Beyond the Golden Gate Research Symposium 2022

Host Institutions

Californian Cooperative Ecosystem Studies Unit
Coastal & Marine Sciences Institute, at U.C. Davis
Cordell Bank National Marine Sanctuary
Golden Gate National Recreation Area
Greater Farallones Association
Greater Farallones National Marine Sanctuary
Point Blue Conservation Science
Point Reyes National Seashore
Estuary and Ocean Science Center at San Francisco State University
San Francisco Bay National Estuarine Research Reserve

If you did not receive an announcement of the workshop and wish to be added to the GFNMS research mailing list or if you have comments on this or future research symposia, please submit written request and suggestions to Jan Roletto, Jan.Roletto@noaa.gov, GFNMS, 991 Marine Dr., The Presidio, San Francisco, CA, 94129.

The Proceedings and PDFs of the presentations are available on the symposium website at: https://sfbaynerr.sfsu.edu/BGGRS

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BEYOND THE GOLDEN GATE RESEARCH SYMPOSIUM

A symposium focused on the oceanography, geology, and ecology of the Gulf of the Farallones and adjacent waters between Point Arena and Point Año Nuevo – including Cordell Bank, Point Reyes and central San Francisco Bay

San Francisco Bay Area, CA
19-20 January 2022

Preface

The planning committee for the Beyond the Golden Gate Research Symposium [Californian Cooperative Ecosystem Studies Unit (CCESU), Coastal and Marine Sciences Institute at U.C. Davis (CMSI), Cordell Bank National Marine Sanctuary (CBNMS), Golden Gate National Recreation Area (GGNRA), Greater Farallones Association (GFA), Greater Farallones National Marine Sanctuary (GFNMS), Point Blue Conservation Science (Point Blue), Point Reyes National Seashore (PRNS), Estuary and Ocean Science Center at San Francisco State University (SFSU), and San Francisco Bay National Estuarine Research Reserve (SFBNERR) are pleased to convene a multidisciplinary symposium on research in the Gulf of the Farallones and adjacent waters between Point Arena and Point Año Nuevo – including Cordell Bank, Point Reyes, and central San Francisco Bay. After a six-year hiatus since the last regional research symposium, this forum provides an opportunity for researchers and resource managers to collaborate and exchange information about their projects with each other, educators, and members of the public. Symposium topics include marine resource management, including climate change impacts and indicators, restoration and mitigation activities, defining and identifying ecological hotspots, oceanographic patterns, the integration of biological and physical observations, habitat characterization, and the importance of long-term monitoring of our marine and estuarine habitats and species. Our goal is to increase our understanding and protection of regional marine and estuarine ecosystems, to support and guide wise management of the environment.

Abstract requests were sent to the community of researchers and marine educators, private organizations, schools, and public agencies known to be investigating or educating the public about the ecosystem in this region. This year we received 40 abstracts from a broad range of disciplines on ongoing projects, projects recently completed, and projects that will begin soon.

For the first time, this year the symposium is conducted virtually. To increase the exchange of ideas among researchers from many disciplines we have created a virtual digital whiteboard that allows for remote collaboration on a shared space. This forum will be used throughout the symposium for participants to ask questions, post links to papers and reports, and exchange

ideas about relevant overarching topics such as habitat compression, influences of San Francisco Bay on the coastal ocean, marine heat waves and the El Niño-Southern Oscillation. We hope that you use this virtual forum to critique and contribute to each other's work, as well as to develop new collaborations.

Several investigators were not able to attend the workshop but their abstracts are included in the Proceedings. The data and information produced through the research and monitoring projects represented are vital to the continued wise management of the bay, coastal and pelagic sanctuaries, parks, and reserves.

The institutions sponsoring this symposium are leaders in the field of marine, coastal, and estuarine research and resource protection and each contributes to our regional collective efforts through research, teaching, or management. This year Office of National Marine Sanctuaries celebrates 50-years of protecting our ocean and Great Lakes and wilderness, cultural and maritime heritage resources throughout the U.S. just beyond the Golden Gate. GFNMS protects the wildlife, habitats, and cultural resources of one of the most diverse and bountiful marine environments in the world, an area of 3,295 square miles off the northern and central California coast. CBNMS protects 1,286 square miles of ocean off the coast of Point Reyes and are committed to education, science, and protection of this offshore environment. PRNS has an ongoing commitment to marine science, conservation, and education. They lead the research and restoration of Drakes Estero and continue long-term monitoring of pinniped, seabird, rocky-intertidal and State marine protected areas along the PRNS coastline. In 2022, Golden Gate National Recreation Area will celebrate its 50th anniversary of protecting coastal resources and providing access to the public. SFBNERR encompasses over 3,700 acres of tidal marshes and undeveloped uplands that serve as research sites, outdoor classrooms, and recreation destinations. Reserve staff work to restore tidal marshes and strengthen the coastal community through research, monitoring, training, and education. GFA partners with GFNMS and CBNMS to conserve the wildlife and habitats of the north-central California coast through scientific research, environmental education, and community-based conservation. The University of California at Davis' Bodega Marine Laboratory continues to strengthen research interests in this region, integrating across disciplines and combining discovery with formal education opportunities through degree programs. Point Blue Conservation Science celebrated 55 years in 2020 and is committed to advancing nature-based solutions to climate change, habitat loss, and other environmental threats for wildlife and people, through science, partnerships, and outreach. The protection of our ocean-based natural and cultural resources will be diminished without the research represented in these Proceedings.

The Symposium Sponsors thank you for attending this symposium.

Ben Becker
PRNS & CCESU

Alexandria Bevan
Greater Farallones Association

Darren Fong
GGNRA

Aimee Good
SFBNERR & SFSU

Jaime Jahncke
Point Blue

Kirsten Lindquist
GFA

Karina Nielsen
SFSU

Jan Roletto
GFNMS & CBNMS

John Largier
CMSI

Danielle Lipski
CBNMS & GFNMS

Adria M. O'Dea
SFSU

Program

Day 1 – January 19

0900-0915 **Welcome, Introductory Remarks & Logistics**
Maria Brown & Jan Roletto

Session 1. Monitoring, Moderator – Ben Becker

0915-1015 **Using environmental DNA to observe life in the sea in the central California Current.**
Francisco Chavez

Using a FlowCAM to analyze zooplankton samples from the Gulf of the Farallones.
Charles Norton, Meredith Elliott, Jaime Jahncke, Wim Kimmerer, Anne Slaughter, Toni Ignoffo, Michelle Jungbluth

Monitoring hypoxia on Cordell Bank.
Rachel Pound, Kate Hewett, David Dann, Robin Roettger, Danielle Lipski, and John Largier

Analysis of river plume remote sensing data.
Will Speiser and John Largier

Seabird feathers track diet and sources of oceanographic carbon and nitrogen in the Greater Farallones from 1880 – 2005.
Ben Becker and Steven R. Beissinger

Session Q&A and Whiteboard Arena Summary
Ben Becker

1015-1020 ***Break***

Session 2. Monitoring, Moderator – Ben Becker

1020-1115 **Associations among mass mortality events, seabird demography, and ocean climate trends in central California.**
Kirsten Lindquist, Pete Warzybok, Meredith Elliott, Julie Howar, Jan Roletto, Nadav Nur, Taylor Nairn and Jaime Jahncke

Passive acoustic monitoring in Cordell Bank National Marine Sanctuary reveals large vessels and baleen whales are primary drivers of the low-frequency ambient soundscape.
Samara M. Haver, Leila T. Hatch, Danielle Lipski, Robert P. Dziak , Sofie M. Van Parijs, Joseph Haxel, Scott A. Heppell, Jaime Jahncke, Megan F. McKenna, David K. Mellinger, William Oestreich, Zoe Rand, Lauren Roche, John Ryan, Jeffrey D. Adams, Jason Gedamke

High-resolution vertical movements of sub-adult and adult white sharks on the Californian coast.
Samantha Andrzejaczek, Taylor Chapple, Salvador Jorgensen, Scot Anderson, Michael Castleton, Paul Kanive, Timothy White, Barbara Block

Automating seal monitoring in Point Reyes National Seashore using convolutional neural networks.
Silas Gifford, Sarah Codde, Benjamin H. Becker

Session Q&A and Whiteboard Arena Summary
Ben Becker

1115-1145 ***Lunch Break***

Session 3. Environmental Change, Moderator – Maria Brown

1145-1245 **Through the lens of Orville Magoon: a technic-personal view of California's coast.**
Douglas George, Melodie Grubbs, Lesley Ewing, Nadia Maher, Kimberly Garvey, and Phyllis Grifman

Tracking ocean acidification in north central California.
Meredith L. Elliott, Danielle Lipski, Jan Roletto, Carina Fish, Tessa Hill, and Jaime Jahncke

Northern Range Expansion of California Coastal Bottlenose Dolphins (*Tursiops truncates*).
William Keener, Isidore D. Szczepaniak, Marc A. Webber, Tim M. Markowitz, Mark P. Cotter, Daniela Maldini, R.H. Defran, Megan Rice, Amanda J. Debich,

Gregory S. Campbell, Aimée R. Lang, Dennis L. Kelly, Alex G. Kesaris, Maddalena Bearzi, Kayla Causey, David Anderson, Laurie Shuster, Thomas F. Norris, and David W. Weller

First record of California coastal bottlenose dolphins in northern California offshore waters.
Marc A. Webber, Isidore D. Szczepaniak, William Keener, Timothy M. Markowitz, Amanda Spears, and Mark P. Cotter

Session Q&A and Whiteboard Arena Summary
Maria Brown

1245-1250 ***Break***

Session 4. Environmental Change – Kirsten Lindquist

1250-1400 **Stranded in history: marine mammal stranding data from 1884-2019 in central California.**
Kate High, Denise Greig, Marisol Garcia Reyes, Doug George, Sean Vitousek, Orhun Aydin, Ellen Hines

