National Marine Fisheries Service

NMFS West Coast Offshore Wind Energy Strategic Science Plan

October 2024

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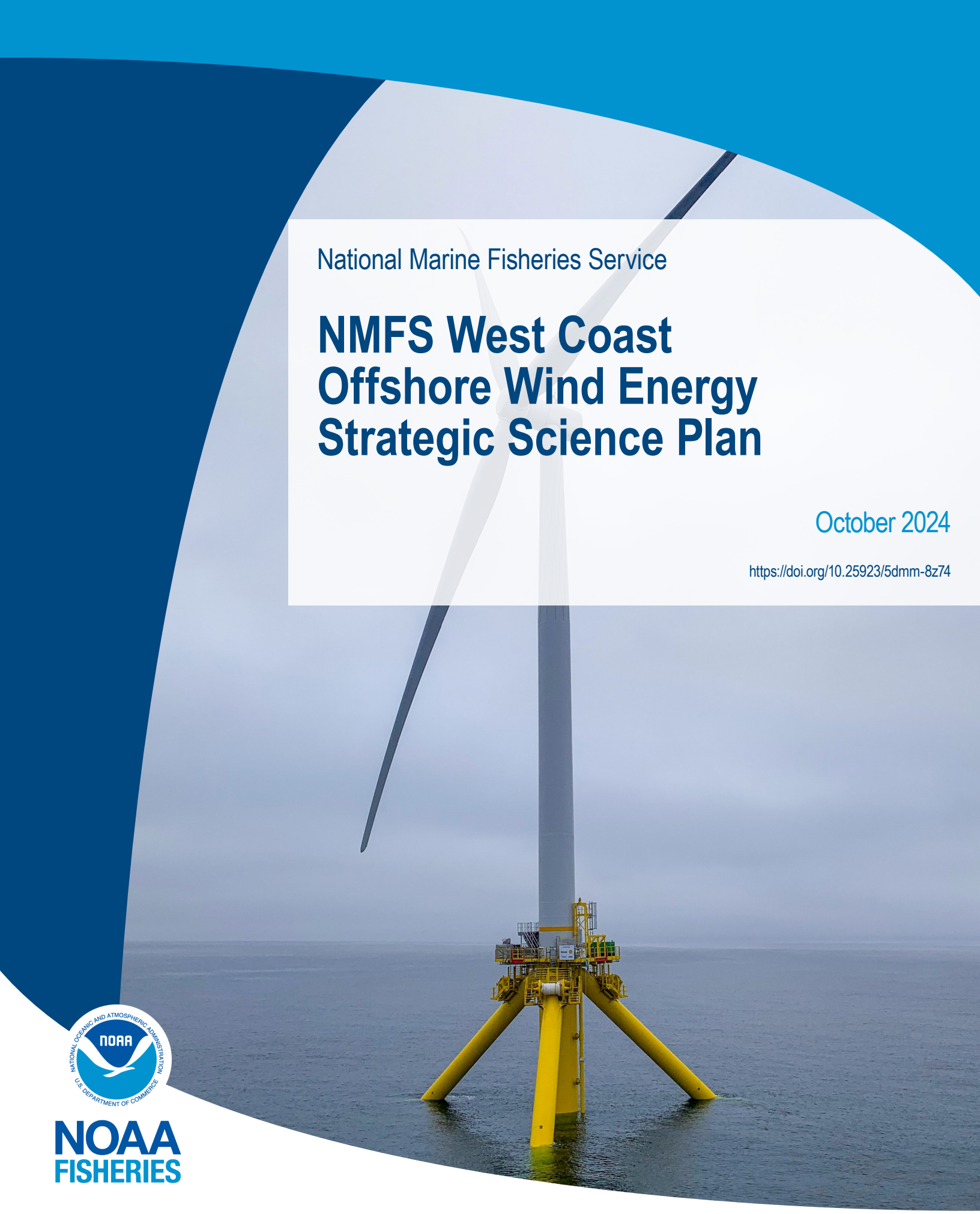

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Page 6: (left) The deep-sea coral *Paragorgia cf. yutlinux* at a site called the "Brush Patch" off the California/Oregon border. Credit: MARE, DSCRTP. (right) © halberg. Boat transfer to substation in offshore windfarm. Adobe Stock #52077805, https://stock.adobe.com.

