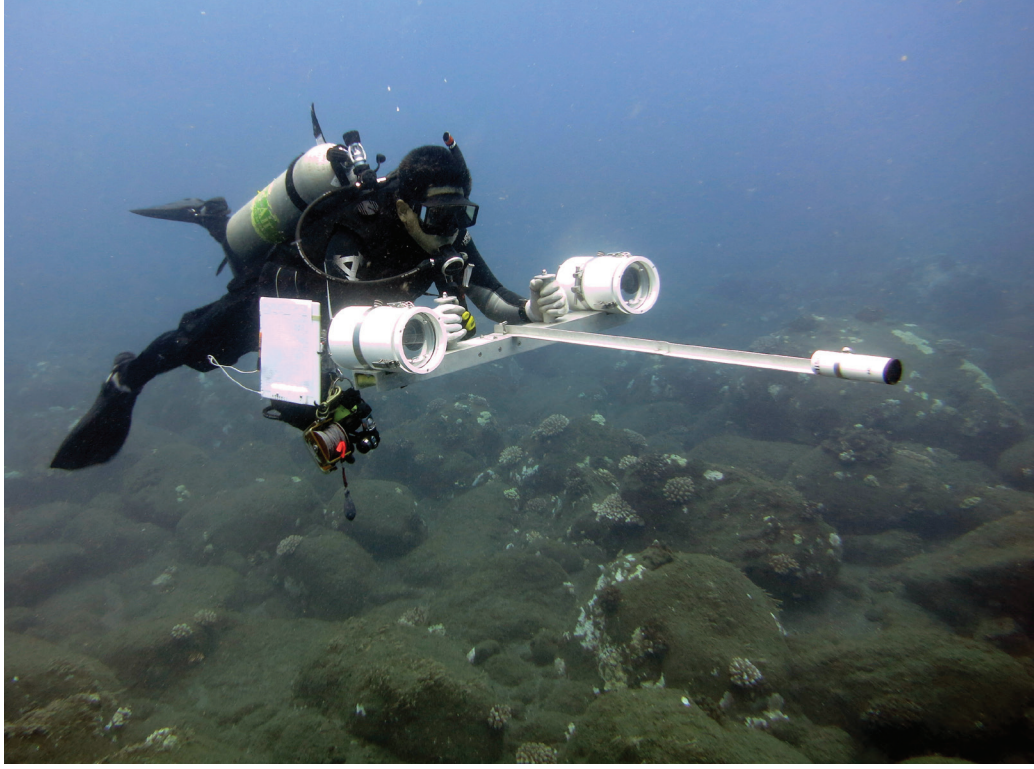
future savings will result from the training supplied at the workshop as all NMFS UDSs are now certified instructors for the CPR, AED, First Aid and Oxygen Administration courses required by the NOAA Diving Program (NDP).

The Diving Unit Safety Assessment (DUSA) program continues to evolve and prove beneficial to our safety record. Slightly less than half the units have now been inspected twice since the inception of the program (due to the number of units, each one is inspected once every three years) and the deficiencies found have decreased considerably in number and severity.

There was considerable financial support from NMFS Headquarters in 2015 with the dedication of over $90,000 for the purchase of new Mares Abyss 22 and Abyss 22 Navy II regulators for NMFS divers. In addition, Headquarters contributed $30,000 to complete the equipping of the new dive locker at the Inouye Regional Center in Honolulu, HI. The re-establishment of a Line Office Diving Officer (LODO) budget in Fiscal Year 2016 will increase acquisition of safety-related equipment. The focus of LODO-directed expenditures in 2016 will be on electronic recall devices to notify submerged divers of changing conditions which require termination of dives.

The largest number of NMFS dives continued to be in support of the Coral Reef Conservation Program (CRCP). Habitat conservation, fishery independent monitoring, and coral restoration remain significant beneficiaries of diving activities. An abbreviated list of the species studied includes: several species of abalone, conch, staghorn and elkhorn coral, hake, lingcod, mutton snapper, red king crab, several species of rockfish, lionfish (invasive on east coast), scallop, sturgeon, several salmon species and several grouper species. Over 20 peer reviewed publications and numerous presentations at national and international scientific meetings were made possible by data collected by NOAA NMFS divers.

“The first in-house rebreather training program in the NDP was begun this year by Ray Boland, the Deputy Line Office Diving Officer and UDS for the Honolulu Unit.”



NOAA Diver Ray Boland using stereo imaging equipment in Hawaii.
Andrew Gray/NOAA

Diving Units by Location

Auke Bay, Alaska

Divers supported a major field expedition to Tracy Arm to collect snips of coral colony for a pilot project on the effects of ocean acidification on the physiology of the corals. This project was conducted with the cooperation of a diver from the NOAA Diving Center. Coordination continued with the U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers on habitat assessments Section 10/404 permitting. Divers also participated in Seaweek, an outreach event designed to educate the public, particularly children, about the oceans and living marine resources. Considerable cost savings were achieved by unit divers performing maintenance on laboratory aquaculture facilities. Several reports were published and several peer-reviewed scientific publications are in press or preparation.

Honolulu, Hawaii

The largest unit in the NOAA Diving Program was once again very industrious in 2015. Scientific dives were conducted in the Main Hawaiian Islands, the Northwestern Hawaiian Islands, Johnston Atoll, Kwajalein Atoll, Howland, Baker, Jarvis, Canton and the American Samoa Islands, Rose Atoll, Palmyra Atoll and Kingman Reefs, with remote operations in the Philippines. The marine debris removal program focused on Midway Atoll in the Northwestern Hawaiian Islands. In Guam and the Northern Mariana Islands, unit divers cooperated with local government divers on ecological assessments. Unit divers also cooperated with local

A still from a video documentary on the king crab hatchery project.

universities and diving programs in the Philippines and with the Hawaii Division of Aquatic Resources and the U.S. Fish and Wildlife Service on projects in the Main Hawaiian Islands. Nine publications were completed in 2015 based upon data collected by Honolulu divers.

Kodiak, Alaska

The Kodiak unit completed the second year of a multi-year study to determine the feasibility of releasing hatchery-raised king crab to enhance local crab populations. For the 2015 season the study site was moved nearer to the laboratory, making it possible to do more intensive post-release monitoring which resulted in a more robust study. Several plots were marked on the bottom and crabs were released in 3 different densities to determine the optimal stocking density. This study could only be completed by highly trained divers as remote technologies are unable to surreptitiously observe the tiny juvenile king crab in the complex rocky habitats surrounding the island. A short video documentary on the experimental hatchery king crab project can be viewed at: https://vimeo.com/102480813. Divers also collected marine organisms for other researchers and the laboratory's interpretive displays, which had over 15,000 visitors in 2015. Diving support was also provided to the Alaska Department of Fish and Game to recover remote temperature monitors.

> "[The study of hatchery king crab] could only be completed by highly trained divers as remote technologies are unable to surreptitiously observe the tiny juvenile king crab in the complex rocky habitats surrounding the island."

La Jolla, California

The diving team focused on abalone research, outreach, and training this year. Abalone projects included collection of brood stock of pink abalone for aquaculture experiments and site assessment for pinto abalone tracking experiments, including line transect surveys to determine abundance. Divers volunteered at the Birch Aquarium to educate the public on kelp forest communities and conducted annual check out dives and rescue training.

Long Beach, California

The Long Beach diving unit conducted projects on several species of abalone (red, green, white, pinto and threaded). Divers outplanted 950

NOAA Diver Melissa Nauman inspects a time lapse camera pointed at a pinto abalone. David Witting/NOAA

green abalone and conducted post-outplant monitoring. There were ongoing white abalone surveys in La Jolla, Point Loma, and Santa Cruz Island. Time-lapse cameras were placed to observe white and threaded abalone for nearly 3 months. A caging study was completed with red abalone at two sites representing anthropogenic sources and natural sources of Rickettsiales-like prokaryote (RLP, the pathogen that causes withering syndrome). Projects for a range test and a final receiver array design for acoustic tracking were completed for pinto abalone. The abalone work resulted in 8 presentations at national and international meetings and will result in several peer reviewed publications.

In addition, over 9,000 lbs of *Sargassum horneri*, an invasive algae species, were removed near Catalina Island and Nearly 40 transects were surveyed for young-of-the-year rockfish in Puget Sound. A major kelp forest restoration project was aided through pre- and post-restoration monitoring of fish, invertebrates and kelp. Collaborations with the National Park Service, and academic and Non-Governmental Organization (NGO) partners continued.

Miami, Florida

Unit divers and colleagues at the Atlantic Oceanographic and Meteorological Laboratory (AOML) and the University of Miami identified, removed and relocated staghorn coral (*Acropora cervicornis*) colonies threatened by silt from the Port of Miami channel expansion. Over 200 colonies were rescued as dredging operations continued concurrently. Over 1,000 fragments from those colonies were successfully transplanted to nearby nurseries. An ongoing collaboration with the Coral Restoration Foundation (an NGO) continues to develop experimental outplanting designs and perform follow-up monitoring

> "Unit divers and colleagues at AOML and the University of Miami identified, removed and relocated [over 200] staghorn coral colonies threatened by silt from the Port of Miami channel expansion."

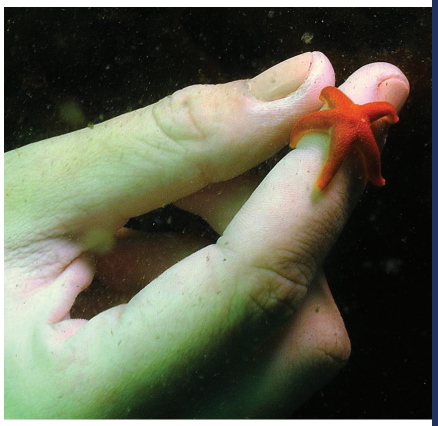
for elkhorn coral (*Acropora palmata*) in the upper Florida Keys. A large outplanting experiment (720 fragments) was initiated in 2015 to examine the differential performance of 4 *A. palmata* genotypes in fore-reef versus patch reef habitats.

Miami divers also continued ancillary activities to quantify bleaching response and consequences in *A. palmata* in the Florida Keys during the second consecutive year of record warm temperatures. This work is in collaboration with Penn State University and University of Miami to better understand the molecular responses and consequences, including potential acclimation, in these back-to-back bleaching events. These and other projects have had considerable management impact related to listings on the Endangered Species Act. Five publications resulted from the work of Miami unit divers during 2015.

Another of NOAA's most accomplished divers retired from the Miami unit at the beginning of 2016; Joaquin (Jack) Javech completed over 4,100 dives during a distinguished 28-year diving career. Mr. Javech served as the unit Diving Supervisor and was one of a select group of initial NOAA Diving Trainers.

Milford, Connecticut

Diving in the Northeast centered on scientific surveys, ship husbandry and maintenance, and training. A continuing bay scallop project was conducted in conjunction with the Guilford, CT Shellfish Commission to support aquaculture research and development. "Pinger" locators were used to find and retrieve sampling modules for an ongoing dinoflagellate cyst survival experiment. Support dives were made for hull and running gear maintenance on several NOAA vessels, inspection of intake pipes, cage recovery, data logging device removal and installation, and the installation and servicing of acoustic arrays in Narragansett, RI. The Unit Diving Supervisor, in conjunction with the U.S. Coast Guard, continues to plan the potential establishment of a NOAA diving unit at the Coast Guard Academy.



A blood sea star discovered during a scallop survey in New England.
Jerry Prezioso/NOAA

Newport, Oregon

NMFS' newest unit became operational in 2015. It shares its location with the Marine Operations Center - Pacific (MOC-P). The unit installed and inspected acoustics equipment on chartered vessels for the Combined Shelf and Slope Trawl survey, inspected and maintained saltwater intake systems at the Mukilteo Field Station (including the replacement of all three salt water intake lines at the Field Station), and installed and maintained acoustic receivers for tracking of salmon, sharks, chimerids, rockfishes and jellyfish. The close proximity to MOC-P also allows divers to assist ships to retrieve equipment lost overboard during non-diving operations. Completing these tasks using NOAA divers saved NOAA a considerable amount of money that would have been used in hiring commercial divers.

Panama City, Florida

Diving activities in northern Florida focused on scientific support, aquaculture maintenance and training. Gear evaluation was conducted for the NOAA Diving Program. Ship husbandry diving has provided significant cost and time savings to Panama City and other Southeast Fisheries Science Center (SEFSC) vessels. Maintenance of aquaculture systems and sea turtle holding pens have also benefited NOAA programs while producing cost savings. Unit divers assisted NOAA Diving Center staff during portions of the NOAA Diver training course when it was held in Panama City for the first time in January. The unit hosted the Annual Meeting of the NOAA Diving Control and Safety Board in April, which included tours of federal and industry diving activities (Naval Diving and Salvage Training Center, Navy Experimental Diving Unit and Kirby Morgan Dive Lab®) as well as facilities utilized during the NOAA Diver training course.