Causes and trends of live strandings of northern fur seals (*Callorhinus ursinus*) along the California coast, 1975-2021.
Michelle R. Rivard, Lisabet M. Hortensius, Tenaya Norris and Cara L. Field

Increased use of San Francisco Bay habitat by gray whales coincides with an Unusual Mortality Event.
Tim M. Markowitz, Isidore D. Szczepaniak, William Keener, Rebekah Lane, Allison Payne, Barbie Halaska, Padraig Duignan, Marc A. Webber

Overview of gray whale (*Eschrichtius robustus)* strandings *in the San Francisco Bay Area* during an "Unusual Mortality Event".
Barbie Halaska, Moe Flannery, Denise Greig, Sue Pemberton, Frances Gulland, Justin Greenman, Justin Viezbicke, Deborah Fauquier, and Padraig Duignan

Sperm whales of the Golden Gate: A brief history of the Richmond whaling stations, sperm whale catches, and what might be learned about their life history and ecology then and now.
Sarah L. Mesnick, Robert L. Brownell, Jr., and John Field

Session Q&A, Whiteboard Arena Summary and Summary of Day 1
Kirsten Lindquist

Day 2 – January 20

0900-0915 **Welcome, Recap of Day 1 & Logistics**
Ben Becker & Jan Roletto

Session 5. Humans in the Environment – Ben Becker

0915-1015 **Effects of seagrass on non-native invertebrates in Tomales Bay, CA.**
Benjamin Rubinoff and Edwin Grosholz

Long-term monitoring of small estuaries in Northern California.
Robin Roettger, John Largier

Northern California doghole ports maritime cultural landscape.
Denise Jaffke and Deborah Marx

Adrift in the California Current: Passive acoustic monitoring for ecosystem studies.
Anne Simonis, Shannon Rankin, Jan Roletto, and Danielle Lipski

Incidence of microplastics in northern anchovies (*Engraulis mordax*) off Central California.
D'Andre J. Alejandro, Ellen Hines, Meredith Elliott, and Jaime Jahncke

Session Q&A and Whiteboard Arena Summary
Ben Becker

1015-1020 ***Break***

Session 6. Humans in the Environment – Ben Becker

1020-1120 **Longitudinal study of entanglement scars on humpback whales (Megaptera novaeanglae) off the coast of central California.**
Allison Payne, Ellen Hines, John Calambokidis, Tim Markowitz, Wim Kimmerer, Jenn Tackaberry

Overlap of Humpback Whale (*Megaptera novaeangliae*) habitat and vessel traffic in San Francisco Bay with insights from tagging.
Rebekah S. Lane, James Fahlbusch, John Calambokidis, Allison Payne, Thomas J. Moore, William Keener, Isidore D. Szczepaniak, Tim M. Markowitz, Marc A. Webber, and Ellen Hines

Whales and kelp: The overlooked Blue Carbon in Greater Farallones National Marine Sanctuary.
Sara Hutto, Rietta Hohman, Sage Tezak, and Maria Brown

Long-term aerial surveys support diverse management and research of protected species off California.
Karin A. Forney and Scott R. Benson

Species on the move: Impacts of marine heatwaves on coastal ecosystems.
Jacqueline L. Sones, Eric Sanford, Marisol García-Reyes, Jeffrey H. R. Goddard, and John L. Largier

Session Q&A and Whiteboard Arena Summary
Ben Becker

1120-1150 ***Lunch Break***

Session 7. Resource Management Issues & Responses – John Largier

1150-1250 **Eradication failure and the use functional eradication for managing aquatic invasive species using community scientists and volunteers.**
Edwin Grosholz, Andrew Chang, Linda McCann, Kate Bimrose, Stephanie Green, Carolyn Tepolt, and Greg Ruiz

Kelp restoration assessment in the Greater Farallones National Marine Sanctuary.
Rietta Hohman, K.E. Elsmore, Ray, J., Lonhart, S., Freedman, R., Garza, C., Lampietro, P.

Ocean observing systems beyond the Golden Gate.
John Largier, Deedee Shideler, Marcel Losekoot, Robin Roettger, David Dann, Tessa Hill, Grant Susner, Carol Vines and CeNCOOS collaborators

Diving deep: characterizing bathymetric zonation and taxonomic diversity of deep-sea corals in Cordell Bank National Marine Sanctuary.
Kaitlin Graiff, Danielle Lipski, and Gary Williams

Drakes Estero post-aquaculture Eelgrass restoration and recovery: Years 1-5.
Ben Becker, Sarah Codde, Amelia Ryan, Taylor Ellis, and Brannon Ketcham

Session Q&A and Whiteboard Arena Summary
John Largier

1250-1255 ***Break***

Session 8. Resource Management Issues & Responses – John Largier

1255-1345 **Small vessel surveys to inform decisions related to the Dungeness Crab fishery in California.**
John Calambokidis, Kiirsten Flynn, Jack Barkowski, Jenn Tackaberry, James Fahlbusch, Kathi George, Ryan Berger, Julia Ohern, and Doug Sandilands

Rocky intertidal monitoring of red abalone in California's north central coast.
Karah Ammann, Melissa Douglas, Maya George, Mirella Cortez, Alexis Necarsulmer and Peter Raimondi

Protecting blue whales and blue skies in California's National Marine Sanctuaries.
Jessica Morten and Michael Carver

A milestone in the making: California's globally recognized marine protected area network decadal management review.
Stephen Wertz, Sara Worden, Chenchen Shen, Amanda Van Diggelen, Elizabeth Pope, Michael Prall, Kara Gonzales, Lara Slatoff, Tamara Heitzenrater, and Becky Ota

Session Q&A and Whiteboard Arena Summary
John Largier

1345-1400 Symposium Summary & Closing Remarks – John Largier & Maria Brown

Abstracts Not Presented

Year-round foraging patterns in adult Western gulls (Larus occidentalis) from Southeast Farallon island.
Katherine Douglas, Scott Shaffer, Mike Johns, Pete Warzybok

Long-term waterfowl abundance trends in central California outer coastal bays and lagoons.
Tanya R. Graham and Susan E. De La Cruz

Behavior mediates dispersal of nearshore larval fishes between Point Reyes and Point Arena.
Helen Killeen, Steven Morgan and John Largier

Abstracts

Listed Alphabetically by First Author's Last Name

Incidence of microplastics in northern anchovies (*Engraulis mordax*) off Central California.

D'Andre J. Alejandro[1], Ellen Hines[1], Meredith Elliott[2] and Jaime Jahncke[2]

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As a highly urbanized estuary, the San Francisco Bay area is a major supplier of marine plastic debris to the surrounding aquatic ecosystem. Plastics in textiles and household products are widely used and enter the San Francisco watershed discharging into the Gulf of the Farallones in Central California. Plastic particulates can then be ingested by a wide variety of marine species including fish that are then consumed by upper trophic level predators such as nesting seabirds on the Farallon Islands. While observations of plastic in the environment are rapidly increasing, publications related to microplastic ingestion in California marine species are limited. This research represents the first investigation of microplastic ingestion in a fish species within the Gulf of the Farallones. The primary aim of this study was to determine the extent of microplastic ingestion of a commonly consumed prey fish species, the northern anchovy (*Engralis mordax*), and document changes in ingestion from samples procured through a long-term seabird diet survey (2000-2020). After extraction of the fish's stomach and digestion using 10% potassium hydroxide (KOH), remaining contents were vacuum filtered and screened for microplastics using epifluorescence microscopy. Further, we analyzed suspected plastic particles through Fourier-Transform infrared spectrometry (FT-IR) to compare polymer frequency and occurrence within samples. To date, 77% (n=75) showed incidence of suspected plastic particulates in the stomachs. Microfibers > 100 µm were the most frequent (64%) microplastic particle found. Ultimately, the detection of particle accumulation in northern anchovies will advance our limited understanding of the incidence of microplastics in prey fish species and the potential consequences of microplastic pollution to upper trophic levels in Central California.

Rocky intertidal monitoring of red abalone in California's north central coast.

Karah Ammann, Melissa Douglas, Maya George, Mirella Cortez, Alexis Necarsulmer and Peter Raimondi

Long Marine Laboratory, University of California Santa Cruz, Santa Cruz, CA. Emails: karah.ammann@ucsc.edu, melissa.douglas@ucsc.edu, mgeorge@ucsc.edu, anecarsu@ucsc.edu, milcorte@ucsc.edu, and raimondi@ucsc.edu

Our UC Santa Cruz research group monitors the rocky intertidal ecosystem in collaboration with MARINe (Multi-Agency Rocky Intertidal Network). Key elements of this monitoring program include assessment of biodiversity, community structure, and species of special interest. Here we focus on our monitoring of an ecologically and economically important species of interest, red abalone (*Haliotis rufescens*) within the focal area between Pt. Arena and Año Nuevo. Useful for capturing and understanding broad scale temporal and spatial changes, this long-term monitoring also informs policy and management decisions. In 1997, the red abalone fishery in California was restricted to north of the Golden Gate Bridge. Due to a significant decline in stocks resulting from multiple environmental stressors, the red abalone recreational fishery was closed in 2017. Subsequent kelp bed decline and lack of population recovery resulted in the Fish and Game commission extending the closure to at least 2026. We most recently monitored this critical species during summer 2021. Here we report our findings, from 3 sites, along with a discussion of possible influencing factors and implications. Following an ocean warming event and offshore kelp declines, the red abalone appeared to find temporary refuge in the intertidal. This was followed by a decline in intertidal red abalone as kelp cover decreased in the intertidal. Red abalone declines over the 11-15 year sampling period suggest environmental conditions as well as the recreational fishery impact the population to varying degrees throughout their range. We hope that continued monitoring, used to inform active management strategies, will aid in the recovery of red abalone back to sustainable numbers.

High-resolution vertical movements of sub-adult and adult white sharks on the Californian coast.