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Page 9: Photograph courtesy of TetraSpar Demonstrator ApS. The TetraSpar concept floating turbine, which is a tubular steel structure with a suspended keel, being towed from Grenaa, Denmark, to the Metcentre test site in Norway.

Page 10: Photograph by Mark Lovewell, NMFS/WCR. Sean Naman brings the net on board, tow net—Puget Sound Pelagic Food Web Study, Hood Canal, September 2011. Available: https://www.flickr.com/photos/nmfs_northwest/7545341540.

Page 11: (left) Photograph by Enrique Patino, NMFS/WCR. Western gull (*Larus occidentalis*) in La Push, Washington—low tide at First Beach, October 2011. Available: https://www.flickr.com/photos/nmfs_northwest/7545148684. (right) Photograph by Craig D'Angelo, NMFS/WCR. A commercial fisherman lands an albacore on the FV *Her Grace*, 100 nautical miles west of Astoria, Oregon. Available: https://www.flickr.com/photos/nmfs_northwest/23480139940.

Page 12: (left) Photograph by Bernardo Alps, NMFS/WCR. Listening for right whales. CLAWS research trip aboard NOAA Ship Reuben Lasker in the Gulf of Alaska. Available: https://www.flickr.com/photos/nmfs_northwest/23014564514. (right) Photograph by NOAA Fisheries. J50 and researchers, permit #21368. Available: https://www.flickr.com/photos/nmfs_northwest/43893124301.

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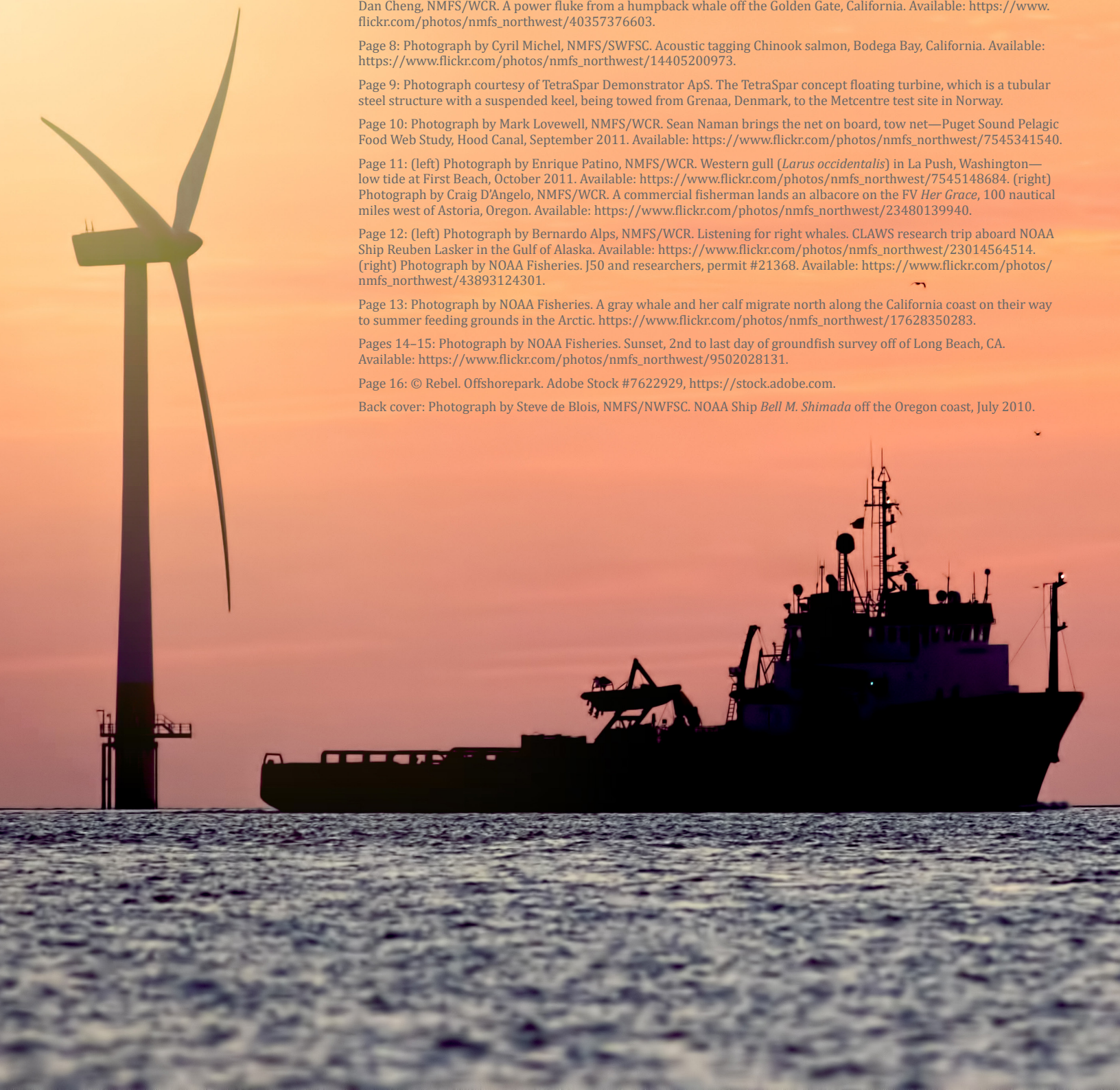
Back cover: Photograph by Steve de Blois, NMFS/NWFSC. NOAA Ship *Bell M. Shimada* off the Oregon coast, July 2010.