Pascagoula, Mississippi

The Mississippi unit develops and evaluates fisheries conservation and utilization gear for its impacts on threatened and endangered species collected as bycatch in commercial fishing operations. Research to develop Turtle Excluder Devices (TEDs) for shrimp and fish trawls provided essential data for regulatory changes on bar spacing to offer greater protection to smaller sea turtles. In an international collaboration, unit divers assisted the Mexico INP (*Instituto Nacional de la Pesca*) to evaluate fish traps, shrimp trawls, and gill nets. This unit conducts some of the most physically demanding dives in the NOAA Diving Program due to the difficulty of working on operating trawls at speeds approaching three knots.

Santa Cruz, California

This northern California unit completed several significant projects in

A grouper watches a diver watching her. NOAA

2015 to monitor the juvenile rockfish population to help predict the number of adults that will be available to the fishery in future years. The results of these studies are compared with other studies on juvenile rockfish abundance conducted from the Santa Cruz Lab to determine timing of settlement and overall health of the populations.

Toward this goal, unit divers completed juvenile rockfish transect surveys to determine abundance, size estimates, and habitat associations, while a community assessment survey enumerated and identified all habitats, algae, and animals in the transects. Juvenile rockfish were also collected for growth and stomach analyses.

The unit worked with a variety of community, academic and governmental organizations to collect a significant amount of valuable data on rockfish and distribution. In effect, the unit's Lead Diver trained recreational divers from Reef Environmental Education Foundation (REEF), Bay Area Underwater Explorers (BAUE), and Central California Diving Council to identify juvenile rockfish and participate in the data collection process for this project. Academic and governmental agencies that also contributed data included the University of California (UC) Santa Barbara, UC Santa Cruz, California State University Monterey Bay, National Marine Sanctuaries, and California Department of Fish and Game. The aggregate data is used to determine identifications of different juvenile rockfish and compare diving survey results.

Santa Rosa, California

The Santa Rosa diving unit supports northern California NMFS field offices by documenting existing conditions of riverine and estuarine habitat and by evaluating in-river structures on the Sacramento and San Joaquin rivers, their tributaries, and in the Delta that may negatively affect adult of juvenile salmonids and sturgeon. This includes recording fish habitat and fish behavior data near fish screens through visual

> "Research to develop Turtle Excluder Devices for shrimp and fish trawls provided essential data for regulatory changes on bar spacing to offer greater protection to smaller sea turtles."

> "The screens [installed and maintained by the Santa Rosa diving unit] protect all fish from entrainment and loss, and preserve listed species for future generations by preventing their illegal take."

observations and video or still photography, and deploying and retrieving fish monitoring equipment. Diving may also be used to support near-screen water velocity studies by strategically placing velocity probes near the screen surface.

Diving operations were conducted to inspect and maintain fish screens that had been installed using public funds to ensure they continued to function as designed and, thus, to protect the public investment. The screens protect all fish from entrainment and loss, and preserve listed species for future generations by preventing their illegal take. Pacific salmon, a commercially viable and economically important species, is the primary design target for the fish screens, although other commercially important species also benefit, including white sturgeon, American shad, and striped bass.

Seattle, Washington

The majority of diving at the Northwest Fisheries Science Center (NWFSC) is in support of research either through direct data collection or installation and maintenance of equipment. This year's projects included long-term monitoring of eelgrass assemblages with emphasis on the effects of crab predation and nutrient input on invertebrate communities in Puget Sound eelgrass assemblages, maintenance of VR2 acoustic receiver networks in support of studies on salmon and sea star movement behavior, installation and maintenance of C-POD porpoise listening devices in support of the Marine Mammal Program, placement/collection of settlement plates for genetic mapping of marine invertebrates in Puget Sound, and collection of video footage of diving operations in support of research and NOAA outreach activities.

NWFSC divers also collaborated with the Olympic Coast National Marine Sanctuary to conduct benthic surveys in the Sanctuary. These surveys repeated historical surveys from the 1980s and 1990s, which focused on sea otter food items such as urchins and snails to evaluate the effect of the reintroduction of sea otters to the Washington coast in the late 1960's and early 1970's. Cost savings were achieved by in-house maintenance of the saltwater intake system at the Mukilteo Field Station in support of numerous research projects. Several publications that focused on data collected by divers were in development in 2015.

Silver Spring, Maryland

This unit has divers from multiple line offices (National Marine Fisheries Service (NMFS), National Ocean Service (NOS), Office of Exploration and Research (OER), Office of Marine and Aviation Operations (OMAO), National Environmental Satellite, Data, and Information Service (NESDIS), and the NOAA Office of Communications) and while each has varying missions and tasks, there are consistent themes of observations and monitoring, sampling and photo documentation which require diving support. Divers from the unit performed dives to identify navigation hazards and to recover gear with the University of New Hampshire, assisted the NOAA Chesapeake Bay Office (NCBO) with oyster transect monitoring in Chesapeake Bay, and conducted joint training with U.S. Secret Service divers in a quarry and pool. In an excellent example of cross-line office cooperation, the unit continued to combine diving opportunities with the two other Silver Spring-based units for required annual training sessions - consisting of classroom refresher training, underwater check out skills, physical fitness and swimming tests. Monthly training sessions are jointly scheduled to maximize opportunities for unit divers.

St. Petersburg, Florida

The primary mission of the central Florida unit is to conduct assessment, restoration and emergency response activities in support of NOAA's Natural Resource Damage Assessment (NRDA). A secondary mission is to support and assist scientific diving partners in NOAA and from various state, Non-Governmental Organizations and other government and academic entities in their data collection activities. Specific projects included a mission to Riley's Hump in the Dry Tortugas for lobster counts, lionfish counts, habitat transects, and predator-prey surveys as well as the identification and enumeration of spawning aggregations of ocean triggerfish, mutton snapper, and cubera snapper. During 2015, NOAA's Restoration Center and its partners have outplanted approximately 35,000 corals listed in the Endangered Species Act from coral nurseries in Florida, Puerto Rico and the U.S. Virgin Islands to help restore populations of these species and restore impacted and degraded reefs. A well-developed vessel grounding notification system allowed unit divers to quickly respond to a 49' recreational vessel grounded on a reef within a newly established Marine Reserve. An oil spill was prevented and approximately 1,500 corals, including 100 fragments of *Acropora palmata,* were reattached and 10m^3 of rubble was removed from the site during restoration.

NOAA Diver Andrew Gray conducting pool training for Closed Circuit Rebreathers (CCRs). Ray Boland/NOAA

NOS

Kimberly Roberson
Line Office Diving Officer

National Ocean Service (NOS)

The National Ocean Service (NOS) supports 16 diving units in every region of the country, in the Pacific and Atlantic Oceans, and the Great Lakes. In 2015, 141 NOS divers conducted 3,852 dives (not including reciprocity divers), 34.7% of the 11,116 dives executed by the NOAA Diving Program. This is an increase of 185 dives (2.5%) compared to the 3,667 dives completed by NOS in 2014. The bottom time accumulated by NOS divers increased 9.5%, from 2,146 hours in 2014 to 2,596 hours in 2015. The bottom time logged by NOS divers was one third (35.3%) of the time logged by all divers within the Program. The vast majority of NOS dives were scientific (65.2%) compared to working (14.7%) and non-duty (20.1%). A near equal split between Enriched air (nitrox) and air was used (44.6% vs 55.4%) by NOS divers. NOS divers represent 37.1% of the total number of NOAA divers and conducted 34.7% of all NOAA dives to support NOAA's mission through the Center for Operational Products and Services (CO-OPS), the National Center for Coastal Ocean Science (NCCOS), and the Office of National Marine Sanctuaries (ONMS). 2015 saw an addition of 15 new NOS divers, an 11.9% increase from 2014. NOS had the deepest dives logged on duty, reaching 300 fsw, a milestone for the NOAA Diving Program.

NOS Leadership continues to support NOS divers with contributions to safety, training, and equipment. In 2015, NOS headquarters provided $78,000 to purchase new Mares Abyss 22 and Abyss 22 Navy II regulators for NOS divers. In addition, headquarters contributed over $40,000 to dive safety equipment and to support the attendance of NOS Unit Diving Supervisors (UDSs) at the triennial UDS Workshop in Seattle, WA in March of 2015. At the workshop, UDSs were certified as instructors for CPR, AED, First Aid and Oxygen Administration. Bringing this training capability in-house will result in significant cost-savings.

NOS offices with diving units have a wide variety of missions that span from CO-OPS's focus on oceanic instrument installation and

Sea Star. Greg McFall/NOAA

maintenance to NCCOS's and ONMS's broader emphasis on research, monitoring, resource protection, and outreach and education. NOS divers participate in research missions that include biological monitoring and sampling, invasive species studies, climate change, damage assessment, restoration and monitoring of coral and sea grass habitats, and maritime archaeological surveys. Many of the NOS diving units seek to actively engage the public in NOAA's mission through live dive broadcasts, documentary films, training and engaging NOAA volunteer divers in research, and the installation of mooring buoys to allow the public safe access to diving sites and to protect habitats and maritime archaeological resources. NOS divers and their respective offices work in collaboration with dozens of partners to accomplish their missions including Federal and State agencies, universities, and non-profit organizations.

> "NOS had the deepest dives logged on duty [in 2015], reaching 300 fsw, a milestone for the NOAA Diving Program."

Diving Units by Program Office and Location

Center for Operational Oceanographic Products and Services (CO-OPS)

CO-OPS provides the national infrastructure, science, and technical expertise to monitor, assess, and distribute tide, current, water level, and other coastal oceanographic products and services that support NOAA's mission of environmental stewardship and environmental assessment and prediction. Divers install, maintain, and remove underwater components for tidal and current measurement stations. They primarily service the National Water Level Observation Network (NWLON) and the National Current Observation Program (NCOP), including the Physical Oceanographic Real Time Systems (PORTS®), Hydrography and special projects.

Atlantic Operations Branch (AOB), Chesapeake, Virginia

Divers at AOB safely install and maintain underwater components of the NWLON and the PORTS® on the East and Gulf Coasts, Caribbean and

NOAA Divers from the CO-OPS Pacific Operations Branch prepare to remove remporary tide stations that were used as part of the tidal datums project at the Tulalip Indian Reservation in Washington.
Jena Kent/NOAA

all 5 Great Lakes, meeting the CO-OPS mission of providing accurate and reliable water level data to the public in support of safe navigation, sound ecosystem stewardship, coastal hazard preparedness and response, and the understanding of climate change. They successfully and safely completed over 75 dives in 2015, 15 more than in 2014. AOB divers kept over 195 water-level recording platforms fully operational at all times, providing high quality data for the Department of Commerce.

Pacific Operations Branch (POB), Seattle, Washington

POB divers maintain the NWLON and PORTS® stations along the West Coast, Alaska and Pacific Islands. These stations support the National Weather Service Tsunami Warning Centers, tsunami researchers and modelers, long term climate studies, global sea level research, storm surge warnings, forecasts, and models, and state and federal maritime boundary and sea level determinations. Short term tide stations were removed at the conclusion of projects supporting the Tulalip tribes of Washington. POB divers safely completed 156 dives in 2015.

“Divers [from the Atlantic Operations Branch in Virginia] kept over 195 water-level recording platforms fully operational at all times, providing high quality data for the Department of Commerce.”

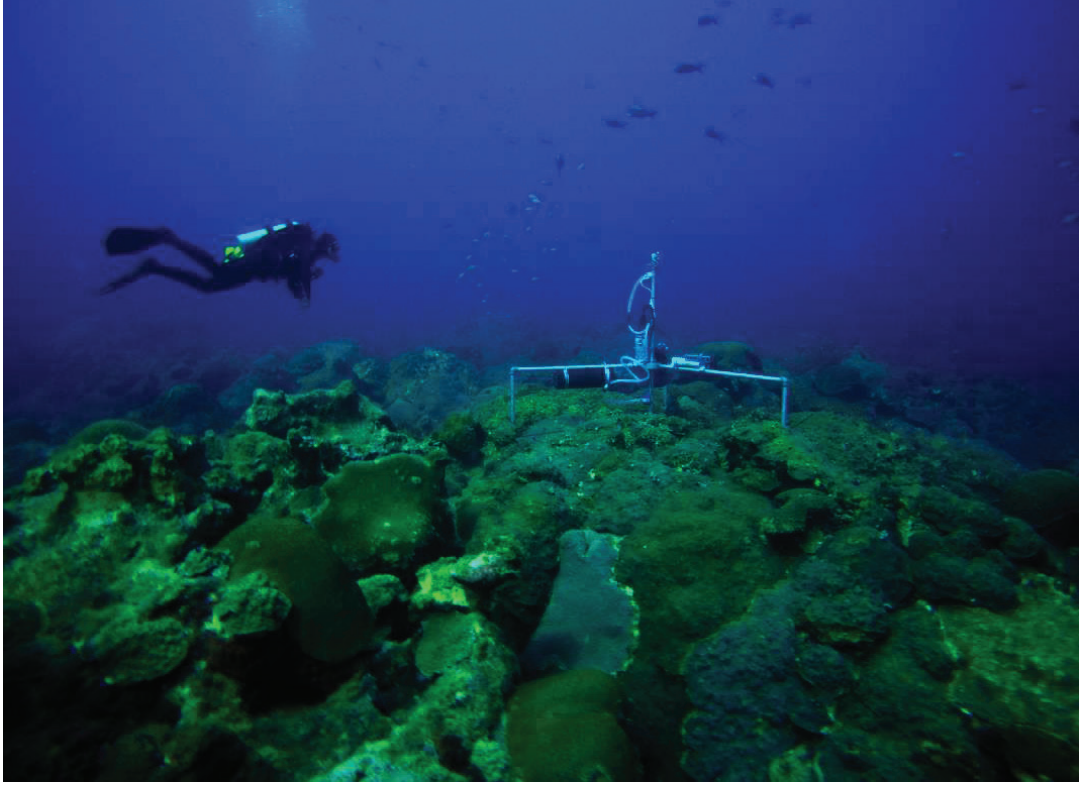
NOAA Diver Michelle Johnston installs an ocean acidification monitoring station at Flower Garden Banks NMS as part of a partnership project with the National Coral Reef Monitoring Program. Ryan Eckert/NOAA

National Centers for Coastal Ocean Science (NCCOS)

The National Ocean Service (NOS) is the nation's leader in observing, measuring, assessing, protecting, and managing coastal, ocean, and Great Lakes areas. NOS provides science-based services to inform decision making, thereby positioning America's communities, economies and ecosystems for the future. The National Centers for Coastal Ocean Science answer questions about the impacts of environmental stress and change on the function of ecosystems and health of coastal resources and people.

