



Briefing on Fish and White Sharks in Greater Farallones National Marine Sanctuary and Cordell Bank National Marine Sanctuary

State of the Resource

Condition Report Data

Since the previous condition reports, six out of the seven rockfish species have recovered from an overfishing or overfished status, with the exception of yelloweye rockfish in both Greater Farallones National Marine Sanctuary (GFNMS) and Cordell Bank National Marine Sanctuary (CBNMS).

CBNMS

- Rockfish were selected as focal species for CBNMS. Overall, rockfish in CBNMS appear to be stable.
- Rockfish recruits, as measured by the National Marine Fisheries Service (NMFS) Rockfish Recruitment and Ecosystem Assessment Survey, appear to be stable with a peak observed in 2013-2016.
- Rockfish catch per unit effort (CPUE), as measured in the West Coast Groundfish Bottom Trawl Survey from 2014–2019, was stable (within one standard deviation of the long-term mean and did not increase or decrease more than one standard deviation). Mean CPUE during previous (2003–2008) and current (2009–2019) condition report periods were similar.
- Rockfish on Cordell Bank appear to be stable with no major changes observed in pygmy, rosy, squarepot and yelloweye rockfish, based on CBNMS remotely operated vehicle (ROV) surveys.
- Groundfish diversity, measured as species per trawl as an estimate of species density, in the West Coast Groundfish Bottom Trawl Survey was stable on the upper slope but declined following a high in 2016 on the shelf. Means were similar from the 2003-2008 and 2009-2019 condition report periods
- Limited data of flatfish on the shelf showed that they appeared to be abundant and stable (based on CBNMS ROV surveys).

GFNMS

- Anchovy were selected as a foundation indicator species as they are forage for seabirds and marine mammals. Their relative abundance increased from 2015-2021 in GFNMS, as measured by the NMFS Rockfish Recruitment Ecosystem Assessment Survey.
- Juvenile rockfish were selected as a focal species. There was peak abundance in 2013–2016 followed by a decline. Abundances are still within one standard deviation of the long term mean. Juvenile rockfish in the kelp forest appear to have decreased in 2011 and remained suppressed during the 2014–2016 marine heat wave.

- White sharks were selected as a focal species. The waters around the Farallon Islands, Año Nuevo Island, Tomales Bay, and Point Reyes National Seashore are some of the most important known sites for seasonal aggregations of adult and subadult northeastern Pacific white sharks (*Carcharodon carcharias*). These sites provide critical feeding areas for the population during their annual migration. White sharks appear to be increasing in the sanctuary, which may be a result of the increase in abundance of pinnipeds and a reduction of mortality in fisheries. In 2011, 184 +/- 33 (SE) adult and subadult white sharks were estimated to have occurred in GFNMS. In 2018, the estimated number of white sharks increased to 262 +/- 21 (SE) in the Gulf of the Farallones region.
- Groundfish diversity, measured as species per trawl as an estimate of species density, in the West Coast Groundfish Bottom Trawl Survey was stable on the shelf (deeper than 50 meters) and upper slope with a slight decline in recent years.

Climate Vulnerability Assessment Findings

- Blue rockfish have a moderate vulnerability score based on moderate sensitivity to temperature, pH, salinity, and disturbance regimes; moderate exposure to increased temperature, decreased pH, disturbance regimes, and increased storminess; and high adaptive capacity as a result of high dispersal of larval and juvenile stages and more limited movement of adults.
- Widow rockfish have a moderate vulnerability score based on moderate sensitivity to dissolved oxygen, wave ocean, dynamic ocean conditions, and pH; moderate exposure to dynamic ocean conditions, decreased pH, changes to sea surface temperature, increased storminess, and decreased dissolved oxygen; and high adaptive capacity based on expected planktonic dispersal of larvae.
- Northern anchovy and Pacific sardines have a moderate vulnerability score based on moderate sensitivity to sea surface temperature, currents, mixing, stratification, and oxygen and high sensitivity to disturbance regimes (for sardine only); high exposure to dissolved oxygen and altered currents and mixing; and high adaptive capacity for anchovy and moderate for sardine.
- Tidewater goby have a moderate vulnerability score based on moderate sensitivity to precipitation, sea level rise, and coastal erosion; moderate exposure to changes in precipitation, and increased flooding; and low adaptive capacity because of limited habitat suitability and limited ability to disperse.