Introduction

The development of the offshore wind energy sector is creating an entirely new use of the U.S. ocean. The federal government and several states are pursuing an ambitious schedule for developing offshore wind energy. As part of the Biden–Harris Administration's clean energy and climate mitigation priorities, the President set a goal of responsibly deploying 30 gigawatts of offshore wind energy nationwide by 2030 while protecting biodiversity and promoting ocean co-use, and this is intended to be a pathway to developing 110 gigawatts by 2050.[1]

The Bureau of Ocean Energy Management (BOEM) is the lead federal agency for offshore energy siting, leasing, and permitting. NOAA's National Marine Fisheries Service (NMFS, or NOAA Fisheries) is responsible for the stewardship of the nation's living marine resources and their habitat. BOEM seeks consultation from NMFS under the Endangered Species Act (ESA) and under the Magnuson–Stevens Fishery Conservation and Management Act for essential fish habitat. Developers seek incidental take authorizations from NMFS under the Marine Mammal Protection Act. Given our unique expertise in fisheries, marine and anadromous species and their habitats, and the ecosystems in which they live, NMFS also contributes data to BOEM's siting process, and provides comments on potential impacts to NMFS trust resources included in BOEM's Environmental Assessments and Environmental Impact Statements prepared under the National Environmental Policy Act. Our efforts to identify information gaps and address critical scientific information needs will be of value to multiple agencies, U.S. West Coast tribal nations, industry, and a wide range of other parties.

Along the U.S. West Coast, NMFS manages federal fisheries for salmon, groundfish, coastal pelagic species, and highly migratory species. We do this with our state and tribal co-managers and the Pacific Fishery Management Council. NMFS also works to conserve and recover protected species, such as marine mammals, sea turtles, and ESA-listed fish. The research and monitoring conducted by NMFS' Northwest and Southwest Fisheries Science Centers (NWFSC and SWFSC) help ensure that NMFS' management decisions are based on the best available scientific information and are supported by innovative technologies.

The steep continental shelf along the U.S. West Coast will require floating (as opposed to fixed) offshore wind turbines, a distinct technology that is as yet unprecedented in the world at a commercial scale. Development of this new technology and ocean-use sector creates the need for a unique set of scientific research objectives. It will also require modifications to NMFS' scientific surveys and monitoring designs to support our stewardship mandates and inform approaches to developing this new ocean-use sector responsibly and sustainably.

Meeting these challenges will require an investment in science, research, and technology to understand the impacts of offshore wind energy on marine species, the marine ecosystem and oceanographic processes, fishing communities, and U.S. West Coast tribes that depend on these resources. Much of NMFS' past, present, and future scientific research plans will be informative to this understanding; however, a new, focused science initiative is needed with the transition to a novel energy sector sited within the marine ecosystem.