Headquarters, Silver Spring, Maryland

The divers working for the NCCOS headquarters are based in Silver Spring, MD. Most of this unit's diving is scientific and occurs at partner sites that include the U.S. Virgin Islands (USVI), Puerto Rico and the Great Lakes. Diving occurs from shore, small boats, and NOAA ships. Diving depths range from 1-110 feet, both fresh and seawater, and in conditions from warm, clear Caribbean waters to cool, dark, turbid Great Lakes waters. In 2015, a total of 14 divers from NCCOS, the Center for Coastal Monitoring and Assessment (CCMA), Biogeography Branch, and Coastal Ocean Assessment (COAST) completed 320 dives with 100% safety record. Two divers maintained their NOAA Divemaster status, and we welcomed one new NOAA Diver. NCCOS divers from headquarters successfully implemented NOAA's Coral Reef Conservation Program's National Coral Reef Monitoring Program throughout the USVI and Flower Garden Banks National Marine Sanctuary (FGBNMS) through partnerships with FGBNMS, the National Park Service, USVI Department of Natural Resources, University of the Virgin Islands, and University of Miami. Fifty three divers conducted over 1,450 dives, collecting data on coral reef fishes and habitats to gauge changing conditions of U.S.



A NOAA Diver observes water quality instrumentation placed by divers to measure ocean acidification at the Flower Garden Banks NMS during a partnership project with the National Reef Monitoring Program. Michelle Johnston/NOAA

coral reef ecosystems, which are among the most biologically diverse and economically valuable ecosystems on earth. Other projects include investigating the connectivity of protected and unprotected marine areas around Virgin Islands National Park and mussel collection around Lake Erie as part of the Great Lakes Mussel Watch Project, a multi-agency effort to assess baseline contaminant conditions throughout the Great Lakes.

Center for Coastal Fisheries and Habitat Research (CCFHR) and Southeast Fisheries Science Center (SEFSC), Beaufort, North Carolina

The Beaufort diving operations support projects focused on biological monitoring of fish, coral and substrate, reef health assessment, fish spawning aggregation studies, video and still photography of habitat and flora/fauna, collection of invertebrate and vertebrate live specimens for identification and classification, and deployment of scientific equipment in various locations and habitats. Work is conducted in close collaboration with the Office of National Marine Sanctuaries, specifically Florida Keys, Grays Reef, Flower Gardens and Monitor National Marine Sanctuaries. Other partners in 2015 included: the Florida Fish and Wildlife Conservation Commission, Rosenstiel School of Marine and Atmospheric Science (University of Miami), University of North Carolina at Chapel Hill, University of North Carolina Wilmington, Duke University, Georgia Southern University, University of Connecticut, Oregon State University and Reef Environmental Education Foundation (REEF).

> “The Center for Coastal Fisheries and Habitat Research diving unit co-hosted the 6th annual Scientific Diver Symposium at the North Carolina Aquarium at Pine Knoll Shores.”

The CCFHR diving unit co-hosted the 6th annual Scientific Diver Symposium at the North Carolina Aquarium at Pine Knoll Shores. This symposium allowed scientific and educational divers from Duke University, the University of North Carolina (UNC) at Chapel Hill, UNC Wilmington, North Carolina State University, East Carolina University, the North Carolina Division of Marine Fisheries, the North Carolina Division of Cultural Resources, Monitor National Marine Sanctuary, Coastal Carolina University, and the North Carolina Aquariums to present papers highlighting the contributions diving made to their institutions' research and education. Divers Alert Network (DAN) also gave a presentation. The diving unit also conducted outreach events and gave numerous presentations to area elementary schools.

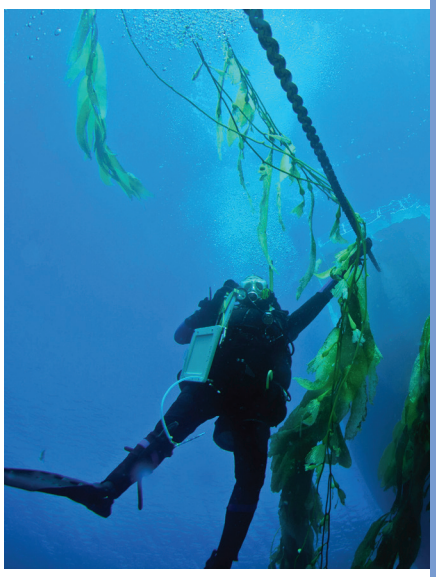
Office of National Marine Sanctuaries (ONMS)

The mission of the National Marine Sanctuaries is to conserve, protect and enhance the biodiversity, ecological integrity and cultural legacy of these special underwater places.

Channel Islands National Marine Sanctuary (CINMS)

This unit's diving operations support projects that help CINMS better understand living marine resources and their ecosystem. Diving operations also produce materials that are used in educational and outreach programs.

In 2015, divers collected data for studies of behavioral ecology of fish that included monitoring of fish movement patterns, fish abundance, habitat characterization, and fish/habitat associations, serviced instrument moorings, maintained west coast ocean observatories moorings (temperature loggers and Vemco VR2 acoustic receivers), conducted white abalone habitat characterization surveys, and annual survey and monitoring of shipwrecks in support of the ONMS regional maritime heritage coordinator's office. The unit also supported non-NOAA diving reciprocity projects including University of California Santa Barbara PISCO (Partnership for Interdisciplinary Studies in Coastal Oceans)



Channel Islands NMS Unit Diving Supervisor Julie Bursek makes her way down to a white abalone monitoring site. Adam Obaza/NOAA

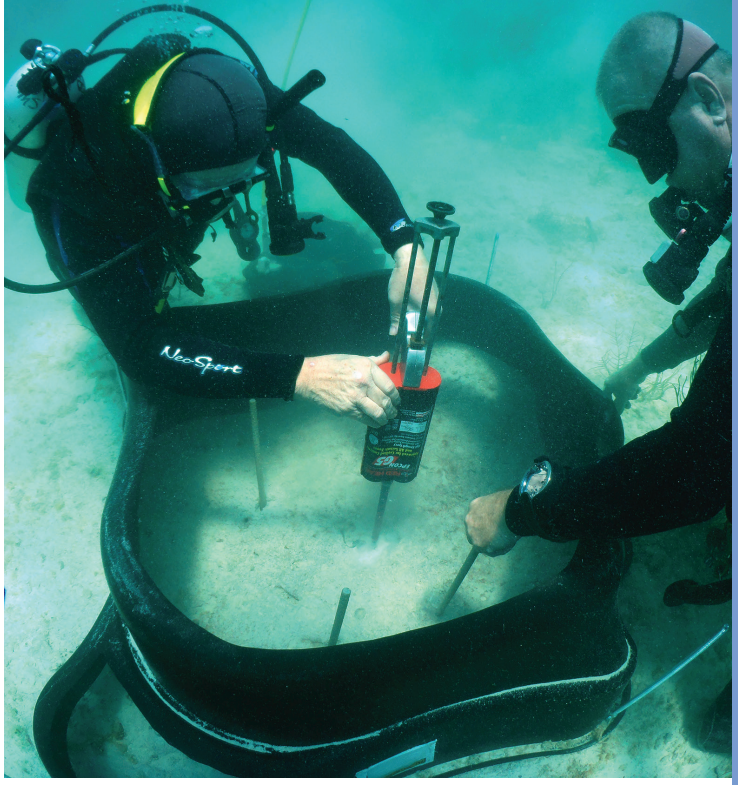
NOAA Diver Bill Goodwin cements re-located *Porites astreoides* colonies using a hammer/chisel, brush, cut nails, and hand-mixed cement balls at South Carysfort Reef, near Key Largo, FL, at Florida Keys NMS. Kelsey Jeffers/NOAA

Marine Protected Areas (MPAs) monitoring surveys and Cal Poly San Luis Obispo Kellet's Whelk Surveys. NOAA Divers in the unit conducted a total of 134 dives.

White abalone habitat characterization surveys were conducted in partnership with the NOAA Restoration Center and the National Marine Fisheries Service's West Coast Regional Office to identify suitable habitat that will eventually support the reintroduction of endangered white abalone to CINMS and the mainland coast. This project supports the 2008 White Abalone Recovery Plan Prepared by the White Abalone Recovery Team for the NOAA National Marine Fisheries Service and Office of Protected Resources.

Florida Keys National Marine Sanctuary (FKNMS)

Divers in this unit support the FKNMS Management Plan in the form of scientific research (biological & maritime heritage), and maintenance of



NOAA Divers Bill Goodwin (left) and Hank Becker apply epoxy on fiber glass rebar into holes drilled on a hardbottom to stabilize a "reef" base during restoration efforts at Cheeca Rocks Reef, off Upper Matacumbe, FL, at Florida Keys NMS. Kelsey Jeffers/NOAA

an extensive mooring buoy program (inspection, cleaning, replacement and installation), ensuring continuity of operations. Diving operations also support the Research and Monitoring, Damage Assessment and Restoration, Maritime Heritage, Mooring Buoy, and Operations Action Plans. FKNMS divers completed coral bleaching and disease surveys in support of the Florida Reef Resilience Program. Divers helped to maintain a coral nursery and also regularly surveyed the area for signs of health-related conditions of corals and sponges. FKNMS divers assisted in NOAA fisheries research on coral spawning observation and coral larvae collection. Divers completed damage assessment, restoration, and monitoring of coral and seagrass habitat subject to vessel groundings or other human-induced injury. Long term monitoring of these sites is critical to evaluating successes of restoration efforts. Divers also supported Catlin Seaview surveys with photographic documentation and participated in the Maritime Heritage: Diving with a Purpose-Hannah M. Bell archaeological shipwreck project. FKNMS continued to collaborate with NOVA Southeastern University in support of the Sanctuary Coral Reef Ecosystem Assessment and Monitoring (SCREAM) project, which completes rapid ecological surveys of benthic communities throughout the FKNMS. Partnerships such as this are vital to the diving support necessary to manage the FKNMS.

Flower Garden Banks National Marine Sanctuary (FGBNMS)

Located off the coasts of Texas and Louisiana, the FGBNMS underwater communities rise from the depths of the Gulf of Mexico atop underwater mountains. FGBNMS currently uses a state of the art diving platform that can support over 15 divers for extended overnight missions to the sanctuary.

> "White abalone habitat characterization surveys were conducted . . . to identify suitable habitat that will eventually support the reintroduction of endangered white abalone to Channel Islands NMS and the mainland coast."

NOAA diver Travis Sterne collects video imagery of a school of bonnetmouth at the Flower Garden Banks NMS. G. P. Schmahl/NOAA

In 2015, the work of FGBNMS divers supported research, monitoring, response, management, education, and outreach. Data were collected during long term monitoring expeditions through the use of random transects, fish counts, urchin counts, lobster counts, and water quality tests. Long term monitoring projects have contributed to a series with over 20 year of data.

The annual spawning project also studied, filmed, and photographed coral spawning events. Special projects also included ocean acidification and coral reef monitoring using stratified random surveys in collaboration with ONMS and NCCOS in support of the National Coral Reef Monitoring Program (NCRMP). Divers also installed and maintained mooring buoys in the FGBNMS to provide safe access for boats to diving sites and to protect reef resources. FGBNMS divers conducted sample collection for ciguatera and mercury analysis, removal of invasive species to protect sanctuary resources (primarily lionfish with 573 removed), equipment maintenance and installation, and refurbishment of and pin installation in study sites.

Gray's Reef National Marine Sanctuary (GRNMS)

The primary mission of diving operations at GRNMS is to support research and monitoring activities in and around the sanctuary. A secondary mission for GRNMS divers is to support education and outreach activities.

Diving operations supported numerous research and monitoring projects during 2015, including an ongoing telemetry project designed to track fish movement in the sanctuary, fish surveys to investigate cryptic fish abundance, habitat surveys to characterize habitats and examine cryptic organisms living in invertebrate habitats, mobile invertebrate surveys, fish behavior surveys to assess fish and invertebrate

> "... data (collected by NOAA Divers related to CO_2 levels in the sanctuary) will aid in understanding potential climate change and its impacts to the resources of Gray's Reef."