Samantha Andrzejaczek[1], Taylor Chapple[1,2], Salvador Jorgensen[3], Scot Anderson[3], Michael Castleton[1], Paul Kanive[4], Timothy White[1], Barbara Block[1]

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Over the past two decades, satellite tags deployed on white sharks *Carcharodon carcharias* on the coast of central and northern California have revealed a predictable migratory cycle. Foraging white sharks aggregate on the coast near pinniped rookeries from late summer and undergo long-distance migrations (> 2000 km) to offshore pelagic habitats in winter. Our current understanding of the vertical movement patterns exhibited by white sharks during coastal phases, however, remains limited. Here, we used recovered datasets from 31 archival satellite tags to quantify the cryptic vertical movement patterns of white sharks during the coastal foraging phase of their migration. Tags were deployed on sub-adult and adult individuals between 2000 and 2018 and recorded depth and temperature data at 1-120 second intervals before being recovered up to a year after deployment. Additionally, four individuals were concurrently tagged with acoustic tags, providing horizontal position data that allowed us to explore how reported vertical movements vary spatially between areas such as Año Nuevo, Tomales Bay, San Francisco Bay and the Channel Islands. While on the coast, white sharks moved at a mean depth ± SD of 14.3 ± 4.0 m, and occupied significantly deeper depths during the day than the night. High individual, temporal and spatial variation was evident in vertical movements, while consistent diel and lunar effects emphasized the importance of light-level driving vertical behavior around hunting sites. The vertical movement behaviors reported here provide knowledge of how white sharks may directly and indirectly interact with their mammalian prey in a dynamic three-dimensional system during their capital foraging phase. Combining these novel findings with higher-resolution biologging techniques in future studies will allow us to further contextualize fine-scale vertical movement behaviors of white sharks and examine the specific foraging events that could not yet be isolated in the tagging data.

Seabird feathers track diet and dources of oceanographic carbon and nitrogen in the Greater Farallones from 1880 – 2005.

Ben Becker[1], and Steven R. Beissinger[2]

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The California Current ecosystem has undergone both directional and cyclic variation in oceanography and biodiversity over the past 140 years. Both of these changes generally leave isotopic evidence where nitrogen isotopes (1) enrich with trophic level due to metabolism and (2) carry a signature of both the source waters and processes of nitrogen fixation. Similarly, carbon isotope ratios provide information on both location and condition of source waters. Carbon and nitrogen isotope ratios of seabird feathers provide information on both the isotope environment of the ocean where seabirds feed and molt as well as trophic relationships between predators and prey when the feathers were grown. We analyzed the carbon (bulk) and nitrogen (bulk and compound specific amino acids) isotope ratios of over 1700 seabird feather samples collected between 1880 and 2005 in the Greater Farallones and Northern Monterey Bay NMS from 5 species of locally molting seabirds: common murres (*Uria aalge***)**, Cassin's auklets (*Ptychoramphus aleuticus*), Marbled Murrelets (*Brachyramphus marmoratus*), pelagic cormorants (*Urile pelagicus*), and Rhinoceros Auklets (*Cerorhinca monocerata*). Bayesian generalized linear and additive mixed models (implemented in Stan) indicate that *trophic* level nitrogen isotopes were relatively stable over the study period while *source* level nitrogen isotopes declined with increases in upwelling measured by the California Current winter index (CCWI). The Southern Oscillation Index, intrusion of oxygen minimum zones in Southern California, latitude, and season (spring or late summer molts) were less important. The importance of the CCWI is consistent with increased upwelling introducing depleted nitrogen into the food web, resulting in the appearance of a trophic level decline when examining bulk isotopes. Carbon isotope ratios increased over the study period, also consistent with an increase in upwelled ^{13}C enriched waters. Seabird feathers provide an additional window into long-term variation in ocean biogeochemistry.

Drakes Estero post-aquaculture eelgrass restoration and recovery: Years 1-5.

Ben Becker[1], Sarah Codde[2], Amelia Ryan[3], Taylor Ellis[2], and Brannon Ketcham[2]

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Between August 2016 and May 2017, the National Park Service (NPS) removed 95 wooden oyster racks (~8 km in length) and associated aquaculture debris from Drakes Estero, a shallow federal Wilderness estuary and state MPA within Point Reyes National Seashore, Marin County, California. A total of 1.7 million kg of aquaculture debris was removed from the estero, with the majority consisting shell, pressure treated wood, and plastic debris on the estero floor where it precluded the growth of eelgrass (*Zostera marina*). In order to (1) detect any impacts on eelgrass, (2) document recovery of eelgrass post-restoration, and (3) track changes to benthic communities including non-native species, we implemented an annual subtidal monitoring program from 2016 (pre-restoration) to 2021 (5 years post-restoration) with control sites and analyzed before and after restoration images for percent cover of benthic communities.

Eelgrass growth into disturbed plots was variable, with more rapid growth in less disturbed plots. 3 years post-restoration, mean eelgrass cover increased from ~23% to ~53% in *low debris* areas, likely due to elimination of shading and disturbance from oyster culture infrastructure. Similarly, the *woody* (generally large timbers on the estuary floor) debris areas showed a significant increase in eelgrass cover from 46% to 72% cover. The most impacted areas that required clean-up of *major debris* on the estero floor showed less dramatic, but encouraging, patchy increases in eelgrass cover. All of the *major debris* (extensive debris cover on estuary floor) area recovery was on 3 of the 7 treatment areas with the overall mean increasing from 1% to 7% cover through year 3. In this presentation we will present updated year 5 results. Passive eelgrass restoration has been largely successful in this wilderness estuary.

Small vessel surveys to inform decisions related to the Dungeness crab fishery in California.

John Calambokidis[1], Kiirsten Flynn[1], Jack Barkowski[1], Jenn Tackaberry[1], James Fahlbusch[2], Kathi George[3], Ryan Berger[3], Julia Ohern[3], and Doug Sandilands[4]

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Reports of large baleen whales entangled in fishing gear, especially associated with the Dungeness crab fishery along the US West Coast (and especially California), have increased in the last decade and become a major concern. We conducted small boat surveys funded by the California Ocean Protection Council to inform efforts by a Dungeness Crab Working Group, CDFW, and NOAA to try and reduce entanglements. These surveys were conducted in different regions from southern to northern California in Fall, Spring, and Summer to provide short term data on whale distribution including overlap with fishing activities, behavior and feeding information including selective tag deployments to help inform risk of entanglement, and long-term data on photo-identification for abundance estimation. Survey teams were experienced in whale entanglement documentation and response in case entangled animals were encountered. Surveys were conducted starting in Fall 2020 and 2021 in multiple areas where commercial Dungeness crab fishing occurs. The surveys off central California in late October 2020 yielded over 200 large whale sightings of 400 whales and revealed concentrations of humpback and blue whales in several key areas relevant to the Dungeness crab fishery. Those surveys helped inform decisions by CDFW and the Dungeness crab working group delaying the start of the fishery and additional surveys conducted in November and December documented when whales started to leave the area putting fewer whales at risk from fishing activity. Mark recapture of photo-identified whales was also used to estimate an abundance of about 5,000 humpback whales along the coast of California and Oregon and whether humpback whales belonged to a particular DPS (Distinct Population Segments) since these have different threatened or endangered status under the Endangered Species Act and have continued to increase at an average of 7-8% per year.

Using environmental DNA to observe life in the sea in the central California Current.

Francisco Chavez

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The use of environmental DNA (eDNA) for studying the ecology and variability of life in the sea is reviewed here in the context of measurements made in the Central California Current from Pt. Concepcion to Humboldt Bay. These efforts were funded in part by grants to establish an operational Marine Biodiversity Network for the region. The field of eDNA, relatively new but growing rapidly, is reviewed briefly and specific examples of the type of information that eDNA provides regarding the changing distribution of life in the sea over space (horizontally and vertically) and time are provided. eDNA also offers a means to scale biological observations globally to a level similar to those currently made for ocean physics and biogeochemistry; examples of technology development directions are described.

Year-round foraging patterns in adult western gulls (*Larus occidentalis*) from Southeast Farallon island.

Katherine Douglas[1], Scott Shaffer[1], Mike Johns[2], Pete Warzybok[2]

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Despite their prominent populations, habitat usage of the Family Laridae is largely undocumented during the non-breeding season. Given their ecological role as generalist foragers, tracking year-round movement patterns of western gulls (*Larus occidentalis*) can contribute significantly to understanding marine and terrestrial resource usage along Pacific coastlines. During May to June 2021, 17 western gulls were equipped with Ornitela GPS trackers to determine year-long western gull habitat usage during the breeding and non-breeding periods, and frequency of visitation to SEFI during the non-breeding season. Results showed that during the breeding season gulls (May – Aug, n = 13) made 335 trips to the island, travelled a maximum distance of 76.3 km, and frequented off-island and coastal areas. During the start of non-breeding season gulls (Aug – Oct, n = 11) made 59 return island trips, travelled a maximum distance of 1072.2 km, and were commonly tracked in urban environments. These initial results indicate that during the breeding season western gulls utilize short-range pelagic foraging trips, with SEFI as the "home base" point of return for foraging. During the non-breeding season gulls expanded their foraging range, while the amount of return trips to SEFI decreased as birds centralized onto urban resources of the mainland, a trend that will likely continue to decline in the coming winter months. These preliminary findings support the concept that gulls do not utilize SEFI as a central place from which to forage during their non-breeding period, thus providing support for the proposed eradication of house mice (*Mus musculus)* set for SEFI's winter season.

Tracking ocean acidification in north central California.