The *NMFS West Coast Offshore Wind Energy Strategic Science Plan* outlines research directions that are needed to: a) fulfill NMFS' consultation and authorization mandates with respect to offshore wind energy development; b) advance the scientific understanding of the interactions between offshore wind energy development and NMFS trust resources on the U.S. West Coast, including assessing the effects of planned offshore wind energy activities on fish, fisheries, protected species, habitats, and ecosystems; and c) support the development of strategies to mitigate impacts.

This plan outlines six priority areas for research:

1. Habitat impacts
2. Physiological and physical effects
3. Species abundance and distribution
4. Fisheries socioeconomic impacts
5. Ecosystem and climate interactions
6. Impacts to NMFS' scientific surveys

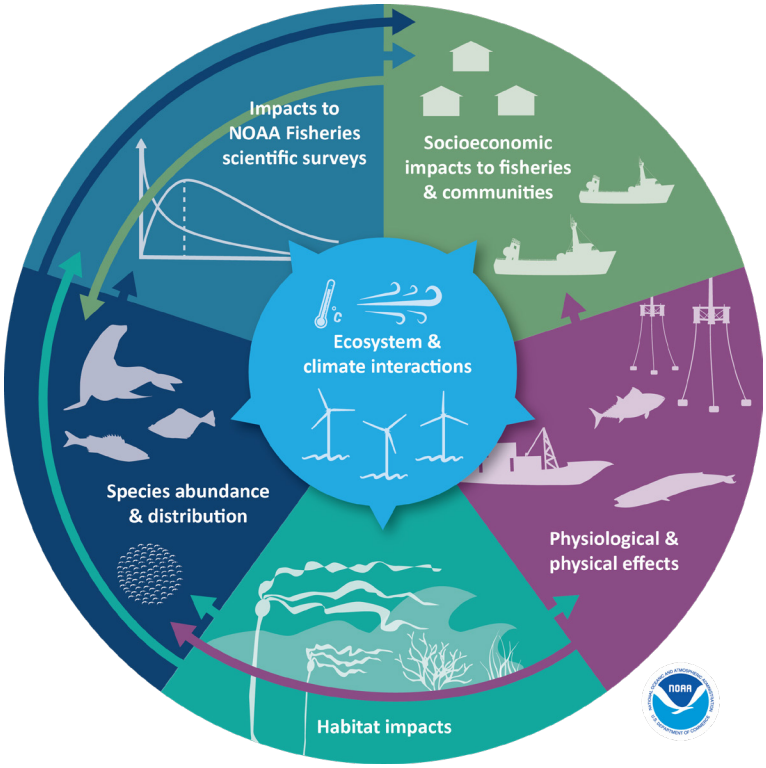


Figure 1. Interdependencies of the research foci of the NMFS West Coast Offshore Wind Energy Strategic Science Plan.Graphic by Su Kim, NMFS/NWFSC.

These focus areas are interdependent and build off information developed in other areas (Figure 1). This is followed by sections on overarching challenges and opportunities, feasibility, and partnerships and outreach. The plan was developed by members of the NMFS West Coast Offshore Wind Energy Coordination Team and other NMFS subject matter experts. It was informed by the agency's long history of providing analyses to meet regulatory needs, along with the agency's experience with offshore wind development along the U.S. East Coast. This plan is intended to be a living document, adaptive to new scientific advancements, newly identified needs, and the priorities of the federal government and our partners. Implementation of this plan will require additional resources and close collaboration with other federal agencies, states, tribes, and other partners.