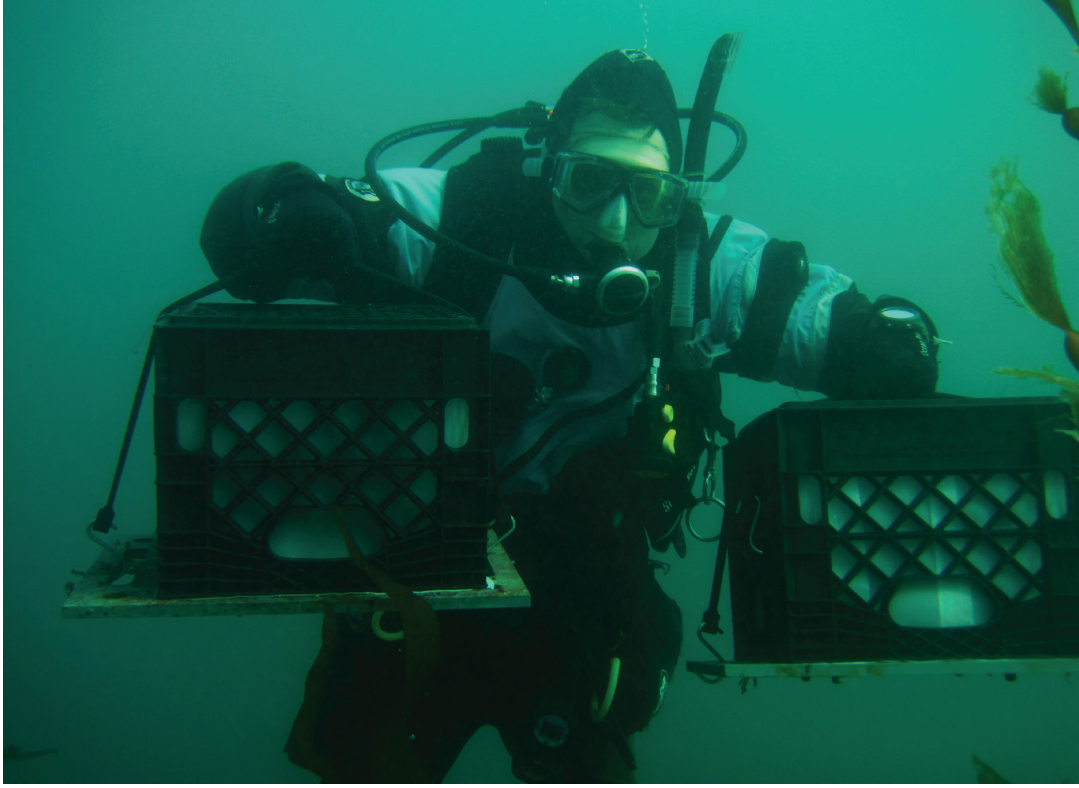
populations, and oceanographic studies to monitor changing CO2 and other parameters in the sanctuary. Divers' efforts to remove the invasive lionfish have shown direct benefit to the ecosystem of the sanctuary, as have investigations into other invasive species in GRNMS. In addition, several university graduate and undergraduate students collected data and samples necessary for the pursuit of their degrees. GRNMS divers also supported diving operations conducted by partner organizations and institutions, including Georgia Southern University, the University of Georgia, Valdosta State, University of Connecticut, and NOAA's NCCOS. To conduct diving operations, GRNMS depends upon the support of volunteer divers that make up the "Team Ocean" program. These divers are critical to the accomplishments of the GRNMS diving unit.

Monitor National Marine Sanctuary (MNMS)

MNMS's primary diving mission is to conduct archaeological surveys of submerged cultural heritage sites. This consists predominantly of photo-video documentation, diver deployed instrumentation, measuring and creating scaled drawings in-water and observation. Diving operations were mission critical in 2015. One of the primary goals was to engage with recreational diving communities in a more hands-on way. Two field operations, one to the *Caribsea* and one to the *Carl Gehard*, were conducted in coordination and support of avocational groups. These missions allowed valuable archaeological information to be collected, while providing meaningful education and outreach with primary stakeholder groups.

MNMS works with multiple partners and community stakeholders. MNMS divers collaborated with divers from The Maryland Collaborative Archaeological Study and the Bureau of Ocean Energy Management (BOEM) to survey a lease area for wind energy development. Reciprocity divers comprised the vast majority of dives conducted by MNMS in 2015. The majority of reciprocity divers are affiliated with the American Academy of Underwater Science (AAUS) at the University of North Carolina Coastal Studies Institute and East Carolina University, and

NOAA Diving Program Manager Greg McFall (center) shows Alison Scott (left) and Dr. Barbara Phillips how to conduct a buddy check while training them to become volunteer divers at Gray's Reef NMS.
LTJG Jared Halonen/NOAA



NOAA Diver Chad King retrieving two Autonomous Reef Monitoring Structures (ARMS) from a kelp forest in Monterey Bay NMS.
Steve Lonhart/NOAA

with BOEM. Additionally, we began a new 5-year study for Battle of the Atlantic Shipwrecks associated with the First World War. Diver-collected data comprises the majority of the dataset for the study. This will aid in the development of a comprehensive publication in 2016.

Monterey Bay National Marine Sanctuary (MBNMS)

MBNMS is one of the largest National Marine Sanctuaries, stretching from Marin to Cambria Counties in California. The Sanctuary has a limited diving staff, and operates two vessels that support day and overnight operations. The diving team at MBNMS primarily conducts or participates in operations that characterize and monitor the habitats (primarily kelp forest ecosystems) within and adjacent to MBNMS. During 2015, these activities included monitoring at Alder Creek related to landslide material entering the sanctuary, training to use the XL Catlin SVX camera system, training American Academy of Underwater Science (AAUS) divers to identify invertebrates and algae, conducting surveys for sea star wasting syndrome, recording photo and video from the newly expanded Greater Farallones National Marine Sanctuary, deploying and retrieving Autonomous Reef Monitoring Structures (ARMS) in Monterey Bay, studying diver avoidance by feeding fishes inside vs. outside Marine Protected Areas (MPAs), surveying MPAs in central California, and conducting Reef Environmental Education Foundation (REEF) surveys in Monterey and Carmel Bays. Reciprocity divers participated in almost all projects listed above.

To contain the crown-of-thorns sea star outbreak at the NMS of American Samoa, the unit received assistance from the NOAA Diving Center (NDC), Papahānaumokuākea Marine National Monument (PMNM) and Gray's Reef National Marine Sanctuary (GRNMS). The NOAA Divers and vessel Captain (from GRNMS) were (from left to right): Nick Jeremiah (NDC), Dan Wagner (PMNM), Todd Recicar (GRNMS), Randy Kosaki (PMNM), Jason Leonard (PMNM), and Brian Hauk (PMNM). NOAA

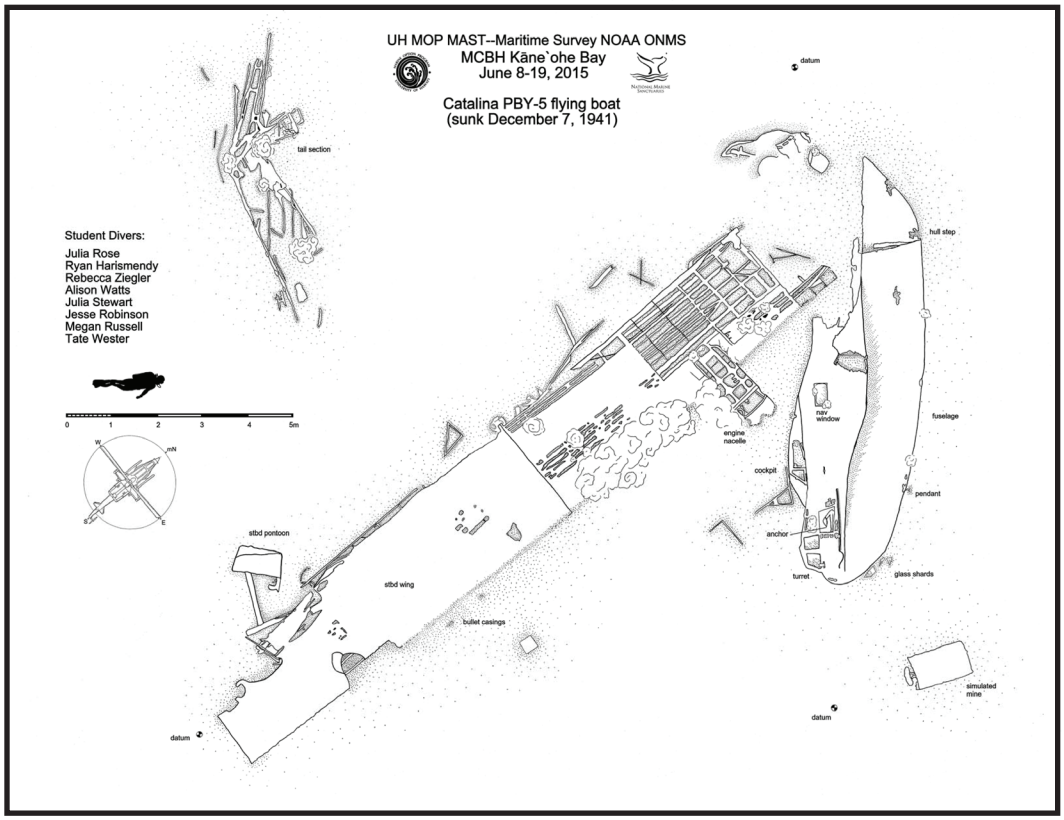
National Marine Sanctuary of American Samoa (NMSAS)

The NMSAS supports the greatest diversity of tropical marine life in the Sanctuary System, including a wide variety of coral and other invertebrates, fishes, turtles, marine mammals and marine plants. The sanctuary protects extensive coral reefs, along with deep water reefs, hydrothermal vent communities, and rare marine archaeological resources. The sanctuary is also the most remote location within the system and the only diving unit south of the equator. NMSAS diving activities support research and monitoring objectives contained within the NMSAS site management plan. Impacts monitored by the diving team include crown-of-thorns sea star outbreaks, hurricanes, coral bleaching, and anchor damage. NMSAS divers also conduct biological surveys to establish a resource baseline that is essential for understanding changes over time and for the protection of Sanctuary resources. In 2015, divers conducted coral surveys, monitored reported bleaching events and photographed underwater. The unit currently has only one NOAA Diver, and this affects the Sanctuary's ability to maintain training for that diver and to conduct monitoring projects.

Pacific Islands Region (PIR)

The PIR regional Unit Diving Supervisor provides training and oversight services in support of NOAA diving operations throughout the region. This primary diving mission is to provide diver training including conducting check out dives and bi-annual rescue and in-water skills training. The PIR regional maritime heritage coordinator also conducts

> "In 2015, [NMS of American Samoa] divers conducted coral surveys, [and] monitored reported bleaching events . . . The unit currently has only one NOAA Diver, and this affects the Sanctuary's ability to . . . conduct monitoring projects."



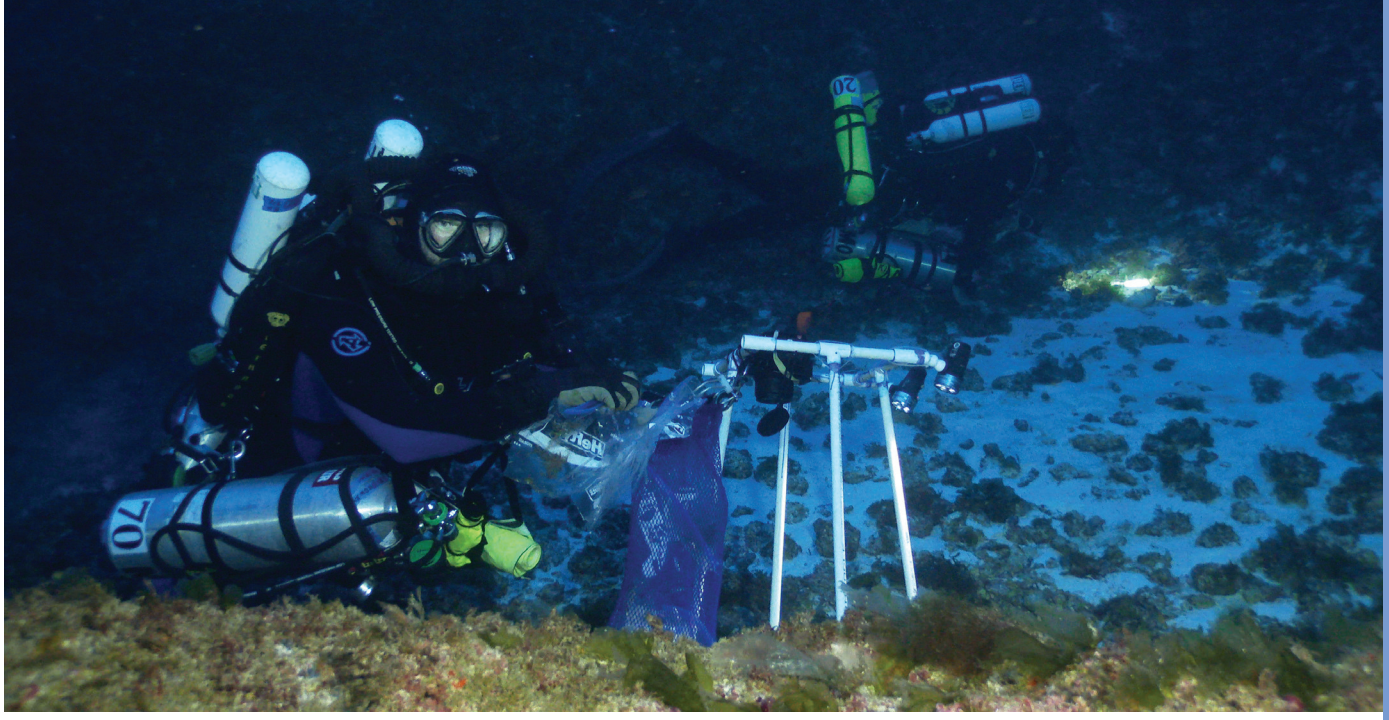
Map of the Catalina PBY-5 flying boat wreck site surveyed by Hawaii Marine Option Program students during a course taught by Pacific Island Region NOAA Divers and reciprocity divers. NOAA

assessment and training dives on submerged cultural resources, adding to the inventory of NOAA's submerged historic properties and enhancing outreach and education efforts for coastal and marine resources. In 2015, PIR collaborated with the University of Hawaii's (UH) Marine Option Program to teach a 10-day Maritime Archaeology Survey Techniques (MAST) course with UH scientific reciprocity divers, conducting non-invasive mapping, sketching, and photo documentation of naval aircraft PBY-5 (sunk on December 7th, 1941) in Kaneohe Bay. Diving surveys of heritage resources in the main Hawaiian Islands provides field data pertinent to state and sanctuary resource management.