Meredith L. Elliott[1], Danielle Lipski[2], Jan Roletto[3], Carina Fish[4], Tessa Hill[4], and Jaime Jahncke[1]

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The Applied California Current Ecosystem Studies (ACCESS) project has been conducting ocean research in Cordell Bank and Greater Farallones National Marine Sanctuaries since 2004. The private/public partnership tracks many climate indicators, including ocean acidification. In collaboration with Dr. Tessa Hill's laboratory at the University of California, Davis, we have collected water samples during at-sea cruises. Chemical analyses of these water samples, in conjunction with water property data collected with a conductivity-temperature-depth recorder, was used in a calculation of aragonite saturation state based on commonly measured water variables (temperature, salinity, and dissolved oxygen). Based on this formula, we are able to reconstruct the aragonite saturation state in north central California going back to 2010. Waters low in aragonite appeared closer to the surface during periods of upwelling (e.g., spring 2012), while the Northeast Pacific marine heatwave of 2014-2016 generally saw undersaturated waters at deeper depths (e.g., spring 2014). Lower counts of the pteropod *Limacina helicina* and juvenile krill are associated with low aragonite saturation exposure, confirming results of other studies. We are working with other researchers to further California's Ocean Protection Council's objectives for coordinated state-wide monitoring for OAH and biological impacts. As part of this collaboration, ACCESS is contributing zooplankton specimens (primarily pteropods and crab larvae) to be analyzed by the Southern California Coastal Water Research Project (SCCWRP) for shell and exoskeleton thickness and we will be exploring standardized protocols for OAH monitoring amongst the collaborative. Understanding the impacts of ocean acidification on these and other taxa is critical to the health and sustainability of our ocean.

Long-term aerial surveys support diverse management and research of protected species off California.

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As part of ongoing research and monitoring efforts for marine mammals and leatherback turtles, NOAA's Southwest Fisheries Science Center has conducted aerial line-transect surveys off California for over three decades, including areas within three central California National Marine Sanctuaries. The objectives of these aerial surveys are 1) to monitor the abundance and population trends of harbor porpoise stocks; 2) to assess the distribution, abundance, and habitat of endangered leatherback turtles, 3) to provide aerial support for leatherback capture operations for health assessments and telemetry studies to characterize movements and population structure; and 4) to periodically assess whale and sea turtle distributions in support of entanglement risk reduction in California fixed-gear fisheries. Aerial survey methods follow Distance sampling protocols, with a team of three observers and one data recorder. Surveys are conducted in high-wing, twin-engine Partenavia P-68 or NOAA Twin Otter aircraft, flown at 650-700 ft altitude and 90-100kts airspeed. The longterm surveys have allowed the estimation of population trends between 1986 and 2017 for four California harbor porpoise stocks, including a first empirical estimate of the maximum population growth rate for harbor porpoise (9.6% per year for the Morro Bay Stock). Three porpoise stocks evidenced marked population growth following the reduction or elimination of gillnet bycatch. In contrast, the longterm aerial surveys also documented an 80% decline in the abundance of leatherback turtles between 1990 and 2017. Satellite-linked telemetry tracks have elucidated broad-scale movements and connectivity of leatherback turtles throughout the North Pacific Ocean. Since 2017, the aerial surveys and leatherback telemetry studies have directly contributed to the management of the California Dungeness crab fishery as part of the Risk Assessment and Mitigation Program (RAMP) that allows managers and stakeholders to assess relative entanglement risk for leatherback turtles and whales in near-real time.

Through the lens of Orville Magoon: a technic-personal view of California's coast.

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Technological resources for coastal studies have expanded significantly in the past few decades, with the use of LiDAR surveys, detailed geo-referenced data, stereoscopic aerial photographs and Structure-from-Motion, to name a few. These new advances assist in the acquisition and analysis of current conditions and predictions of future coastal conditions; however, they have limited ability to provide historic data and often lack personal connections to the coast. Historic photos of the coast accompanied with stories help provide context for science-based coastal management in a changing climate.

In 2018, the California Shore and Beach Preservation Association (CSBPA) acquired over 4,000 slides (site photos) taken by Dr. Orville Magoon during his coastal career. The slides, spanning 1960-2001, depict areas of the California coast from a time prior to the proliferation of digital content. Dr. Magoon was a strong and vocal advocate for the coast and recognized that engineering solutions were just part of coastal management. He supported multi-disciplinary approaches to coastal situations and advocated for sand rights, or the natural movements of the sand in water, whether coming down the streams to the oceans or along the coast. Stemming from his broad efforts to protect shoreline habitats, his photo collection provides an important perspective on the coast. Within the north-central coast of California alone, more than 150 slides cover Bodega Bay, Bolinas, San Francisco, Alameda, Pacifica, El Granada, Half Moon Bay, and Greyhound Rock.

Automating seal monitoring in Point Reyes National Seashore using convolutional neural networks.

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As the populations of elephant seals *(Mirounga angustirostris)* and harbor seals *(Phoca vitulina)* in Point Reyes National Seashore (PRNS) have grown to over 4,000 and 6,000, over the past 40 years, they are occupying more beaches and moving to areas, like cliff sides, where on-the-ground counts are increasingly unreliable. Consistent, long-term monitoring has allowed PRNS management to make informed decisions related to the protection of elephant seals and harbor seals. However, as the seals moved to new beaches, the human safety risks for the cliff-side surveys increased at some locations and other locations are inaccessible to view for accurate counts. Satellite and aerial imagery in combination with convolutional neural networks and object detection could dramatically decrease the amount of time, energy, and resources the National Park Service and volunteers put in to monitor these populations as well as increase the accuracy of counts and the safety of the surveyors. We compiled training images from Google Earth Engine and Maxar's Global Enhanced Geoint Delivery catalogs, tiled with some overlap using ArcGIS, and labeled any seals found with an encircling polygon. We then used a 80-10-10 training-validation-testing split and worked in R using the TensorFlow and Keras libraries. Three separate models were fit: (1) harbor seal molting season (June-July) where the only age class was "adult", (2) harbor seal breeding season (March-May) where the age classes were "adult" and "pup", and (3) elephant seal breeding season (December-March) where the three age/sex classes were "pup," "cow", and "bull". We discuss whether the same data processing techniques and model architecture will work for all groupings of seals and if the technique generalizes to other locations where harbor seals and elephant seals are found. We also propose next steps needed to scale-up the process for a long-term monitoring program.

Long-term waterfowl abundance trends in central California outer coastal bays and lagoons.

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More than 700,000 waterfowl rely on the resources of San Francisco Bay (SFB) region to build reserves for migration and reproduction each year (Accurso 1992). In fact, scaup and scoters in SFB comprise nearly 40% of all those counted in the lower Pacific Flyway during the Midwinter Survey (MWS; USFWS 2009). The MWS provides valuable data on relative waterfowl abundance and distribution at a large spatial scale, and annual counts of an area can provide an index to temporal changes in populations for that area. USGS has collaborated with USFWS to complete the MWS of the SFB region, and present here the data from coastal bays and lagoons of the outer central California coast. Aerial surveys for waterfowl were conducted in January each year from 1981-2020 (weather permitting) over established transects in Abbots Lagoon, Bodega Bay, Bolinas Lagoon, Drakes Estero, Rodeo Lagoon, and Tomales Bay (altitude ~45m; speed ~170 kph). From 1981-2020, we observed >778,000 waterfowl from ≥28 species. Species included greater/lesser scaup (25% of total abundance), bufflehead (23%), scoter species (16%), American wigeon (11%), ruddy duck (5%), Northern pintail (5%), black brant (4%), and canvasback (2%), which together comprised >90% of all waterfowl observed. Northern pintail, ruddy duck, and scoters appeared to have greatest abundances in the first decade of the study, with decreasing trends thereafter. Scaup species and American wigeon peaked from 2000-2010, also decreasing thereafter. Bufflehead and canvasback abundances appeared stable throughout the study period, while the trend for American wigeon was less clear. Black brant abundance increased from 1981-2000 and has appeared stable since 2000. Trends observed in these outer coastal areas speak to the importance of the SFB region-wide MWS. By comparing the coastal data with other SFB areas we gain insight into region-wide abundance/distribution trends that surveys at smaller spatial and temporal scales cannot elucidate.

Diving deep: characterizing bathymetric zonation and taxonomic diversity of deep-sea corals in Cordell Bank National Marine Sanctuary.

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Cordell Bank National Marine Sanctuary (CBNMS) protects 1,286 mi^2 of benthic and pelagic habitats of the continental shelf, slope, Bodega Canyon and Cordell Bank. Benthic surveys on Cordell Bank have been conducted from 2002 to present, but until recently very little was known about the deep-water habitats of the CBNMS slope and canyons, which were added to the sanctuary in 2015. In 2017 and 2019 the Office of National Marine Sanctuaries collaborated with the Ocean Exploration Trust to collect the first video observations and specimen collections in Bodega Canyon and unnamed canyons on the deep-slope from 744-3318 m. Identifying deep-sea coral communities was of special interest because they are long-lived, slow growing, and provide habitat for other species. Coral taxa were identified from 102 hours of underwater video and a total of 53 coral samples were collected by the ROV. These ROV surveys revealed new information about the abundance and taxonomic diversity of deep-sea corals, resulting in a preliminary assessment of zonation by depth of various coral taxa. Sea pens (pennatulaceans) anchor in soft sediments and consequently inhabited the full range of depths surveyed and black corals (antipatharians) were also found within a wide depth distribution. The bamboo corals (isidid gorgonians) exhibited an extensive depth range of approximately 900-3300 m. The bubblegum coral, *Paragorgia yutlinux*, was collected from 950 m and represents a new record and depth extension for the region. The only chrysogorgiid gorgonian collected in the surveys so far, *Radicipes stonei* from 2600-2700 m, is an extraordinary range extension as this species was previously known only from Alaska. These surveys are greatly expanding our understanding of taxonomic diversity and depth zonation of corals in CBNMS, allowing us to better characterize this habitat, and will support more effective management and conservation of deep-water benthic habitats and their associated communities.

Eradication failure and the use functional eradication for managing aquatic invasive species using community scientists and volunteers.