Other science information

According to NMFS, many West Coast salmon and steelhead have declined substantially from their historic numbers and now are at a fraction of their historical abundance. Factors contributing to the declines include: overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices.

Two species of salmon found in GFNMS and CBNMS are listed as endangered or threatened under the Endangered Species Act:

- California Coastal Chinook Salmon - Threatened
- Central California Coast Coho Salmon - Endangered

Pressures on Fish and White Sharks

- Fishing
- Climate change
- White shark disturbance (attracting and approaching)

Summary of Relevant Regulations

See full text, definition, and exemptions on the [GFNMS](#) and [CBNMS](#) websites.

The following regulation in GFNMS prohibits attracting a white shark anywhere in GFNMS; or approaching within 50 meters of any white shark within Special Wildlife Protection Zone 6 and 7 (The Farallon Islands) or within one nautical mile from these zones.

Lawful fishing is exempt from GFNMS and CBNMS regulations. The regulation of fishing is not authorized by either sanctuaries' terms of designation. GFNMS terms of designation specify that aquaculture is considered lawful fishing.

Summary of Relevant Sanctuary Projects

Conservation Science

- The sanctuaries track forage fish abundance and distribution during Applied California Current Ecosystem Studies (ACCESS) surveys, and track the species, distribution, and abundance of groundfish during visual surveys of the seafloor. This work is used to understand what species are present, how fish use sanctuary habitat, to gain basic science information about these species, and to evaluate and inform management efforts such as implementation of, or changes to, fishery management areas.
- The science team works with the resource protection team to identify issues and areas to study and with the education team to share findings.

Resource Protection

- The sanctuaries review project proposals, including proposed actions from other agencies that are likely to destroy, cause the loss of, or injure fish other than from lawful fishing.
- GFNMS manages the White Shark Stewardship Project, which is the umbrella for all white shark programs of the sanctuary.
 - GFNMS issues permits for educational tours in order to provide the public the opportunity to change their misperceptions about white sharks, learn about the role that white sharks and the sanctuaries play in creating a healthy, balanced

marine ecosystem, and better understand white shark conservation and protection efforts.

- All white shark education permits require naturalist training for tour operators. Additionally, each excursion is required to have a minimum of one naturalist on-board who has completed the training.
- GFNMS assesses the impacts of human activities on white sharks near the Farallon Islands¹, the effectiveness of permit conditions, determines compliance with sanctuary regulations, and detects emerging issues to help guide decisions to protect white sharks.
- GFNMS has issued research permits to two research organizations to attract white sharks for tagging and photo identification purposes to provide information about their life history and ecology (e.g., migration patterns, genetic isolation, site loyalty, environmental factors affecting abundance and success, and population structure such as sex-ratios, local population estimates, and trends).

Education and Outreach

- School programs:
 - GFNMS Visitor Center Field Trips: Home Sweet Habitat (6th grade); Salmon and Watersheds and Suitcase for Survival (3rd grade) – Adaptations of White Sharks
 - At Your School Programs: Sharkmobile (4th-6th grades) focuses on the biology, natural history and conservation of sharks. Fisherman in the Classroom (7th-12th grades)
 - Ocean Afterschool Programs: Salmon and Shark Classes (3rd-5th grades)
- Community programs:
 - Sharktoberfest (annual public festival celebrating sharks)
 - Salmon and Shark Family Workshops
 - Sanctuary Soirées included one Salmon Soiree, two Shark Soirees, and one Mola mola Soiree
 - Salmon and shark lessons during Marine Explorers Camp (3rd-6th grade)
 - Sanctuary Naturalist Program training includes fish and shark classes and a Fish chapter in the Manual. In addition, as part of the White Shark Stewardship program, training for naturalists on white shark tourism boats is offered.
- Exhibits & Signs:
 - Greater Farallones Visitor Center
 - California Academy of Sciences, California Coast Exhibit
 - Ocean Exploration Center at Point Reyes National Seashore Lighthouse
 - Bear Valley Visitor Center at Point Reyes National Seashore
 - Oakland Museum of California, Cordell Gallery
 - Randall Museum, Ocean Habitat Exhibit
 - Series of six signs on fishing at Pillar Point Harbor
- Media & outreach activities:
 - Digital media & social media on fish and sharks (“Marine Life Mondays”)
 - *Sanctuary in the Sea* film highlights white sharks (featuring Ron Elliott)