Papahānaumokuākea Marine National Monument (PMNM)

The PMNM diving unit conducts characterization, monitoring, research and resource protection of natural and maritime heritage resources in the Northwestern Hawaiian Islands (NWHI) in support of management objectives of the Papahānaumokuākea Marine National Monument. Diving operations include the use of both standard scuba and Closed Circuit Rebreathers (CCR) to characterize both shallow (0-130 ft) and deep reef (up to 300 ft) environments. Additional diving operations conducted by PMNM divers included inspections of alien species, training and technical proficiency diving operations both internally and with partner agencies (State of Hawaii, Bishop Museum, University of Hawaii and Hawaii Institute of Marine Biology).

"Scientists believe it is highly likely that many of the collected organisms constitute undescribed species which are completely new to science."



NOAA Diver Brian Hauk collecting specimens at Kure Atoll in the Northwestern Hawaiian Islands. He and other divers from the Papahānaumokuākea Marine National Monument explored Monument waters at depths of up to 300 ft., where they made significant scientific discoveries.
Robert Whitton/Bishop Museum and NOAA

Supporting PMNM's mission to characterize the deep water habitats of the Monument, the team used CCR diving technology to survey mesophotic coral ecosystems (deep coral reefs at depths between 150 and 300 ft.) The 2015 expedition collected numerous unidentified organisms, including sea cucumbers, sea urchins, algae and fish. Scientists believe it is highly likely that many of the collected organisms constitute undescribed species which are completely new to science. A maritime heritage team made significant discoveries at Maro Reef and Midway Atoll, namely, the wreck of U.S. Navy Ship *Mission San Miguel* at Maro Reef and an as-yet unidentified WWII-era fighter plane at Midway Atoll. Divers also worked with Dr. Neal Pollock from the Diver's Alert Network (DAN) and Duke University Medical Center on a decompression study which analyzed divers before and after technical decompression dives. Testing included baseline fitness, spirometry, echo-cardiogram heart scans, urinalysis, blood draws and daily health surveys. Preliminary results indicate that light exercise during decompression may have a significant physiological impact on reducing the quantity of bubbles in the diver's tissues.

> "A maritime heritage team [of NOAA Divers discovered] the wreck of the U.S. Navy Ship Mission San Miguel at Maro Reef and as-yet unidentified WWII-era fighter plane at Midway Atoll."

Stellwagen Bank National Marine Sanctuary (SBNMS)

SBNMS conducts dives to characterize, protect and interpret the sanctuary's natural and cultural resources. These surveys provide data and imagery which are also used in materials that help to interpret the sanctuary for the public through exhibits, websites, publications, and social media. Photographs and archaeological resource information of shipwreck characterization were utilized in the recently published

NOAA Diver and archaeologist Deborah Marx shines a light on a flounder hiding on the shipwreck *North Star*. Matthew Lawrence/NOAA

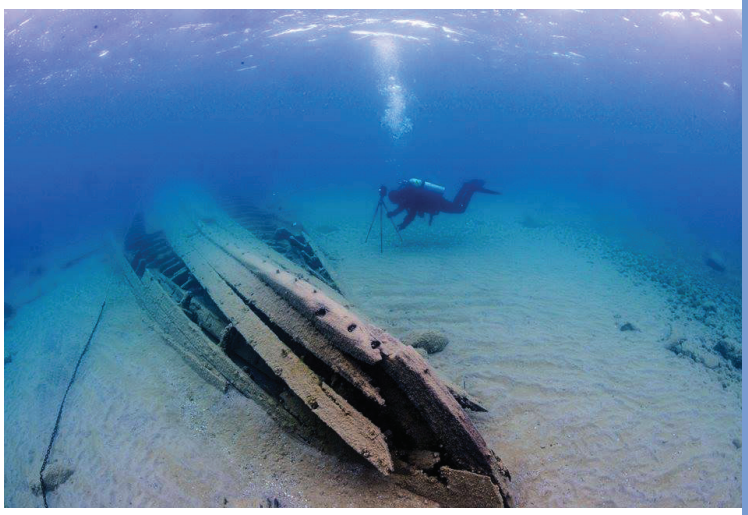
book *Stellwagen Bank Shipwrecks: Disaster in New England's National Marine Sanctuary* published in June 2015. Two of the authors, Matthew Lawrence and Deborah Marx, are NOAA divers.

During 2015, SBNMS Unit Diving Supervisor Matthew Lawrence continued to direct the Elbow Reef Shipwreck Characterization Project in the Florida Keys National Marine Sanctuary (FKNMS). The project seeks to map the landscape of shipwrecks grounded on Elbow Reef. The project's partner is "Diving With a Purpose" (DWP), an avocational archaeology program which has brought almost 50 volunteer divers to the project since 2012. In 2015 alone, DWP diving volunteers contributed $25,000 in labor hours to the project. As a result of DWP's work in FKNMS and Biscayne National Park to conserve the underwater cultural heritage, the Advisory Council on Historic Preservation bestowed the organization with its Chairman's Award for Achievement in Historic Preservation in 2015, with NOAA being recognized for the agency's contribution alongside DWP.

Thunder Bay National Marine Sanctuary (TBNMS)

TBNMS's primary diving mission involves the documentation and management of submerged cultural resources. The sanctuary supports numerous partnerships with other government agencies and university research programs. Often, these partnerships utilize sanctuary assets and divers to complete a diverse array of scientific diving tasks including biological and geological sampling, underwater photo and videos surveys, and water quality research. During 2015, TBNMS conducted the

NOAA Diver and archaeologist Phil Hartmeyer uses a Catlin Seaview Survey camera system to document the wreck of the *City of Alpena*. NOAA

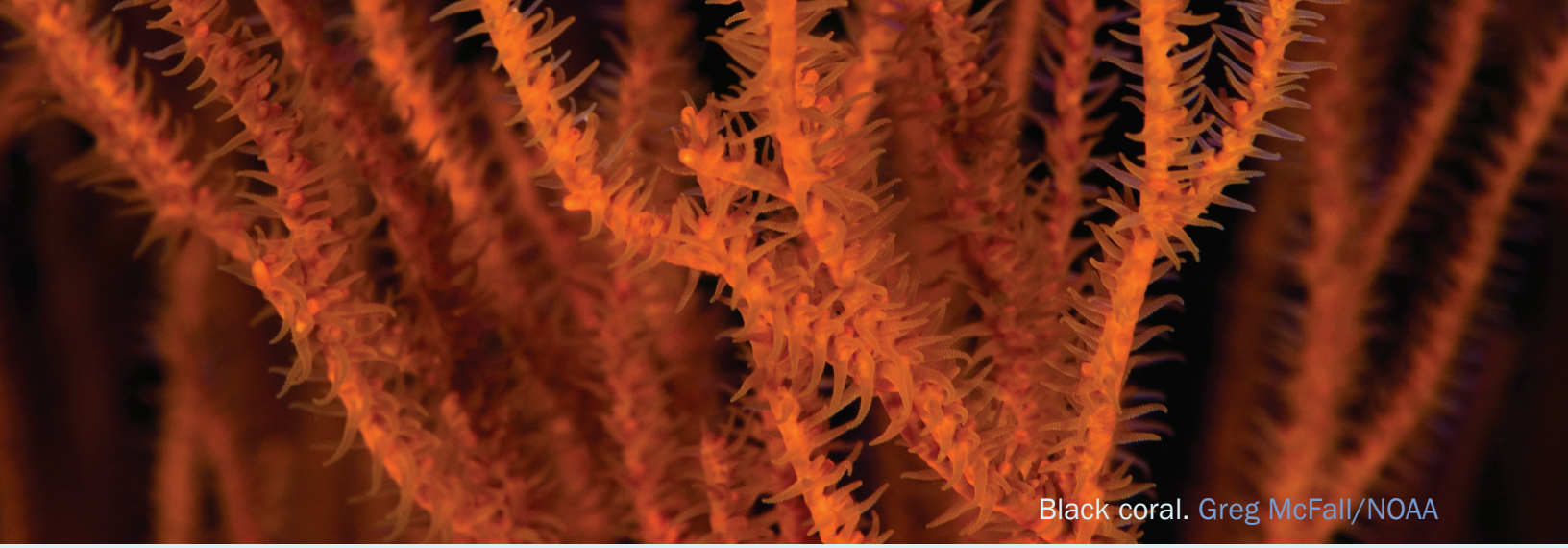


following types of diving: archaeological documentation of submerged cultural resources, biological surveys, scientific equipment installation and removal, shipwreck mooring buoy installation, maintenance, and removal, marine biological sampling, environmental monitoring, water quality sampling, sediment core sampling, photographic documentation and survey, and video documentation.

Additionally, Thunder Bay divers completed training dives focused on the use of closed-circuit rebreathers (CCRs), economizing the logistical and operational requirements for conducting scientific dives, especially below 130 feet. Combined with the physiological benefit offered to the diver, these efficiencies justify the proliferation of CCR diving throughout Thunder Bay and the Sanctuaries program.

In 2015, Sanctuary divers partnered with the Alpena High School for the fourth year to co-teach courses in environmental sciences, supported the state of Michigan to host an avocational archaeological expedition in southern Lake Huron, and supported Alpena Community College's Marine Technology Program with tank and locker supplies.

> **"Photographs and archaeological resource information of shipwreck characterization [collected by NOAA Divers] were utilized in the recently published book *Stellwagen Bank Shipwrecks: Disaster in New England's National Marine Sanctuary* published in June 2015."**



Black coral. Greg McFall/NOAA

OAR

Andrew David
Acting Line Office Diving Officer

> "Diving in support of these projects led to four peer-reviewed publications in 2015."

Office of Oceanic and Atmospheric Research (OAR)

Miami, Florida

The primary diving mission of the Atlantic Oceanographic and Meteorological Laboratory (AOML) is to support local and international ocean chemistry, ecosystems and physical oceanography research through scientific diving. AOML's collaborations are very extensive; in 2015 these included, within NOAA, the Pacific Islands Fisheries Science Center, Pacific Marine Environmental Laboratory, National Marine Sanctuaries at the Flower Garden Banks, Florida Keys and American Samoa, Southeast Fisheries Science Center, National Centers for Coastal Ocean Science, and the Center for Satellite Applications and Research. Other governmental partners included Florida Fish and Wildlife Commission, US Geological Survey, Department of Environmental Quality (Saipan), and the National Park Service. Academic and Non-Governmental Organization (NGO) partners included the University of the Virgin Islands, University of Puerto Rico – Mayaguez, Nova Southeastern University, University of Miami - Rosenstiel School of Marine and Atmospheric Science (RSMAS), Texas A&M, Florida Technical Institute, University of New Hampshire, Scripps, University of Rhode Island, Columbia University and the Living Oceans Foundation.

Specific projects included site surveys for monitoring equipment installations for the Coral Health and Monitoring Program (CHAMP) / Coral Reef Early Warning System (CREWS), ocean acidification surveys of coral reefs in South Florida, the Caribbean, and the Pacific for the Coral Reef Conservation Program (CRCP), deployment of bottom mounted Acoustic Doppler Current Profiler (DCP) units, assessment and data collection for the Florida Area Coastal Environment (FACE), and instrument deployment, physical oceanographic data collection and instrument maintenance for the Western Boundary Time Series (WBTS). Diving in support of these projects led to four peer-reviewed publications 2015.