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The goal of this project was to locally eradicate a relatively closed population of a damaging invasive predator, the European green crab (*Carcinus maenas*) in Seadrift Lagoon (Stinson Beach, CA). Using intensive annual trapping campaigns, we successfully reduced the green crab population by >90% over a five-year period (2009-2013). However, in 2014 we unfortunately witnessed a dramatic 30-fold increase in the population size relative to the previous year. Population dynamics models show that harvesting can paradoxically increase the equilibrium level of a population due to a process known as overcompensation. Subsequent experiments found that this population explosion was the result of overcompensatory reproduction created by our own eradication efforts. By reducing the adult green crab population, we had also reduced control of recruitment (cannibalism), and, thus, facilitated the large recruitment event. Concurrent survey data from nearby estuaries showed no similar population increases at other sites and genomic studies verified that source of the dramatic recruitment event was entirely internal. These results provide an important, cautionary lesson for resource managers, and consequently, we recommend using "functional eradication" when eradication is not likely. This involves suppression of the invader below population levels causing unacceptable ecological effects within high-priority locations where this effort is feasible. Since 2014, we have been able to maintain a lower abundance of green crab abundance in Seadrift Lagoon through the participation of community volunteers and community scientists, who were also instrumental during the first phase of the project. Our results demonstrate that community scientists and volunteers can provide the capacity necessary to maintain functional eradication programs for high priority species and locations and should be an important component of future management strategies.

Overview of gray whale (*Eschrichtius robustus)* strandings in the San Francisco Bay Area during an "Unusual Mortality Event".

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Marine mammal stranding events can provide insights into the health status of local species and entire ocean ecosystems. The gray whale (*Eschrichtius robustus)* is one such species that migrates along the west coast of North America to forage primarily in sub-Arctic and Arctic waters and winter in the lagoons of Mexico. In early 2019, there was a significant increase in numbers of dead and stranded gray whales found in the wintering lagoons and other parts of their range, causing the National Oceanic and Atmospheric Administration to declare an "Unusual Mortality Event (UME)". This presentation will describe necropsy findings for gray whales that stranded in the greater San Francisco Bay Area (San Mateo County to Sonoma County) during this ongoing UME investigation. Of the 502 stranded gray whales since 2019, 65 occurred throughout California with 32 localized to the greater San Francisco Bay Area. We will give an overview of the primary causes of death for individual whales including 9 blunt force trauma due to vessel collision, 1 killer whale predation and 22 with open or unknown causes. Mounting evidence from necropsies, photogrammetry and census data on live migrating whales, and prey changes in the Arctic point towards environmental factors leading to malnutrition as the primary underlying problem. Necropsy efforts across the west coast of North America are not only crucial to determine specific factors impacting gray whales but can provide insight into broader environmental issues and causes for concern.

Passive acoustic monitoring in Cordell Bank National Marine Sanctuary reveals large vessels and baleen whales are primary drivers of the low-frequency ambient soundscape.

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Passive acoustic monitoring of ocean soundscapes can provide important information to resource managers about the status of marine ecosystems. The Ocean Noise Reference Station Network is a U.S.- wide array of twelve calibrated low-frequency (10 Hz – 2 kHz) passive acoustic recorders, jointly established by the National Oceanic and Atmospheric Administration (NOAA) and the National Park Service. Four of the twelve acoustic monitoring sites are in national marine sanctuaries, including one that is the focus of this presentation, Cordell Bank National Marine Sanctuary (CBNMS). A recorder has been deployed there since 2015. The listening range of the CBNMS hydrophone also extends into Greater Farallones National Marine Sanctuary. Analysis of passive acoustic data recorded in CBNMS supported the hypothesis that vocalizing baleen whale species and large commercial vessels in the shipping lanes accessing San Francisco Bay are primary drivers of the low-frequency ambient soundscape. However, vessel contributions to daily sound levels were more stable, while seasonal peaks (September-November) in very-low-frequency (10 Hz – 100 Hz) sound levels were associated with vocalizing blue, fin, and humpback whales. Lowest levels were measured in the summer (June-August). Throughout the year, these very-low-frequency sound levels were the most variable of all frequency bands; large vessels and whales overlap in their contributions to ambient levels within this range. To verify the relationship between large

vessel activity and low-frequency sound levels, daily vessel movement data from the Automatic Identification System were compared to daily sound level metrics. This characterization of soundscape conditions in CBNMS establishes baselines for long-term monitoring and offers standardized methods to make comparisons with other underwater environments, such as the other sites included in the Ocean Noise Reference Station Network. Standardized monitoring of soundscapes supports NOAA's ability to evaluate and report on conditions of marine environments, including National Marine Sanctuaries, and to identify places and times for more detailed investigation regarding environmental impacts

Stranded in history: marine mammal stranding data from 1884-2019 in central California.

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The detection of and response to marine mammal carcasses is crucial to informing our knowledge of the health of marine mammal populations. Marine mammals have long life spans, positioned at the top of the food chain, along with sharing similar foods and coastal habitats to humans making them valuable indicators of the ecosystems health (Mössner & Ballschmiter, 1997; Bossart, 2011; Ross, 2000). From 1884-2019, a total of 9,369 dead marine mammal strandings were recorded throughout the central California coast, including San Mateo and Sonoma Counties, the San Francisco Bay and Delta. A total of nine families were represented, with Otariidae (58.68%), Phocidae (23.50%), and Phocoenidae (7.85%) being the most abundant. 70.29% of strandings of the total dataset have occurred from 1995 onward, which correlates with efforts to standardize formal stranding networks in the United States. Significant increases in overall strandings occurred in years 1982-1983, 1997-1998, 2009, and 2015-2019 coincident with major oceanographic events such as El Niños and marine heatwaves. As the impacts of climate change continue, the number and severity of environmental stressors, marine mammal mortality trends can help us understand and predict individual and population level responses to these stressors.

Kelp restoration assessment in the Greater Farallones National Marine Sanctuary.

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With severe loss of kelp forest habitat in Mendocino and Sonoma Counties persisting since 2014, it is critical to evaluate kelp ecosystem health and restoration site suitability to inform kelp restoration and management efforts, as well as better understand important factors that may contribute to kelp persistence. The 2021 GFNMS Kelp Restoration and Research Cruise was a comprehensive assessment of priority kelp restoration sites in the sanctuary aboard the R/V Fulmar, and by shore during inclement weather. This cruise was a partnership between three national marine sanctuaries, the California Department of Fish and Wildlife and CSU Monterey Bay. The goals of this cruise were to 1) characterize the state of the sanctuary's rocky reef ecosystems that once supported a rich kelp ecosystem, (2) assess areas of kelp persistence within the sanctuary, (3) identify opportunities to develop facilitated kelp recovery approaches, and (4) to build State, Federal and academic partnerships to enhance monitoring and management capacity within sanctuary boundaries. Ecosystem assessment surveys were conducted through a combination of approaches, including subtidal monitoring to characterize reef structure and invertebrate and algal densities, as well as monitoring using Uncrewed Aerial Systems (UAS) or drones to characterize aerial kelp canopy extent and density. Rocky reefs along northern CA surveyed in 2021 were dominated by urchins and exhibited relatively low persistence of kelp and other algal species. There was a modest increase in kelp cover across sites, however it was still well below average extent prior to severe loss in 2014. Results from this assessment will inform the development of a kelp restoration effort within the sanctuary. This effort highlighted the benefits of state-federal partnership in the emerging landscape of kelp restoration and management and identified opportunities for additional capacity building.

Whales and kelp: the overlooked blue carbon in Greater Farallones National Marine Sanctuary.

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Coastal and marine ecosystems play a significant role in the global carbon cycle, sequestering and storing carbon over long timescales. Well-managed marine protected areas protect and enhance these valuable blue carbon habitats and processes. Sequestration processes for coastal vegetated habitats are well studied and well understood, but oceanic processes, including export of kelp and fish carbon to deep-sea environments, and whale falls (the sinking of dead whales to the ocean floor), are often overlooked in research programs and management considerations. However, research indicates these oceanic processes are likely much more significant than coastal sequestration. MPA managers do not have easy access to oceanic blue carbon information for their site, or guidance on how to apply that information to management decisions, greatly limiting the impact MPAs can have in national and international climate mitigation discussions and policy development.

This presentation will briefly review the latest science of oceanic carbon sequestration, and will present findings from novel research conducted by the Greater Farallones Association in Greater Farallones National Marine Sanctuary to quantify carbon sequestration of two oceanic processes, whale falls and kelp carbon export. Together, these processes were found to have the potential to sequester 3,512 megagrams of carbon (MgC) each year which is over 3x greater than carbon sequestered by the Sanctuary's coastal blue carbon habitats. The Sanctuary plans to use this information to inform policy and management decisions, and to prioritize protection and restoration programs. Understanding carbon sequestration within MPAs is key for managing changes to stored carbon, which has global climate relevance. This novel assessment is a foundational step in increasing the protection and enhancement of critical coast and ocean climate mitigation services.

Northern California doghole ports maritime cultural landscape.

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The expansion of the Gulf of the Farallones National Marine Sanctuary into Greater Farallones National Marine Sanctuary in 2015 resulted in an expansion of the sanctuary boundary, extending along the coast from Bodega Bay to Manchester Beach just north of Point Arena. This action triggered a cultural resources inventory in the newly defined sanctuary and included a significant portion of California's north coast shoreline where several historic doghole ports sites are located. Archaeologists and historians from Parks, National Oceanic and Atmospheric Administration (NOAA), Sonoma State University, and San Francisco Maritime National Historic Park worked together to document the physical remains of 14 doghole port sites, both above and below the tide line.

Life, industry, and society along the coast was shaped by interaction with the sea for thousands of years; the era of doghole ports and the timber industry representing just one example of this interaction. These landings, known regionally and colloquially as "doghole ports," essentially defined the Northern California coastal maritime landscape of the mid- to late 19th and the early 20th centuries. The network of doghole ports were essential components to successful lumbering ventures and community development. Engineering and technological development made partially hospitable coves into centers of commerce. These ports were key to the industry for over seventy years until roads and railroads replaced water as the main shipping outlet.