¹ Through a partnership with Point Blue and US Fish and Wildlife Service

- Collaboration with the International Ocean Film Festival includes a shark-themed section of the festival. Past film festival at Point Arena included *Near Miss* film
- KWMMR Radio Shows and recorded podcasts on fish and sharks
- GFNMS 50th Anniversary poster and Visitor Center mural poster both feature white sharks

Infrastructure and Vessels

Sanctuary infrastructure that supports research on, protection of, and education about fish and white sharks includes office infrastructure, at-sea assets, and specialized tools.

- The sanctuary hosts naturalist training courses at the Crissy Field office
- The Crissy Field Visitor Center and partner exhibits deliver information related to fish and white sharks in the sanctuaries
- GFNMS and CBNMS conduct single and multi-day missions on the regional research vessel *Fulmar* and longer missions on larger NOAA ships and the exploration vessel *Nautilus*. These at-sea research missions contribute to the overall characterization of sanctuary resources.

Summary and Staff Recommendations

Summary

Based on data presented in the condition reports, the abundance of anchovy, white sharks, and adult shelf and slope groundfish in GFNMS and CBNMS appear to be stable or increasing, but salmon are decreasing coastwide. In GFNMS, the condition of several nearshore rockfish species complexes was not assessed and the extent of potential declines of juvenile rockfish in kelp is not known. Sanctuaries do not manage fisheries, and lawful fishing is exempt from sanctuary regulations. GFNMS regulations prohibit attracting or approaching white sharks. The sanctuaries' science projects focus on understanding fish species distribution and abundance. Resource protection for fish includes reviewing proposals from other agencies and individuals for projects or management actions and managing the White Shark Stewardship Project. Education projects focus on the importance and roles of fish and sharks in the ocean ecosystem with an emphasis on salmon and white sharks. Projects include school programs, community programs, exhibits, signs, and media and outreach. This work is supported by office infrastructure as well as sanctuary and partner vessels.

Staff Recommendations

Conservation Science: Continue research and monitoring of species abundance and distribution during ACCESS and benthic surveys; and continue exploration to better understand fish species presence, distribution, abundance, and habitat use in deep sea habitat to assess status and trends, identify sensitive habitats, and inform management efforts.

Resource Protection: Increase sanctuary knowledge of impacts to the nearshore fish species complex and impacts in the sanctuary. Continue the White Shark Stewardship Project. Understand how Federal and State fishing regulations impact the sanctuaries habitat and ecosystems and determine if modifications are needed to protect the sanctuaries. Review the

effectiveness of GFNMS white shark regulations in protecting white sharks from disturbance while feeding in the sanctuary.

Education and Outreach: Maintain a dynamic array of community and school education programs about fish, including contributing to the White Shark Stewardship Project to increase public understanding of the importance and roles of fish and sharks in the ocean ecosystem. Partner with Pillar Point Harbor on a “Fishing in the Sanctuaries” interpretive trail and mural to educate the public about the importance of a healthy sanctuary to support fish populations.

Infrastructure: Maintain collaborative meeting space at Crissy Field and Bear Valley campuses, increase Crissy Field visitor center programming space and update exhibits at Crissy Field and partner facilities as needed to educate the public about the importance of fish and white sharks to the sanctuaries’ ecosystem.