A NOAA Diver during a coral reef survey at the Hawaiian Islands Humpback Whale NMS. Maya Walton/NOAA.

OMAO

LCDR Justin Keesee
Deputy Line Office Diving Officer

Office of Marine and Aviation Operations (OMAO)

OMAO diving operations are comprised of the NOAA Diving Center and 16 ships in the NOAA fleet that have NOAA Commissioned Corps Officers, Wage Mariners, and CAPS/GS employees working as divers. During 2015, all NOAA ships had a trained NOAA Diver on board, and all but one maintained a functional diving team throughout the year. On average there are 100 divers working directly for OMAO.

NOAA Ships

OMAO operates a wide variety of specialized ships to execute NOAA's environmental and scientific missions. NOAA's fleet provides hydrographic survey, oceanographic and atmospheric research, and fisheries research vessels to support NOAA's mission and strategic objectives. To maintain its fleet and assist in scientific operations, OMAO authorizes its Wage Mariners, CAPS/GS employees, and NOAA Corps Officers to participate in the NOAA Diving Program. Their primary duty is to conduct ship husbandry dives to ensure their vessels are operating effectively and efficiently. Many of these vessels also support diving expeditions sponsored by other Line Offices. Additionally, while the divers are not always in the water with the scientists, having a diving background helps OMAO's employees better serve the scientists.

All 16 of OMAO's ships have divers currently on board. Shipboard dives usually entail inspection and cleaning of the ship's hull and running gear. Many of the tasks involved in these dives can be accomplished with simple hand tools and a little elbow grease, but without the skill to perform scuba dives, we would have no access to this part of the vessel.

Additionally, due to the various missions that the ships preform, crew members must routinely clean, inspect or swap out sensors and instruments that are affixed to the hull. This could be done by a contract diving company, but the shipboard divers have unique knowledge of the

School of spadefish. Greg McFall/NOAA

ship and its features. As the nature of NOAA's work takes its fleet further and further from home port, divers also play the role of an insurance policy. In the event there is a mishap with gear or the ship runs across floating debris in the middle of the night, divers are available to inspect possible damage and in most cases, enact repairs.

All dives associated with ship husbandry are classified as OSHA working dives which is why OMAO performs the majority of working dives within the Diving Program. An example of a routine task with significant impact that OMAO divers perform is regularly cleaning marine growth from the ship's hull to reduce the ship's acoustic signature and promote optimal performance between maintenance periods, thereby reducing fuel costs. Additionally, when working in marine protected areas, removing organisms from the ship's hull prior to entering these fragile ecosystems helps reduce the potential for transporting invasive species. The Hawai'i ships working within the Papahānaumokuākea Marine National Monument save thousands of dollars annually by conducting this task in-house.

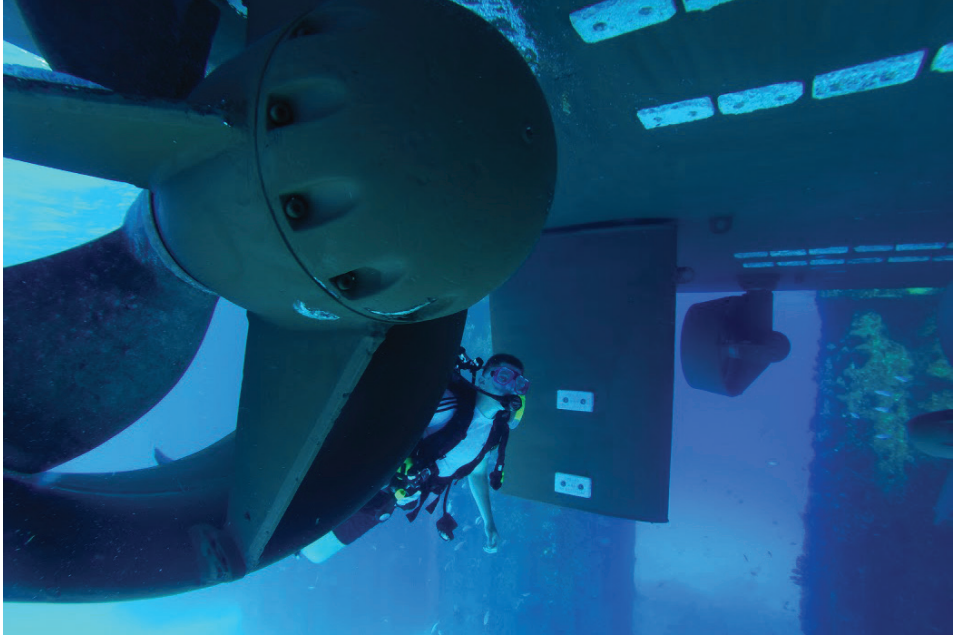
Below is a list of NOAA Ships that have diving units.

Marine Operations Center - Atlantic
Norfolk, Virginia

Ferdinand R. Hassler
Gordon Gunter
Henry B. Bigelow
Nancy Foster
Okeanos Explorer
Oregon II
Pisces
Ronald H. Brown

"Many of the tasks involved in these dives can be accomplished with simple hand tools and a little elbow grease, but without the skill to perform scuba dives, we would have no access to this part of the vessel."

OMAO



ENS Conor Maginn inspects *Nancy Foster*'s Z-drives, rudder, propeller, and zincs during a hull inspection in Cozumel, Mexico.
LCDR Jeff Shoup/NOAA

Marine Operations Center - Pacific
Newport, Oregon

Bell M. Shimada
Fairweather
Oscar Dyson
Rainier
Reuben Lasker

Marine Operations Center - Pacific Islands
Honolulu, Hawaii

Hi'ialakai
Oscar Elton Sette

The following ships completed unique projects in 2015.

Marine Operations Center - Atlantic
Norfolk, Virginia

NOAA Ship *Henry B. Bigelow*

With a working area in the Northeastern Atlantic, the *Bigelow* greatly benefits from having divers aboard to remove line from their running gear. In 2015, the ship divers were involved in a unique situation when the U.S. Coast Guard (USCG), taking advantage of the *Bigelow*'s position, asked for assistance with their search and rescue operations on a downed plane off Atlantic City, NJ. The *Bigelow* was able to use its advanced sonar systems to locate the fuselage of the downed aircraft, and as USCG divers were set to inspect the wreck, NOAA Divers were asked to standby in case assistance was needed. The *Bigelow* divers were not asked to assist

as weather conditions pre-empted a continued search. Kudos goes out to the divers for being willing to splash, and to work with the USCG on an unusual request.

NOAA Ship *Nancy Foster*

A total of 340 dives were conducted off the *Foster*'s small boats in support of operations for OMAO, other NOAA Line Offices, and organizations that were awarded ship time. This unit conducts monthly hull inspections and performs ship husbandry tasks to ensure vessel readiness in-port and while underway. Additionally, the unit supports and participates in a variety of scientific diving operations during scheduled ship projects and is equipped with an air/nitrox compressor that provides divers with a safe gas mix.

82 working dives were conducted by ship divers. Dives conducted while the ship was moored included hull inspections (to clean z-drives, propellers, rudder, sea chests and transducers), installation of a 300 kHz Acoustic Doppler Profiler (ADCP) in a moon pool and ensure proper alignment, removal and replacement of a Reson 7125 multi-beam receiver for repairs, and replacement of a sound velocity probe and cable. These dives saved the ship from having to hire professional divers and resulted in thousands of dollars in savings. These tasks were completed during a jam-packed field season, so it also potentially saved sea days by not having to contract the work out.

> "Tasks [performed by the *Foster* divers] were completed during a jam-packed field season, so [their work] also potentially saved sea days by not having to contract the work out."

Scientific dives by shipboard divers were conducted in support of research at Florida Keys National Marine Sanctuary (FKNMS) in June 2015, and to inspect deployed scientific instruments off Frying Pan Shoals, NC in July 2014.

At the Florida Keys National Marine Sanctuary (FKNMS), dives by various NOAA line offices and the Florida Fish and Wildlife Conservation Commission included installing and servicing acoustic telemetry receivers, surgically tagging trapped fish in situ with acoustic tags, conducting reef visual census fish surveys, servicing thermographs and placing identification tags on corals in the Tortugas coral restoration area.

Environmental Protection Agency (EPA) divers conducted sediment sampling and habitat assessments at Fernandina Beach Ocean Dredged Material Disposal Site (ODMDS) with 74 scientific dives conducted over 4 days. EPA divers also conducted benthic assessments at the New York Historic Area Remediation site and Reef Reference site with 24 scientific dives conducted over 3 days.

NOAA Ship *Okeanos Explorer*

The primary mission of the *Okeanos Explorer*'s diving unit is to carry out ship husbandry dives to regularly clean and maintain the ship's hull and its multi-beam sonar transducers, resulting in great cost-savings to OMAO. The ship's divers have a thorough understanding and knowledge of the extremely sensitive sonar equipment and of the specific tools and techniques required to safely maintain it. Cleaning it prior to use greatly enhances its functionality.

Later in the year, the diving unit performed a thorough inspection of the bow thruster when an oil leak was identified during a routine test. With previous familiarization of the bow thruster and the ability to quickly perform consecutive dives, the divers were able to determine that the bow thruster was not actively leaking oil. This information allowed ship's personnel to determine what was causing the leak in the bow thruster and take measures to prevent the leak from happening again.

The dives conducted on the *Okeanos Explorer* saved the ship an estimated $15,000 dollars that would otherwise cost much more to contract commercial divers and allowed the ship to maintain a high operational tempo with short port calls (3-5 days) and long cruises (20+ days).

NOAA Ship *Pisces*

The primary mission of the *Pisces* diving unit is to provide quick and effective diving response to both ship and scientific underwater needs. These needs include hull inspections and cleanings, and retrieval of scientific gear.

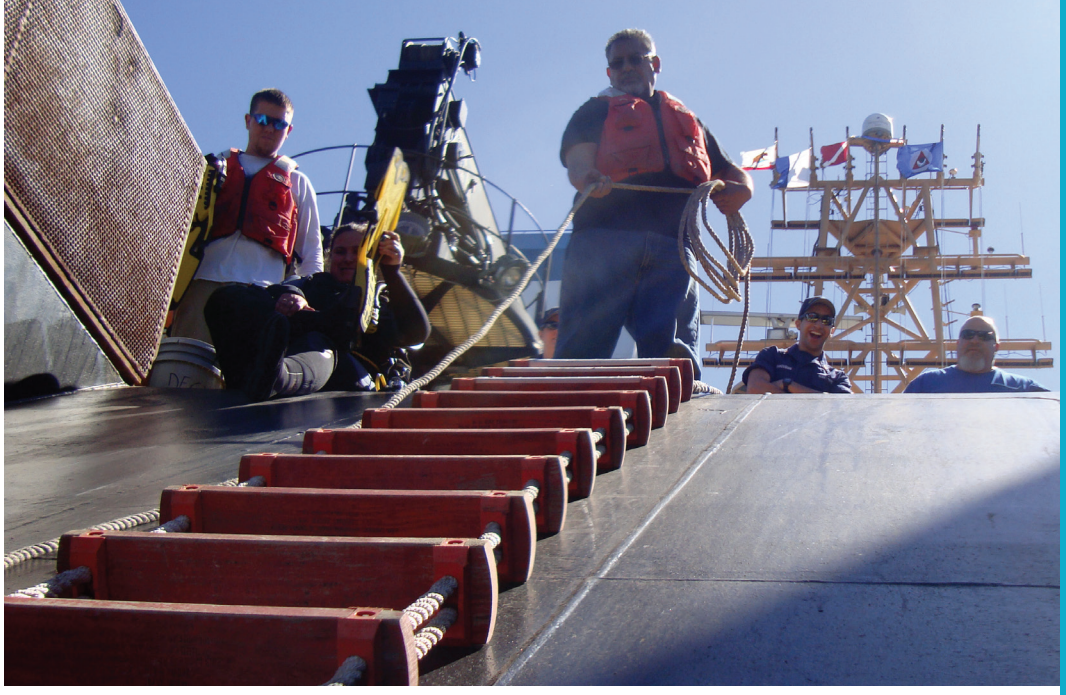
The unit's largest impact this year was their ability to locate and retrieve a chevron trap outfitted with numerous cameras. The unit executed a circle search to locate the gear and attached a float to the trap so the ship could retrieve the gear. The retrieval of the lost trap and camera array was significant to the scientific program in terms of both the expense of the trap and cameras, and the scientific value of the data recovered.

"The retrieval of the lost trap and camera array was significant to the scientific program in terms of both the expense of the trap and cameras, and the scientific value of the data recovered."

NOAA Ship *Ronald H. Brown*

The *Brown* is one of OMAO's vessels that transit the globe and is often many thousands of miles away from the nearest port, where a ship needs to be self-sufficient. Divers are a great resource during its long and lengthy travels and regular maintenance performed by the ship's crew and divers allowed the *Brown* to complete 97% of her scheduled sea days.

Midway through the 2015 field season, ship divers were deployed to visually inspect the propellers, which, after nearly a year underway, had developed serious marine growth. In teams of two, divers spent time



A view up the Jacob's ladder from which the *Shimada* divers exit the water. Deck crew wait to assist divers and pull their gear on board.
ENS Nikita Norton/NOAA

scrubbing and cleaning them, alleviating any cavitation as a result of the growth.