The project focused on answering fundamental questions related to location, condition, and age of terrestrial and submerged resources, identifying environmental threats and anthropogenic impacts to those resources, and evaluating how historic narratives, photographs, and maps compare with archaeological remains associated with each site. This presentation will summarize notable findings from the project, highlight important aspects of a recent National Register nomination, and propose steps toward enhancing awareness and appreciation of California's maritime heritage along the north coast.

Northern range expansion of California coastal bottlenose dolphins (*Tursiops truncatus*)

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The genetically distinct California coastal stock of bottlenose dolphins expanded its range north from Southern California into Central California coincident with the 1982–1983 El Niño event. To determine contemporary northern range limits, photo-identification efforts were carried out in San Francisco Bay and nearby coastal waters from 2007–2018 during which 84 individuals were identified. Re-sightings of theses dolphins, which represent 18% of estimated 453 marked dolphins in the stock, showed a significant range expansion along the California coast to Sonoma County (38.7° N). Comparisons with photo-identification catalogs compiled south of San Francisco from 1981–2015 revealed that 92% of the 84 dolphins were matched to Monterey Bay (77), Santa Barbara (27), Santa Monica Bay (29), Orange County (9), Corona Del Mar (2), San Diego (31), or Ensenada, Mexico (1). Many of the 84 dolphins (54%) showed long-range movements across the stock's range between the Southern California Bight and the San Francisco Bay Area. The greatest movement distance recorded was by two individuals first observed in San Diego, California in the 1980s and subsequently in Puget Sound, Washington (47° N) in 2017, setting a coastal bottlenose dolphin long-distance movement record of at least 2,500 km. The stock's northward expansion, with plausible links to climate change, has potential consequences for local marine communities as this top predator encounters novel food resources and interacts aggressively with harbor porpoises.

Behavior mediates dispersal of nearshore larval fishes between Point Reyes and Point Arena.

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Strong, seasonal upwelling drives offshore movement of surface waters throughout the California Current and is especially pronounced off central and north central California. Upwelling-driven offshore advection has been identified as likely factor limiting the recruitment of juvenile fishes to nearshore habitats in this region. However, research on a wide variety of invertebrate taxa with planktonic stages has shown that larval behavior, particularly depth preferences, reduces offshore advection and increases nearshore retention of larval propagules. In this study, we collected larval fishes along two cross-shelf transects during peak upwelling season (Mar-July, 2017-2019) at Bodega Bay (38.3° N) and Stewart's Point (38.6° N) in order to identify and describe species-specific larval swimming and depth preferences for a diverse, economically and ecologically important group of fishes. Over 75% of nearshore fish larvae were retained within 10 km of shore at both sites. Nearshore larvae also exhibited distributional patterns consistent with fixed, ontogenetically-variable, and environmentally-cued depth preferences, which likely mediate alongshore dispersal and facilitate nearshore retention despite strong offshore surface currents. Our findings suggest that behavioral regulation of dispersal is common among nearshore fish species between Point Año Nuevo and Point Arena as well as in other upwelling regions. Furthermore, the behavioral patterns documented in this study may serve to improve biophysical- and individual-based dispersal models used to predict spatial population connectivity, recruitment, and the design of marine protected areas linked by planktonic dispersal.

Overlap of humpback whale (*Megaptera novaeangliae*) habitat and vessel traffic in San Francisco Bay with insights from tagging.

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Since 2016, humpback whales (*Megaptera novaeangliae*) have regularly been observed in San Francisco Bay (SF Bay) and the Golden Gate Strait (GGS) from April to November. The conservation status of humpback whale populations feeding in this area combined with dense vessel traffic emphasizes the need for research on the risk of vessel strikes. Mortality by ship strike is estimated to be twice the federal limit along the California coast, but ship strike risk has not been assessed in SF Bay. Our research addresses the degree of overlap between the distribution of humpback whales and vessel traffic in the study area throughout 2017, including a case study of three tagged individuals from a single day. We collected 184 humpback whale sightings and compared them against vessel data from Automatic Identification Systems (AIS) for 2017. We analyzed the distance from each sighting to vessels transiting through the study area. Vessels mapped ranged from pleasure craft to 335 m container ships. All whale locations occurred within 100 m of at least one vessel transit in 2017. On 23 July 2017, Cascadia Research Collective personnel tagged three humpback whales in SF Bay using suction-cup attached, multi-sensor tags. Tagged individuals spent an average of 56% of time tagged at less than 15 m depth. Vessels in the study area drafted between 1.3 and 17.5 m, indicating the potential for three-dimensional overlap between whales and large ships. Our data show the close overlap between vessels and whales in the GGS and SF Bay. This application of tagging in combination with the use of AIS data is a viable method to quantify the potential risk of ship strikes to baleen whales in SF Bay and beyond.

Ocean observing systems beyond the Golden Gate.

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For more than two decades the Bodega Marine Laboratory (BML) has kept a finger on the pulse of the coastal ocean beyond Golden Gate, specifically in the region between Point Reyes and Point Arena. Capitalizing on a half-century of data at BML, the Bodega Ocean Observing Node (BOON) was established in 2005 as a founding node in the nascent Central and Northern California Ocean Observing System (CeNCOOS, cencoos.org). Hourly maps of surface current are available since 2001 and have extended from Golden Gate to Oregon since 2006. Yielding insights to plankton dynamics, these data were combined with satellite data to document the link between the upwelling center at Point Arena and the astounding productivity of Cordell Bank and the Gulf of Farallones – a phenomenon that provided an essential argument for northward expansion of the CBNMS and GFNMS. These surface current data are also used to track outflow from San Francisco Bay and have been used to assess MPA connectivity. At the same time, the shore station has been expanded to include an offshore mooring at which data on temperature, salinity, current velocity, chlorophyll fluorescence, turbidity and oxygen have been collected since 2005. BOON also includes moorings on Cordell Bank (Pound et al) and in Tomales Bay along with a shore station directly linked to oyster aquaculture operations with ocean acidification. BOON also maintains moorings in outer San Francisco Bay in collaboration with EOS/SFSU. Seasonal moorings are maintained in the Russian River (Roettger et al). Recent additional activities include HAB monitoring and deployment of an IFCB at BML for time series sampling of phytoplankton. And a glider that tracks the state of the California Current is maintained in collaboration with SIO, transiting 300 km offshore every 2 weeks and enriching other offshore data from ACCESS cruises, HFR monitoring, and satellite data.

Associations among mass mortality events, seabird demography, and ocean climate trends in central California.

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Ocean anomalies and El Niño events have led to several major seabird die-offs along the California coast in the past two decades. Understanding what drives these mortality events is difficult. Point Blue Conservation Science, NOAA's Greater Farallones National Marine Sanctuary, and Greater Farallones Association (GFA) have unique long-term datasets on population and productivity of locally breeding seabirds, as well as carcass deposition data collected by NOAA's Beach Watch Program along the central and northern California coast. We integrated and analyzed these data sets to better understand how beached dead birds relate to local breeding populations. We used negative binomial regression models to analyze carcass count (dependent variable) in relation to basin- and local-scale oceanographic variables, climate indices, prey availability, and seabird demography for each species. We analyzed three seabird species that breed in the Gulf of the Farallones and that experienced major mortality events: Cassin's auklet (*Ptychoramphus aleuticus*) (mortality events in 2005, 2014), Brandt's cormorant (*Phalacrocorax penicillatus*) (2009), and common murre (*Uria aalge*) (2015). We found significant relationships between carcass deposition of all three species and decreased or delayed local upwelling. Carcass deposition rates increased during periods of warm ocean temperatures associated with El Niño for all age classes. While both prey availability and demographic variables were by themselves significantly associated with mortality events, they were not significant once oceanographic and climate variables were included. For these three species, mortality as indicated by carcass deposition was primarily driven by environmental factors independent of demographic parameters at the colony.

Increased use of San Francisco Bay habitat by gray whales coincides with an unusual mortality event.

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Gray whales (*Eschrichtius robustus*) undertake one of the world's longest migrations, between winter breeding grounds in Baja, Mexico and summer feeding grounds in the Arctic. Typically, a few migrating gray whales enter San Francisco Bay for brief stopovers during this long journey. During 2019-2021, concurrent with an Unusual Mortality Event, gray whale sightings in SF Bay increased during their spring northward migration. Data on gray whale habitat use, including positions, behavior, and photo-identification records, confirmed they remained in SF Bay for extended periods with multiple individuals often sighted during vessel surveys. Gray whale distribution overlapped with areas frequented by humpback whales (*Megaptera novaeangliae*), including the Golden Gate Strait and narrows, but gray whales more often occurred further into the bay. Unlike humpback whales that feed on fish and zooplankton in the water column, gray whales are benthic foragers. We often observed apparent foraging behavior by gray whales and confirmed feeding by three individuals in 2021, subsequently corroborated by stomach contents found during necropsies. Increased use of SF Bay by gray whales in a period of unusual mortality suggests this habitat offers shelter and opportunity for supplementary feeding during prolonged migratory stopovers. Use of SF Bay by gray whales likely increases risk of ship strike due to overlap between whale habitat and vessel traffic in this busy port, including recreational, commercial shipping, and high-speed ferry routes. Unlike humpback whales, gray whales neither lunge feed at the surface nor typically engage in surface active behavior. With dive times averaging 5-8 minutes during feeding, gray whales are likely to be less conspicuous to vessel operators than humpback whales. Gray whales sheltering in SF Bay during periods of unusual mortality may already be weakened due to poor body condition, and we recommend further attention be given to the risk of vessel strike by the boating community.

Sperm whales of the Golden Gate: A brief history of the Richmond whaling stations, sperm whale catches, and what might be learned about their life history and ecology then and now.