Briefing on Bolinas Lagoon in Greater Farallones National Marine Sanctuary

State of the Resource

Condition Report Data (in preparation)

In general, information on the condition of Bolinas Lagoon is minimal. However, regular water sampling just outside the lagoon indicates that water quality is good. There is a lack of data on other water quality parameters, contaminants, and habitat integrity inside the lagoon. Eelgrass is thought to be extremely limited in Bolinas Lagoon but has not been assessed recently, and non-native species are present. Two car crashes have occurred in Bolinas Lagoon that may have damaged habitat. Restoration activities have been working towards restoring hydrological function and removing invasive species.

Climate Vulnerability Assessment Findings

- Vulnerability is calculated from exposure to climate and non-climate stressors, sensitivity to those same stressors, and the resource's ability to adapt to the impacts. Ratings presented are from the original 2015 report and from 2023 revisions of some indicators.
- Estuaries have a **high vulnerability** score (second most vulnerable habitat in the sanctuaries) based on very high exposure to climate change stressors, namely increased water temperatures, wave action and sea level rise, and reduced dissolved oxygen, and high or moderate sensitivity to sea level rise, sea surface temperature, and precipitation; however, estuaries do exhibit high adaptive capacity due to high species diversity and value to people. Estuaries also have very high exposure to non-climate stressors such as land use impacts; disturbance from structures, vessels, or moorings; and invasive species. The vulnerability of estuaries did not change since the original assessment. Thorne et al. (2016)¹ indicate that Bolinas Lagoon will experience dramatic habitat transition due to sea level rise (SLR) by 2080 under mid-SLR projections and 2050 under high-SLR projections, with the complete loss of high and mid-marsh habitat.

Other science information

Bolinas Lagoon is an important shorebird, seabird and marine mammal habitat, and is monitored through Beach Watch. For more information, see previous [Topic Briefings](#).

Pressures on Bolinas Lagoon

- Changing hydrological functions
- Invasive plant and invertebrate species

¹ Thorne, Karen M., et al. Effects of climate change on tidal marshes along a latitudinal gradient in California. No. 2016-1125. US Geological Survey, 2016.

- SLR, hardened shorelines, and loss of shoreline transitional habitat
- Human disturbance to wildlife

Summary of Relevant Regulations

All regulations related to discharge, seabed disturbance, wildlife take and possession, introduced species, and motorized personal watercraft. There is a Special Wildlife Protection Area that prohibits disturbing marine mammals and seabirds by flying aircraft below 1,000 feet above ground level throughout Bolinas Lagoon.

See full text, definition, and exemptions on the regulations page of the [GFNMS](#) website.

Summary of Relevant Sanctuary Projects

Conservation Science

- Beach Watch survey sites: one in Bolinas Lagoon, one at Seadrift outside of Lagoon, one at Bolinas Beach outside of Lagoon (includes monitoring mouth of lagoon).
- Habitat characterization, aerial mapping using Uncrewed Aerial System Structure from Motion (a type of 3D imaging), and sediment analysis, in partnership with Greater Farallones Association (GFA).
- Computer modeling to understand the impacts of SLR, erosion, and coastal flooding on ecological health, in partnership with the U.S. Geological Survey and GFA.

Resource Protection

- Review project proposals, including proposed actions from other agencies, that could potentially: 1) violate sanctuary regulations and impact Lagoon habitat, species, water quality and hydrological functions or 2) protect and restore the Lagoon's ecological function. For example, review of Marin County's North End Project to restore wetland connectivity and Caltrans culvert operations.
- Through permitting actions the sanctuary manages, reduces, or eliminates injury to Bolinas Lagoon.
- Work with NOAA's Office of Law Enforcement to document incidents that injure Bolinas Lagoon.
- In partnership with all agencies with jurisdiction in Bolinas lagoon, implement actions that protect and restore the ecological function of Bolinas Lagoon.
- In partnership with Marin County, remove invasive plant species at Kent Island to lower the profile of Kent Island.
- In partnership with GFA, The Seadrift Association, The Smithsonian, and Bodega Marine Laboratory, remove invasive green crabs at Seadrift Lagoon to prevent them from entering Bolinas Lagoon.
- Publish a permitting roadmap that provides tips and guidance to project planners to assist with navigating federal, state, and local permitting and regulatory requirements in order to avoid complications and delays to their projects.