Marine Operations Center - Pacific
Newport, Oregon

NOAA Ship *Bell M. Shimada*

Working dives on the ship's hull and underwater equipment were conducted as needed for cleaning and maintenance and included introductory dives of the vessel to establish hull and equipment familiarization as well as inspection and cleaning of underwater equipment, including intakes and transducers.

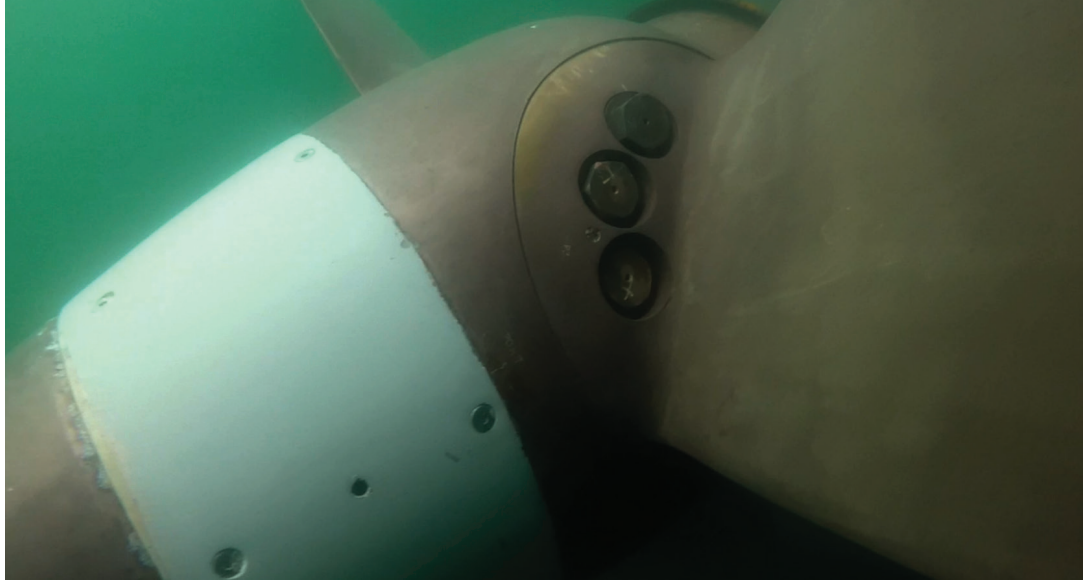
A special installation was completed on an intake scoop weighing 50+ lbs. The metal structure was installed on the starboard side of the hull approximately 15 ft down the side of the ship on the starboard side just above the bilge keel.

In addition, divers from the *Shimada* and many others from the *Rainier*, *Fairweather*, and *Dyson* who frequently dock in Newport, OR, volunteer at the Oregon Coast Aquarium to assist in the cleaning and upkeep of exhibits. By reaching out and maintaining diving reciprocity with the aquarium, NOAA Divers have benefited local organizations and promoted community awareness of NOAA as an organization.

NOAA Ship *Fairweather*

This diving unit is primarily involved in tide gauge installation and removals and ship husbandry.

Line and fishing gear removed from the *Shimada*'s propeller by NOAA Divers ENS Nikita Norton and LCDR Keith Golden.
LT Zach Cress/NOAA



One of the propellers from the NOAA Ship *Fairweather*, documented during a hull inspection by unit divers. LT Ryan Wartick/NOAA

When surveying in remote areas of Alaska that don't have accurate tidal information available, the installation of portable tide gauges is essential for accurate surveys. If the ship didn't keep divers onboard, they would have to contract out a dive team to install the gauges and maintain them.

Fairweather divers installed one tide gauge this year with return trips for routine maintenance, inspection, and removal at the end of the survey. During tide gauge installations, divers used a pneumatic drill for the holes, then installed eye bolts with lag shields and attached tide gauge components to the bolts with hose clamps and zip ties.
The diving team also performed three hull inspection dives to produce video documentation and clean the transducers. They also removed line which was tangled in the propellers.

NOAA Ship *Oscar Dyson*

With the *Dyson* spending the majority of its season in the Bering Sea, diver retention has posed a problem in the past. To ensure that there were enough divers in the ship's diving team to conduct safe operations for routine maintenance or in the event of an emergency, the diving team became NOAA tethered communications certified. This method of scuba diving with communications allowed them to have a two person diving team with a certified topside tender. Having a diving team is crucial for this ship because the ship relies on a low acoustic signature (noise) to conduct acoustic surveys, and the divers clean the hull of accumulated marine growth that may interfere with the surveys by increasing the ship's acoustic signature. The divers are the ones that regularly inspect and clean the hull, rudder, propeller and transducers and provide that information to MACE (Midwater Assessment and Conservation Engineering) program personnel to verify conditions. The cleanings and inspections are therefore critical to the ship's scientific mission as well as to the welfare of the ship.

> "Having a diving team is crucial for [NOAA Ship *Oscar Dyson*] because . . . the divers clean the hull of accumulated marine growth that may interfere with the surveys."

NOAA Ship *Rainier*

The primary mission of *Rainier*'s diving team is to provide support for the hydrographic survey operations conducted throughout the field season. Diving operations typically include the installation of tide gauge orifices as well as inspection of the ship's hull. The installation of tide gauges allows for the collection of tide-corrected hydrographic survey data, which is crucial to the accuracy of the nautical charts produced from it.

Rainier conducted hydrographic survey operations in four project areas in Alaska, including Chatham Strait, Shumagin Islands, Kotzebue Sound, and Kodiak. *Rainier*'s divers conducted one hull inspection in Chatham Strait, one tide gauge removal in Terror Bay, Kodiak, and one tide gauge installation in South Arm Uganik Bay, Kodiak.

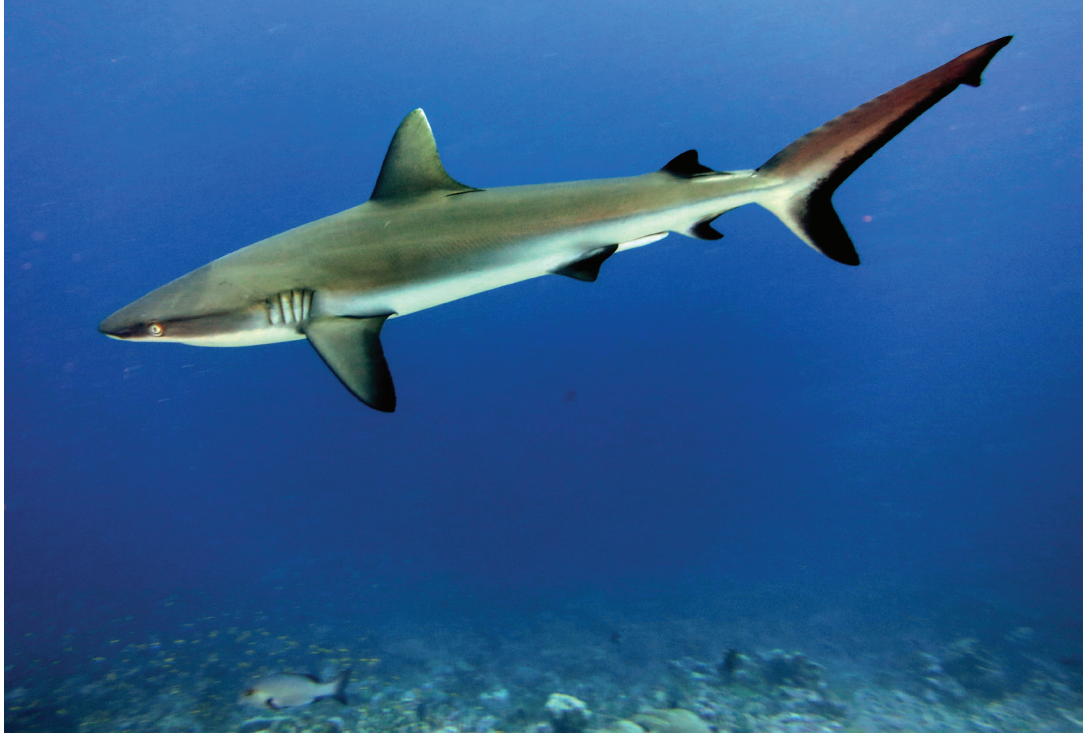
Additionally, the diving team conducted a mock tide gauge installation for training purposes in Women's Bay, Kodiak. Tide gauge installation training allowed for the pass down of knowledge and skills to new divers who had not yet had the opportunity to install a tide gauge in the field. This allowed for an efficient field install in South Arm.

NOAA Ship *Reuben Lasker*

This unit conducted 9 ship's husbandry dives throughout the year. Unit divers received on-site training on best practices from a commercial diving company on 2 occasions. The first occasion utilized combined efforts to clean the hull after an extended time alongside. The second utilized a pressure washer to clean hard growth from their extremely sensitive propeller, which requires specific techniques to clean it properly (no abrasive surface).

The unit also conducted an emergency dive in less than ideal conditions in Ugak Bay, AK to inspect squeaking of the shaft at all RPMs (revolutions per minute). While at anchor, divers were deployed to inspect the shaft for any obvious defects in the system that would identify the issue. The first dive attempt was called off due to high current, but the second

A diver from the *Lasker* splashes into the water. Bernardo Alps/NOAA



A grey reef shark (*Carcharhinus amblyrhynchos*) photographed near Jarvis Island during the 2015 Reef Assessment and Monitoring Project (RAMP) expedition conducted from NOAA Ship Hi'ialakai. Andrew Gray/NOAA

attempt was successful. The shaft was inspected and no debris was found. Photographic and video evidence from the dive was used to eliminate possible problems and allow focus to shift to other possibilities.

A hull inspection dive in San Diego, CA prior to the ship getting underway for Power Trials helped determine if excess growth resulting from extended time alongside would prevent the ship from going full speed and interfere with power testing. The hull Inspection was successful in ruling out growth as a factor, and video of the hull was used as evidence of a continuing mechanical problem.

NOAA Ship *Hi'ialakai*

This ship is the most active diving platform within NOAA. The ship supports scientific monitoring of coral reef ecology in the Main Hawaiian Islands, Northwestern (NW) Hawaiian Islands and American Territories and Trusts in the Pacific. More specifically, unit divers support the safe operation of the ship and perform hull dives when necessary to maintain its operational status.

The *Hi'ialakai* directly supported over 5,200 scientific dives this past year covering everything from reef and fish surveys, sensor deployment/recovery, archaeological surveys, and rebreather dives to 300 feet. Diving projects supported by the *Hi'ialakai* included a Reef Assessment and Monitoring Project (RAMP) in American Samoa as well as various Pacific Territories along the way, a reef fish population study in the

The diving team aboard the NOAA Ship *Hi'ialakai* in September, 2015. The divers completed research in the mesophotic region (between 100-300 ft. deep). Robert Whitton/Bishop Mus./NOAA

Main Hawaiian Islands, and RAMP and biogeography studies in the NW Hawaiian Islands.

This ship is the only vessel in NOAA's fleet that has a hyperbaric recompression chamber onboard and several members of the ship's crew are certified Diving Medical Technicians (DMTs) to support hyperbaric treatments in the event of an emergency.

36 unit dives were conducted for hull inspection and invasive species removal prior to entering Papahānaumokuākea Marine National Monument (PMNM), and to swap out several sensors on the hull. Before the ship works in the leeward Hawaiian chain (PMNM) the monument require a thorough hull cleaning. If completed by contractors, hull cleanings would cost between $10-15,000 per cleaning due to the time required to cover the entire hull. In-house hull cleaning saves $20-30,000 per year. The cleaning also removes invasive species from the ship prior to entering remote and protected waters and helps to maintain the sensitive ecological environment there. The removal of a stray piling at the pier at Midway helped clear the harbor of debris and made it safer for other ships to navigate and moor there. Unit divers also removed a line wrapped in a propeller and visually checked the structural integrity of the hull. The Commanding Officer (CO) and Chief Marine Engineer (CME) were concerned that the propellers or shaft were damaged, and in-house diving operations saved OMAO the cost of contracting outside divers for the job.

"The removal of a stray piling at the pier at Midway helped clear the harbor of debris and made it safer for other ships to navigate and moor there."

publications

A technical diver passes equipment to a free diver at Papahānaumokuākea MNM. Richard Pyle/Bishop Mus./NOAA

Scientists published data collected by NOAA Divers in 20 peer-reviewed articles and 13 technical memoranda, reports and presentations, and one book.

Peer-Reviewed Articles

NMFS

Honolulu, Hawaii

DeMartini, E. E., & Smith, J. E. (2015). Effects of fishing on the fishes and habitat of coral reefs. In Ed. C. Mora (Ed.), *Ecology of Fishes on Coral Reefs*. (pp. 135-144). Cambridge, United Kingdom: Cambridge University Press.