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Two whaling stations operated at Pt. San Pablo in Richmond, California, from 1956 to 1971, when the era of commercial whaling was prohibited under the provisions of the U. S. Endangered Species Act. Catches of *ca*. 175 whales per year, with a range of about 150 miles, San Francisco Bay whalers towed in roquals (blue, humpback, fin, and sei whales), and sperm whales to the Del Monte and Golden Gate whaling stations. From 1959 through 1970, a small team of biologists led by Dale Rice collected data on the whales as they were rapidly processed for their meat, oil, spermaceti and other byproducts. In this brief presentation, we focus on the 637 sperm whales - 392 males and 245 females - examined. Measurements taken included total length, blubber thickness, reproductive condition, stomach contents, growth layer groups of teeth, vertebral epiphyses, and ecto- and endoparasites. We briefly summarize the history of the whaling station, share some initial data analysis by Dale Rice and Allen Wolman, and identify the date, sex, size and location of the last whale killed by commercial whaling in America. We focus on the questions that can be addressed with these data, including the human dimensions of whaling in San Francisco Bay Area; the impacts of environmental variability and climate change on sperm whale demographics and distribution and the abundance and diversity of their prey; and ways we can preserve the past to better understand the present and inform the future.

Protecting Blue Whales and Blue Skies in California's National Marine Sanctuaries.

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Global shipping is vital to the economy, and high volumes of large vessel traffic off of our coastlines can have negative impacts on public health and the marine environment. Large vessels traveling at higher speeds produce more emissions that contribute to reduced air quality. In addition, collisions with large vessels is a main contributor to large whale mortality in California's waters. There were 49 recorded incidents of fatal ship strikes on endangered whales in California recorded from 2007-2020, and researchers estimate that these observed incidents represent a small fraction of the total actual number of ship strike events taking place. In 2017, an incentive-based Vessel Speed Reduction initiative called the Protecting Blue Whales and Blue Skies Program was expanded to the San Francisco Bay region to motivate large vessels to slow down in designated areas to protect endangered whales and reduce air emissions and pollution in the region. In the 2020 program season, 16 global shipping companies enrolled in the voluntary program and slowed their vessels to 10 knots or less for over 181,000 nautical miles between May and November, a time period coinciding with the busiest whale season and peak time periods of air pollution in California. In the 2020 season, ship strike risk from those participating vessels was reduced by an estimated 35%, underwater noise was reduced by an average of 4db per transit, and regional emissions were reduced by more than 740 tons of ozone-forming nitrogen oxides (NOx) and over 24,000 tons of regional greenhouse gases (GHG).

Using a FlowCAM to analyze zooplankton samples from the Gulf of the Farallones.

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The ACCESS (Applied California Current Ecosystem Studies) program collects extensive zooplankton samples from the Gulf of the Farallones, and taxonomic processing of these samples is critical to the goals of this ecosystem monitoring effort. The project described herein is an effort to develop a protocol for use of a FlowCAM fluid imaging device to analyze these zooplankton samples, as a potential supplemental technique to traditional microscopy. The FlowCAM is an instrument which allows a user to capture images and a series of measurements for each particle in a fluid sample. A collaboration between Point Blue and San Francisco State University, this project began in June 2021 with a small subset of ACCESS samples, which were used to develop and test a FlowCAM protocol that is suited to the needs of the program. Extensive trial and error was required to find the most functional arrangement of the FlowCAM system and the most effective software settings. Issues encountered in this process included particle clumping, inadequate image clarity, and inconsistent flow rates. When properly operated, the instrument produced high-quality images that can be used for identification. Processing of ACCESS samples using the preliminary technique developed is ongoing and will further inform the efficacy of this instrument for zooplankton identification and enumeration. More work is needed to determine how closely species identifications, counts, and resulting abundance estimates obtained from FlowCAM analysis compare with traditional microscopy. The FlowCAM can generate and utilize statistical filters which can automate identifying classes of particles, but this has yet to be tested. This project has been an instructive pilot for a promising instrument, and with further work, the potential role of this technology in ACCESS research and other zooplankton applications will become clearer.

Longitudinal study of entanglement scars on humpback whales (*Megaptera novaeangliae*) off the coast of central California.

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The waters off the central coast of California are an important seasonal feeding ground for endangered and threatened populations of humpback whales. Although their numbers have increased since the end of industrial whaling in 1971, humpback whales nonetheless face challenges to recovery, with entanglement in fishing gear cited as a primary threat for California populations. Since 2014, there has been a sharp increase in reported entanglements along the US West Coast, particularly off of central California. The increase in reports has triggered repeated closures for local commercial fisheries. As only a small percentage of entanglements are reported, it can be difficult to ascertain whether increased reports are due to increased entanglements or better reporting. Scar-based studies conducted on individually identified humpback whales are a key method for examining changes in the yearly rate of entanglements based on acquisition of entanglement scars. The resulting yearly entanglement rate is relevant for resource managers who need to assess the effectiveness of important management actions, such as the closure of the commercial Dungeness crab fishery. We used photographs and sightings records collected by Cascadia Research Collective and collaborators to track entanglement scar acquisition for 113 individually identified humpback whales in the area. We estimated that at least 22% of the sampled whales had been previously entangled. We compared linear regressions for annual new scar acquisitions and annual confirmed entanglement reports and found that they increased together, indicating that increases in confirmed reports are due to increases in entanglement, rather than improved reporting systems. We used a Bayesian analysis to compare the rates of scar acquisition between the pre-heatwave (2004-2013) and post-heatwave (2014-2018) periods. The results show an increase in scar acquisition during the post-heatwave period from 1% to 3%.

Monitoring hypoxia on Cordell Bank.

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Low dissolved oxygen (DO), termed hypoxia, is an important parameter for resource managers to monitor because it can alter the structure and function of marine communities. Researchers from Cordell Bank National Marine Sanctuary (CBNMS) and the University of California, Davis Bodega Marine Laboratory are working to record the DO levels at Cordell Bank and to identify the physical and biological drivers of DO levels to better understand conditions in the sanctuary. Cordell Bank is located approximately 20 miles off the coast of Point Reyes, CA and within CBNMS. Since 2014, a light-weight oceanographic mooring outfitted with sensors has been deployed on Cordell Bank to collect continuous DO and temperature data, and in 2016 a conductivity recorder was added to collect salinity data. Results show variability within and between years, with low oxygen events occasionally present for short durations. Changes in DO levels on the Bank could negatively affect many marine species that inhabit the benthic and pelagic environments in CBNMS. Developing an understanding of the variability and the mechanisms that can affect DO dynamics will allow CBNMS to better manage and protect sanctuary ecosystems.

Causes and trends of live strandings of northern fur seals (*Callorhinus ursinus*) along the California coast, 1975-2021.

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Northern fur seals (Callorhinus ursinus: NFS) are a primarily pelagic species, and pups, born in late summer, remain on offshore islands for approximately a 4-month nursing period. The largest breeding colonies are in the Bering Sea with smaller rookeries on San Miguel and Farallon Islands. The life history strategy and habitat range of NFS differs from other pinniped species commonly cared for in California rehabilitation facilities. Previous studies have reported causes of stranding in pinnipeds that frequent the California coast; however, a comprehensive analysis of cause of stranding for NFS does not exist. The objective of this study is to utilize stranding data and medical records to determine causes of stranding in NFS from central and northern California. A retrospective record review of live NFS admitted to The Marine Mammal Center (Sausalito, CA) spanning a 46-year period was conducted, during which time a total of 482 NFS were admitted. Pups (<1 year) comprised 83% of admits, followed by adults (12%), yearlings (3%), and immature age classes (2%). Causes of pup stranding were malnutrition (97%), trauma (1%), infectious disease (1%), and other (1%) with 33% overall mortality. Causes of stranding of remaining age classes were biotoxin (58%), malnutrition (16%), infectious (7%), trauma (6%), and other (13%) with 58% overall mortality. Twenty-three percent of strandings occurred from July 2015 through June 2016 and correlated with a large, persistent warm water event. Analyzing longitudinal marine mammal stranding data in correlation with environmental factors can be used to identify persistent and emerging ecosystem threats.

Long-term monitoring of small estuaries in Northern California.

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In 2009, consistent in-situ data collection began in the Russian River estuary with seasonal deployment of two mooring sites providing dissolved oxygen, salinity, temperature, and current data throughout the water column. In combination with weather stations, NOAA offshore buoy data, remote cameras, and UGSG flow data, the moorings contribute to a comprehensive view of the state of the estuary. A similar setup was introduced in the Pescadero estuary in 2016 with continuous salinity, dissolved oxygen, and temperature data collection at 6-8 sites throughout the estuary. Mooring deployments in both estuaries overlap with seasonal closures, during which stratification and low dissolved oxygen have been recorded. In 2016, a fish mortality event was recorded in Pescadero during a mouth breach event that followed a months-long closure. During the breach, sensors showed the progression of low dissolved oxygen water as it moved throughout the estuary. In 2018, California State Parks began restoration work on parts of the Pescadero estuary, muting a connection between the southern marsh and the main estuary, where it had historically been fully disconnected. Both Pescadero and Russian River estuaries are focal points in their respective communities and have histories of significant human-made alterations to the estuary landscape. Results from long-term data collection allow informed decisions to be made by stakeholders on the future landscape of these estuaries. Researchers from the Bodega Marine Laboratory Coastal Oceanography Group are currently working with similar long-term data collection methods in San Francisco Bay, Tomales Bay, Salmon Creek, Drakes Estero, Bolinas Lagoon, Ten Mile River, and Navarro River.

Effects of seagrass on non-native invertebrates in Tomales Bay, CA.