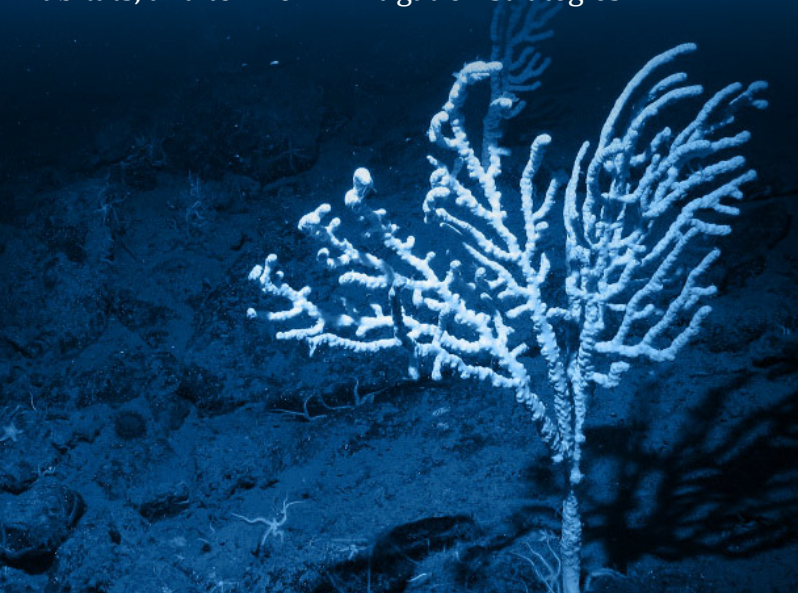
NMFS is committed to fulfilling trust and treaty responsibilities[2] to federally recognized American Indian tribes throughout our work and as we implement the NMFS West Coast Offshore Wind Energy Strategic Science Plan. Tribal cultural significance and sacredness of the ocean and its resources, as well as treaty rights, are acknowledged in the development and implementation of this science plan. We will continue to engage and consult with tribes to identify their nations' scientific priorities for offshore wind energy and potential impacts to tribal rights. We also seek to learn about tribal nations' research priorities regarding offshore wind energy development and its potential impacts to marine resources through collaborative inquiry with tribal nations, incorporating indigenous knowledge with current scientific understanding.

Research Focus 1: *Habitat Impacts*

Description

The development of offshore wind energy will place new infrastructure (e.g., turbines and floating platforms, mooring anchors and lines, electrical substations and transmission cables) in the ocean that will harness the energy of prevailing winds, impact surface and subsurface circulation patterns, and create and modify habitat in and around developed areas. Research Focus 1 identifies scientific needs related to how this new infrastructure along the U.S. West Coast may affect the pelagic and benthic habitats for living marine resources, such as marine mammals, endangered and threatened species, and fisheries stocks.

This research focus area will have significant near-term science needs for regulatory activities (i.e., consultations and authorizations) and for informing the siting of future offshore wind lease areas and infrastructure. Subject matter experts and spatial analysts will need to develop atlases of current data that identify areas of overlap between important habitats for NMFS trust resources and potential wind energy areas and cable routes. Subsequently, the development of oceanographic models, long-term monitoring designs, and risk-assessment tools will be needed to predict, monitor, validate, and assess the relative impacts of offshore wind energy development to pelagic and benthic habitats, and to inform mitigation strategies.