Gove, J. M., Williams, G. J., McManus, M. A., Clark, S. J., Ehses, J. S., & Wedding, L. M. (2015). Coral reef benthic regimes exhibit non-linear threshold responses to natural physical drivers. *Marine Ecology Progress Series, 522,* 33-48. http://dx.doi.org/10.3354/meps11118

MacNeil, M. A., Graham, N. A. J., Cinner, J. E., Wilson, S. K., Williams, I. D., Maina, J., Newman, S., Friedlander, A. M., Jupiter, S., Polunin, N., & McClanahan, T. R. (2015). Recovery potential of the world's coral reef fishes. *Nature, 520*, 341–344. http://dx.doi.org/10.1038/nature14358

NOAA Diver Michael Nemeth working with a volunteer diver while outplanting *Acropora cervicornis* from a coral nursery in La Parguera, Puerto Rico. NOAA

Williams, G. J., Gove, J. M., Eynaud, Y., Zgliczynski, B. J., & Sandin, S.A. (2015). Local human impacts decouple natural biophysical relationships on Pacific coral reefs. *Ecography, 38*(8), 751-761. http://dx.doi.org/10.1111/ecog.01353

Williams, I. D., Baum, J. K., Heenan, A., Hanson, K. M., Nadon, M. O., & Brainard, R. E. (2015). Human, oceanographic and habitat drivers of central and western Pacific coral reef fish assemblages. *PLoS ONE, 10*(4), e0120516. http://dx.doi.org/10.1371/journal.pone.0120516

Miami, Florida

Bright, A. J., Cameron, C., & Miller, M. W. (2015). Enhanced susceptibility to predation in corals of compromised condition. P*eerJ, 3*, e1239. https://dx.doi.org/10.7717/peerj.1239

OAR

Miami, Florida

Enochs, I. C., Manzello, D. P., Carlton, R. D., Graham, D. M., Ruzicka, R., & Collela, M. A. Ocean acidification enhances the bioerosion of a common coral reef sponge: Implications for the persistence of the Florida Reef Tract. (2015). *Bulletin of Marine Science, 91*(2), 271-290. https://dx.doi.org/10.5343/bms.2014.1045

Manzello, D. P., Enochs, I. C., Kolodziej, G., & Carlton, R. Recent decade of growth and calcification of Orbicella faveolata in the Florida Keys: An inshore-offshore comparison. (2015). *Marine Ecology Progress Series, 521*, 81-89. https://dx.doi.org/10.3354/meps11085

Sutton, A., Manzello, D., & Gintert, B. Coupling chemical and biological monitoring to understand the impact of ocean acidification on coral reef ecosystems. (2015). *Oceanography, 28*(2), 28-29. https://dx.doi.org/10.5670/oceanog.2015.28

Towle, E. K., Enochs, I. C., & Landon, C. Threatened Caribbean coral is able to mitigate the adverse effects of ocean acidification on calcification by increasing feeding rate. (2015). *PLoS ONE, 10*(4), e0123394. https://dx.doi.org/10.1371/journal.pone.0123394

NOAA Diver Bill Goodwin collecting baseline data of relocated corals at a restoration site on Cheeca Rocks Reef, at the Florida Keys NMS. Kelsey Jeffers/NOAA

publications

NOS

ONMS

Gray's Reef NMS

Freeman, C. J., Easson, C. G. & Baker, D. M. Niche structure of marine sponges from temperate hard-bottom habitats within Gray's Reef National Marine Sanctuary. (2015). *Journal of the Marine Biological Association of the United Kingdom, 1*, 1-7. https://dx.doi.org/10.1017/S0025315415000363

Reigel, A. M., Harrison, J. D. & Gleason, D. F. Tetranucleotide microsatellites for the barnacle Megabalanus coccopoma (Darwin, 1854). (2015). *Biochemical Systematics and Ecology, 62*, 159-163. https://dx.doi.org/10.1016/j.bse.2015.08.010

Papahānaumokuākea MNM

Gaither, M. & Wagner, D. Promiscuous associations: observations of gold-saddle goatfishes in the Chagos Archipelago (Indian Ocean). (2015). *Bulletin of Marine Science, 91*(3), 321-322.

Kelley, C., Smith, J., Tree, J., Miller, J., Boston, B., Garcia, M., Ito, G., Taylor, J., Lichowski, F., Wagner, D., Leonard, J., Dechnik, B. & Luers, D. New insights from seafloor mapping of a Hawaiian Marine National Monument. (2015). *EOS, 96*. https://dx.doi.org/10.1029/2015EO030235

Papastamatiou, Y., Meyer, C., Kosaki, R., Wallsgrove, N. & Popp, B. Movements and foraging of predators associated with mesophotic reefs and their potential for linking ecological habitats. (2015). *Marine Ecology Progress Series, 521*, 155-170. https://dx.doi.org/10.3354/meps11110

Roche, R. C., Pratchett, M. S., Carr, P., Turner, T. R., Wagner, D., Head, C. & Sheppard, C. R. C. Localized outbreaks of *Acanthaster planci* at an isolated and unpopulated reef atoll in the Chagos Archipelago. (2015). *Marine Biology, 162*(8), 1695-1704. https://dx.doi.org/10.1007/s00227-015-2708-7

Wagner, D. A taxonomic survey of the shallow-water (<150 m) black corals (Cnidaria: Antipatharia) of the Hawaiian Islands. (2015). *Frontiers in Marine Science, 2*, 24. https://dx.doi.org/10.3389/fmars.2015.00024

Wagner, D. The spatial distribution of shallow-water (<150 m) black corals (Cnidaria: Antipatharia) in the Hawaiian Archipelago. (2015). *Marine Biodiversity Records, 8*, e54. https://dx.doi.org/10.1017/S1755267215000202

A potentially new species of seahorse. Brian Hauk/NOAA

Banded coral shrimp, gardner Pinnacles, Northwestern Hawaiian Islands. Greg McFall/NOAA

Wagner, D. & Opresko, D. M. Description of a new species of *Leiopathes* (Antipatharia: Leiopathidae) from the Hawaiian Islands. (2015). *Zootaxa, 3974*(2), 277-289. https://dx.doi.org/10.11646/zootaxa.3974.2.11

Thunder Bay NMS

Patel, S. Last Flight of a Tuskegee Airman. (2015). *Archaeology Magazine, 20*. http://www.archaeology.org/issues/195-1511/trenches/3746-trenches-michigan-underwater-airplane

NOAA Diver Louise Giuseffi taking photo quadrats. Kelvin Gorospe/NOAA

Technical Memoranda, Reports and Presentations

NMFS

Honolulu, Hawaii

Heenan, A., McCoy, K., Asher, J., Ayotte, P., Gorospe, K., Gray, A., Lino, K., Zamzow, J., & Williams, I. (2015). *Ecological monitoring 2014: Stationary point count surveys of reef fishes and benthic habitats of the Northwestern Hawaiian Islands, Mariana Islands, and Wake Atoll.* (Data Report No. DR-15-001: 101). Honolulu, HI: Pacific Islands Fisheries Science Center. https://dx.doi.org/10.7289/V5GT5K6B

McCoy, K., Williams, I., & Heenan, A. (2015). *A comparison of rapid visual assessments and photo-quadrat analyses to monitor coral reef habitats.* (Data Report No. DR-15-011). Honolulu, HI: Pacific Islands Fisheries Science Center. https://dx.doi.org/10.7289/V52805K5

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McCoy, K., Ayotte, P., Gray, A., Lino, K., Schumacher, B., & Sudnovsky, M. (2015). *Coral reef fish biomass and benthic cover along the north coast of Timor-Leste based on underwater visual surveys in June 2013.* (Data ReportNo. DR-15-004). Honolulu, HI: Pacific Islands Fisheries Science Center. https://dx.doi.org/10.7289/v5k0728f

Sundberg , M., Kobayashi, D., Kahng, S., Karl, S., & Zamzow, J. (2015). *The search for juvenile bumphead parrotfish (Bolbometopon muricatum) in the lagoon at Wake Island.* (Administrative Report No. H-15-02) Honolulu, HI: Pacific Islands Fisheries Science Center. https://dx.doi.org/10.7289/V57D2S31

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Kilfoyle, K., Walker, B. K., Fisco, D. P., Smith, S. G., & Spieler, R. E. (2015). *Southeast Florida Coral Reef Fishery-Independent Baseline Assessment.* (2012-2014 Summary Report). Florida Department of Environmental Protection. http://www.coris.noaa.gov/activities/florida_fish_baseline/

Pausch, R. E., Miller, M. W., Williams, D. E., & Bright, A. J. (2015). *Effects of outplant size on Acropora palmata fragment survivorship, growth, and condition.* (Unpublished Report No. SEFSC-PRBD-2015-03). Southeast Fisheries Science Center.

Williams, D.E., Miller, M.W., Bright, A.J., & Pausch, R.E. National Marine Fisheries Service. (2015) *Quick Look Report: 2014 Acropora palmata Bleaching Event in the Upper Florida Keys.* (Unpublished Report SEFSC-PRBD-2015-02). Southeast Fisheries Science Center.

Schull, J. (Ed.). (2015). *SEFSC Coral Reef Program: FY 2014 Project Accomplishments Report.* (NOAA Technical Memorandum No. NMFS-SEFSC-683). Southeast Fisheries Science Center. http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/202/FY14_SEFSC_Accomplishments_Final.pdf

NOS

NCCOS

Beaufort, North Carolina

Paxton, Taylor, Nowacek, Dale, Cole, Voss, Degan, Ebert, & Peterson. (2015). *In situ observations from a marine seismic survey in Onslow Bay, North Carolina.* (OCS Study NO. BOEM 2015-XXX and NOAA Technical Memorandum No. 58). Bureau of Ocean Energy Management and National Oceanographic and Atmospheric Administration.

The egg ribbon of *Hexabranchus sanguineus*.
Greg McFall, NOAA

Curious lobster reviewing data. Jason Leonard/NOAA

ONMS

Gray's Reef NMS

Reigel, A. M. (2015). *The role of artificial structures in facilitating range expansion of the introduced barnacle Megabalanus coccopoma in the southeastern U.S.A.* (Unpublished doctoral dissertation). Georgia Southern University, Statesboro, Georgia.

Papahānaumokuākea MNM

Wagner, D., Opresko, D. M., Montgomery, A. D. & Parrish, F. A. (2015). Spotlight: An update on recent research and management activities of Hawaiian black corals. In: T. F. Hourigan, P. J. Etnoyer, S. D. Cairns, & C. F. Tsao (Eds.), *The State of Deep-Coral and Sponge Ecosystems of the United States: 2015.* (NOAA Technical Memorandum X). https://deepseacoraldata.noaa.gov/library/2015-state-of-dsc-report-folder/Ch6_black_coral_Wagner.pdf

Thunder Bay NMS

Marsden, J. E., Johnson, J., Binder, T., Dingledine, N., Adams, J., & Krueger, C. (2015) Use of Acoustic Telemetry to Evaluate Lake Trout Spawning on Constructed Reefs. In: Proceedings from AFS 2015: *145th American Fisheries Society Annual Meeting*. Portland, OR.

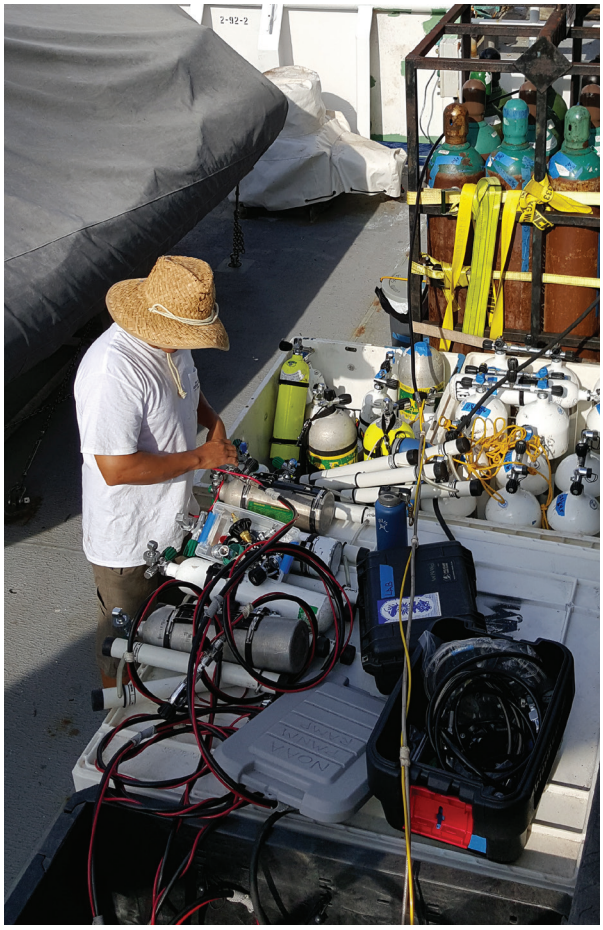
Green sea turtle under Midway Pier. Greg McFall/NOAA

publications

Books

Stellwagen Bank NMS

Lawrence, M., Marx, D., & Galluzzo, J. (2015). *Shipwrecks of Stellwagen Bank: Disaster in New England's National Marine Sanctuary.* Charleston: Arcadia Publishing.



Diving tanks aboard NOAA Ship *Hi'ialakai*.
Brian Greene/NOAA

http://www.omao.noaa.gov/ndp

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NOAA
DIVING PROGRAM

Diving for Science and Technology