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Global transportation and commerce have increased the spread of non-native marine species. Many of these non-native organisms are sessile filter feeding invertebrates, known as fouling species. Despite the abundance and broad distribution of fouling species, few studies have investigated their potential to spread from the initial introduction site into surrounding habitats. One ecologically important estuarine habitat is seagrass, which slows down water flow, modifies water chemistry, provides food for grazers, and serves as a structure for organisms to settle on or take refuge in. In this study, we examined how seagrass directly influences fouling communities and non-native species abundance by modifying flow and recruitment and indirectly influences fouling communities and non-native species abundance by modifying patterns of predation. To do this, we deployed settlement plates and predator exclosures inside and outside of seagrass over the summer of 2018 at Sacramento Landing in Tomales Bay, CA. We found that communities differed significantly inside and outside of seagrass, and that seagrass lowered the abundance, diversity, and richness of fouling species. We also found that predators altered community composition by reducing the abundance of both native and non-native solitary ascidians. Predation on the competitively dominant native and non-native solitary ascidians allowed for other non-native taxa to become more abundant. The effect of predation appeared to be greater outside of seagrass than inside, though this was likely influenced by differences in recruitment of fouling species and therefore differences in the strength of predation effects. Our study provides evidence that seagrass ecosystems alter fouling communities but do not have a greater abundance of non-native fouling species. Predator effects could be more variable than what is previously noted, and local predators are likely not an effective method of biotic control against non-native fouling species.

Adrift in the California Current: Passive acoustic monitoring for ecosystem studies.

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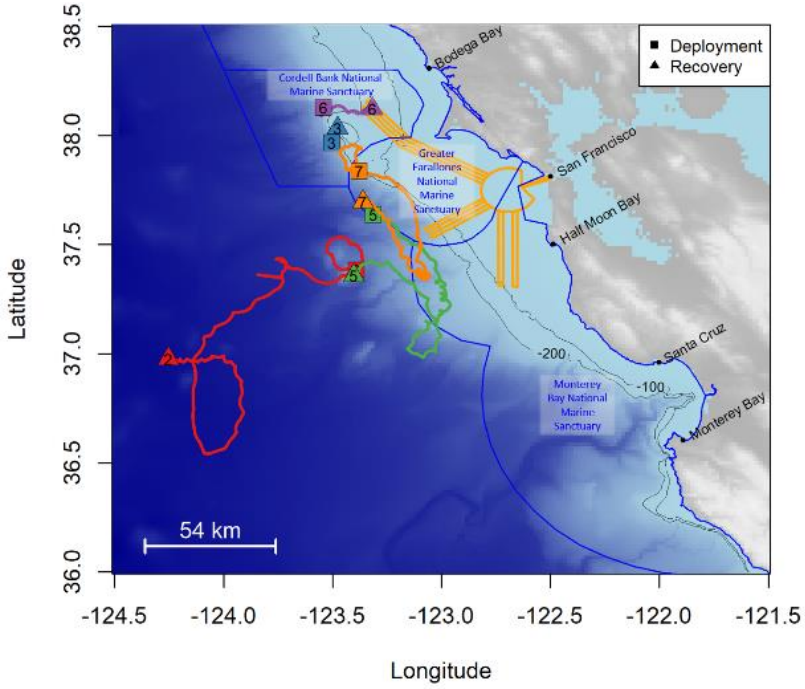
Adrift in the California Current is a passive acoustic study of marine mammals, human activity, and ocean soundscapes using drifting buoys. Acoustic observations are particularly valuable for monitoring remote habitats and visually cryptic species, such as beaked whales (*Ziphiidae)*, dwarf and pygmy sperm whales (*Kogia* spp). By working with existing research projects and local communities to take advantage of vessels of opportunity, this novel survey approach provides increased temporal and spatial resolution for observing protected species, while minimizing costs. During 2021, there were 8 buoys deployed in partnership with the Applied California Current Ecosystem Studies project (ACCESS) in the Greater Farallones, Cordell Bank and Monterey Bay National Marine Sanctuaries, of which 5 were recovered. During June through August 2021, collectively the buoys drifted over 793 km from the northern edge of Point Reyes to pelagic waters offshore Santa Cruz, sampling in waters between 200 and 4,000 m deep. Preliminary acoustic detections of odontocetes include Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), killer whales (*Orcinus orca*), sperm whales (*Physeter microcephalus*), and narrow-band high frequency clicks (likely *Kogia* spp). Noteworthy anthropogenic sounds include explosions of unknown origin, possibly seal bombs. These acoustic detections supplement other regional observations, and can be used to inform regional management strategies, including the placement of shipping lanes. The ADRIFT project is ongoing and welcomes opportunities to collaborate with local partners.



Map of ADRIFT buoy deployments (June - August 2021) in the Cordell Bank, Greater Farallones and Monterey Bay National Marine Sanctuaries.

Species on the move: Impacts of marine heatwaves on coastal ecosystems.

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During 2014-2016, the northeast Pacific experienced one of the largest marine heatwaves on record. In association with an oceanographic anomaly (the so-called “warm-water Blob”) and a major El Niño event, the north-central California coast experienced a series of at least a dozen marine heatwaves and episodes of anomalous poleward alongshore flow. Sea surface temperatures were often 2–4°C above the climatological mean. During these marine heatwaves, we observed substantial changes in geographic distributions and/or abundances across a diverse suite of 67 southern species, including an unprecedented number of poleward range extensions (37 species); a large influx of primarily southern species that are typically rare in northern California; and an increase in the abundance of southern species that are present but typically uncommon north of San Francisco. Our findings suggest that prolonged marine heatwaves can provide a mechanism for relatively rapid and substantial poleward expansions of some coastal species into new regions. Whereas many of these primarily southern visitors disappeared after the heatwaves ended, some of these species established populations that have persisted in our region, including Owl Limpets (*Lottia gigantea*). Members of our team are currently investigating Owl Limpets as a model system to understand the dynamics of geographic range expansions. In particular, by monitoring differences in recruitment, growth rates, and genetics across the geographic range of Owl Limpets we are exploring the ecological and evolutionary processes that influence the success of range expansions during and after marine heatwaves. These understudied processes may play important roles in ongoing shifts in the composition and dynamics of coastal communities in northern California.

Analysis of river plume remote sensing data.

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In the nearshore ocean in Mediterranean climates, the fate of sediment-laden, freshwater outflow from estuaries depends on multiple factors. The dispersion of infrequent large outflows of turbid buoyant water is controlled by an interplay of coriolis force and river flow rate, tidal signature, and wind forcings. In more frequent smaller outflows, these latter controls exert a larger influence than coriolis force, making dispersion pathways more variable and complex. If outflow momentum is small relative to breaking waves and tidal energy, freshwater becomes trapped and transported within the surf zone, preventing offshore extension of turbid plume water. Nearshore trapping and offshore dispersion patterns of freshwater from small estuaries are poorly documented, obfuscating mechanisms that greatly impact nearshore chemistry, biology, and geomorphology. Here, we focus on the Russian River, a highly variable hydrograph and an intermittently closed estuary, as a prototype Mediterranean-climate estuary. We document the spatial distribution of correlations between nearshore ocean color reflectance and environmental parameters by using nearly 20 years of MODIS satellite imagery data and continuous wind, river discharge, estuary inlet state, oceanic water level, and modeled wave energy data. These correlations are calculated for different conditions to observe various previously studied momentum exchanges. We find dynamic spatial patterns that are dependent on the balance between outflow and multiple environmental factors, resembling other plumes found around California. Understanding how various environmental conditions impact dispersion of freshwater and turbidity in the nearshore is fundamental for forecasting future sediment fate, light availability for benthos, and toxigenic/biogenic/pathogenic zones of impact.

First record of California coastal bottlenose dolphins in northern California offshore waters.

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[2]Point Blue Conservation Science, Petaluma, CA.
[3]Okeanis, Moss Landing, CA.

Two distinct ecotypes of bottlenose dolphins (*Tursiops truncatus*), differentiated by morphology and genetics, inhabit the nearshore waters of California: a coastal form typically <1 km from shore in depths of 10-30 m and an offshore form found in deeper waters, usually more than a few km from shore. Until 1982, the coastal bottlenose dolphin stock was limited to the Southern California Bight, but extreme weather events and climate change resulted in their range expansion, bringing them north to the San Francisco Bay Area by 2007. Currently, 105 individual coastal bottlenose dolphins have been photo-identified in this area. On 18 March 2019, three of these coastal bottlenose dolphins were photographed from Southeast Farallon Island, 43 km west of San Francisco. The dolphins, TMMC #21 (Akeakamai), TMMC #22 (Tikawana) and TMMC #31 (Oreo) were observed circumnavigating the island for several hours that day. Akeakamai and Tikawana were sighted back in their regular coastal habitat a few weeks later on 4 April 2019, while Oreo has yet to be re-sighted. Prior to the Farallon event the three dolphins had a history of multiple sightings restricted to the mainland coast of northern and central California. Their occurrence at Southeast Farallon Island represents the farthest offshore record for California coastal bottlenose dolphins. Depending on their route from the mainland, these dolphins traveled across the Gulf of the Farallones between 32-43 km through waters 55-84 m deep. Previously, coastal bottlenose dolphins in Southern California were known to range up to 15 km offshore. Our results confirm that this flexible top marine predator explores novel habitat, and the stock's recent emigration to the San Francisco Bay Area presents ecological opportunities. It is also a reminder that care should be taken when assigning bottlenose dolphins to ecotype based solely on their occurrence in nearshore versus offshore waters.

A milestone in the making: California's globally recognized marine protected area network decadal management review.

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In 2012, California finalized regional implementation of the largest ecologically connected network of marine protected areas (MPAs) in the world. Designed using a scientifically guided, stakeholder-driven approach, the MPA Network consists of 124 individual MPAs and 14 special closures that encompass approximately 16% of California's state waters, with 9% in no-take MPAs. As California approaches the 10-year anniversary of MPA Network completion in December 2022, the California Department of Fish and Wildlife is preparing the first comprehensive review of the MPA Network and Management Program towards meeting the ecosystem-focused goals of the Marine Life Protection Act (MLPA).

The Decadal Management Review will be rooted in the four pillars of the MPA Management Program: Research and Monitoring, Outreach and Education, Enforcement and Compliance, and Policy and Permitting**.** Several components and data streams will inform the review and help link Management Program highlights back to the MLPA goals including expert science guidance, Tribal coordination, stakeholder input, gaps in knowledge, and places for improvement. A milestone in California's history in marine conservation, this first review will result in broad adaptive management recommendations that will inform future MPA management priorities and network evaluations.

California's Network of MPAs,