Education and Outreach

- School programs:
 - West Marin School: Bay Watershed Education and Training (B-WET) Project that included a field trip to Bolinas Lagoon; At Your School Green Crab Program for Bolinas School District (3rd-5th grades); Invasive Green Crab Dissection Lab (3rd-6th grades)
- Community programs:
 - Bolinas Lagoon focused sanctuary explorations: Kent Island Restoration & Birding; Kayaking & Wildlife Viewing; Heron Rookery and Wildlife viewing hikes;
 - Marine Explorers Camp: Kent Island Restoration and Exploration Day
 - Sanctuary Naturalist Program training manual includes Bays & Wetlands chapter with an emphasis on Bolinas Lagoon and a six-hour class on Bolinas Lagoon and Kent Island
 - Town hall events and presentations with partners to inform progress on restoration actions
 - Volunteer opportunities to remove invasive species as part of Bolinas Lagoon Restoration project at Kent Island (plants) and/or Sea Drift Lagoon (green crabs)
- Exhibits/Signs:
 - Interpretive sign about Bolinas Lagoon at Audubon Canyon Ranch. The sign is an interpretive stop for their docent led school tours.
 - Bolinas Museum exhibits.
- Media & outreach activities:
 - Digital media & social media on marine life in Bolinas Lagoon (“Marine Life Mondays”)
 - Earth is Blue Video (*Restoring Bolinas Lagoon*)

Infrastructure and Vessels

Sanctuary infrastructure that supports research on, protection of, and education about Bolinas Lagoon include:

- Meeting space at the Crissy Field Campus for Sanctuary staff to collaborate with partners on Bolinas Lagoon projects.
- Government vehicles to transport staff to Bolinas Lagoon.
- The sanctuary relies on partners to provide kayaks for Green Crab removal in Bolinas Lagoon, and paddle boats for access to Kent Island.

Summary and Staff Recommendations

Summary

Bolinas Lagoon is an important shorebird, seabird and marine mammal habitat with international, federal, state and local designations to protect the Lagoon. In general, information on the condition of Bolinas Lagoon is minimal. GFNMS, with partners, implements actions that protect and restore the ecological function of Bolinas Lagoon focusing on addressing sediment imbalances and invasive species removal. Education projects inform students and adults about the importance of Bolinas Lagoon through school programs, community programs, exhibits and

signs, and volunteer opportunities. The sanctuary supports projects in Bolinas Lagoon by providing meeting spaces, vehicles for staff, and partnerships for use of kayaks..

Staff Recommendations

Conservation Science: Identify research needs, explore research partnerships, and conduct monitoring to understand the status and trends of species in Bolinas Lagoon and to understand the feasibility and effectiveness of restoration efforts in order to protect this United Nations (UN) Wetland of International Significance.

Resource Protection: Restore ecological functions by 1) managing invasive species that pose the greatest risk to native species and 2) restoring transitional shoreline habitat to allow for species migration upland during high tides and with SLR in order to maintain Bolinas Lagoon as a UN Wetland of International Significance for wildlife

Education and Outreach: To increase awareness of the importance of Bolinas Lagoon as a UN Wetland of International Significance the sanctuary should 1) maintain community and school education programs about Bolinas Lagoon; 2) maintain and install an additional wayside exhibit on the importance of Bolinas Lagoon; 3) work with partners to instaff exhibits about Bolinas Lagoon; 4) partner with College of Marin Bolinas Marine Lab on educational programming; and 5) incorporate messaging on the blue carbon value of Bolinas Lagoon into community education programming.

Infrastructure: Maintain collaborative meeting space at the sanctuary offices in San Francisco and Point Reyes Station, enhance Crissy Field visitor center space for exhibits to include information on estuarine habitat, and continue partnerships to use very small vessels in Bolinas and Seadrift Lagoons to implement projects.