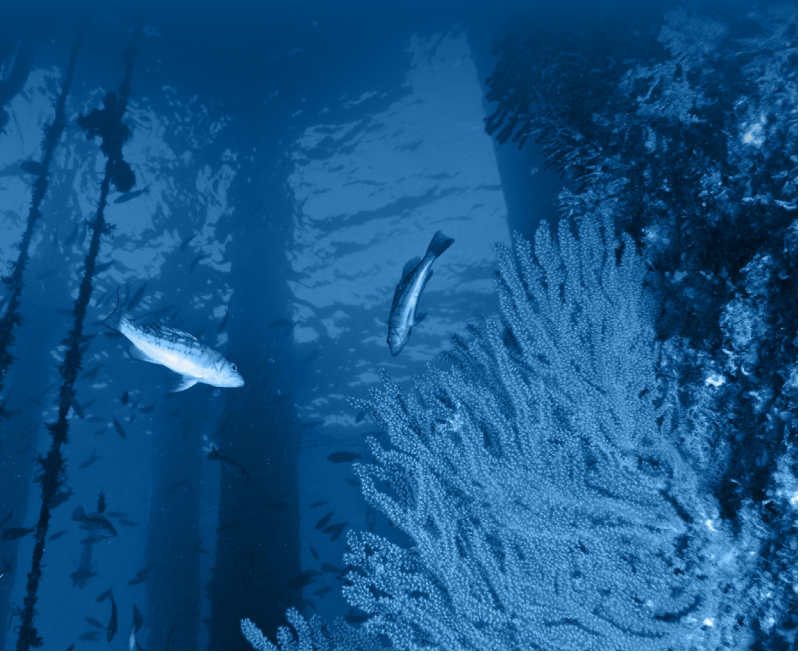
Research Priorities

- Create atlases and other data products of U.S. West Coast habitats that are important for NMFS trust resources that can be used in marine spatial planning and to inform plans for new data collection.
- Understand the potential impacts on atmospheric wind fields and related oceanographic and ecosystem processes, including upwelling, surface currents, formation of mesoscale fronts and eddies, nutrient supply, temperature, and primary productivity.
- Quantify the risks to biogenic habitats (e.g., corals and sponges), methane seeps, carbonate pavements, and other sensitive habitats during the construction or operation phases of offshore wind energy development to identify appropriate conservation buffers.
- Determine whether the addition of artificial structure alters the suitability of pelagic or benthic habitats (e.g., via changes in water-column or bottom-type characteristics) and provides additional settling habitat for fouling organisms and algae.

Research Focus 2:
Physiological & Physical Effects

Description

The development of offshore wind energy will place new infrastructure in the ocean and require an increase in vessel traffic, both of which create stressors that have the potential to cause physiological and physical impacts on ocean organisms. These stressors include noise, electromagnetic fields (EMFs), pollution, changes in food availability, and physical interactions with infrastructure. These topics are routinely addressed in NMFS' consultations and authorizations, and there are modeling frameworks and standards available to guide analyses. However, a critical need is to understand the levels and specifics of noise, EMFs, pollution, and infrastructure in the water column that will be associated with floating offshore wind turbine construction and operations. Because the technology is being developed specifically for deeper waters, such as those off the U.S. West Coast, and similar operations do not yet exist at commercial scales anywhere in the world, NMFS anticipates novel questions will arise as these developments begin to take shape. Better anticipating some of these questions will not only support NMFS in collaborating on answers, but will also inform when and where mitigation can best be implemented, including through lease siting, turbine micrositing, or technological and engineering solutions.



Research Priorities

- Evaluate the impacts of noise on deep-sea communities that will be impacted by cable foundation-driving activities.
- Review the literature and articulate our baseline understanding of the potential effects of large-scale EMFs on U.S. West Coast marine species, including sea turtles, sunflower sea stars, salmon, elasmobranchs, green sturgeon, and euphausiids, as well as diurnal migratory behavior. Identify areas of need for new and updated research.
- Evaluate the potential for floating offshore wind energy platforms to act as fish aggregating devices, haulout structures for pinnipeds, and substrate for invertebrates.
- Evaluate the probability of physical interactions between migrating marine species and offshore wind energy infrastructure, including floating platforms, anchor cables, offshore substations, transmission lines, entangled marine debris, and vessel traffic.

Research Focus 3:
Species Abundance & Distribution

Description

New offshore wind energy infrastructure in the ocean will interact with atmospheric and oceanographic processes, benthic and pelagic habitats, and other ocean-use sectors in ways that will impact a wide variety of species directly or indirectly at multiple spatial and temporal scales. This research focus identifies high-level scientific needs related to how this new infrastructure along the U.S. West Coast may affect the abundance and distribution of NMFS trust resources, such as protected species and fish stocks.

A wide range of impacts may affect the abundance and distribution of individual marine species managed by NMFS. These impacts include alterations to larval dispersal patterns, as well as changes in foraging and migratory behavior, the connectivity among populations, and natural and fishing mortality inside and outside of areas with offshore wind energy infrastructure. It will be increasingly important to develop research that can distinguish changes occurring to the system due to offshore wind energy development from the current background of climate variability on the U.S. West Coast.

Research Priorities

- Evaluate the risk of direct and indirect entanglement mortality on protected species.
- Evaluate the risks and effects of plankton entrainment at substations.
- Evaluate how offshore wind energy development will affect the migratory and/or movement patterns of marine mammals, seabirds, sea turtles, and fish species.
- Determine whether spatial distribution and population dynamics could be altered by floating offshore wind energy development.
    - Assess whether the transport, dispersal, settlement, and/or distribution of fish and shellfish larvae is altered.
    - Identify whether the addition of artificial habitat (e.g., mooring lines and anchors, transmission cables, platforms, substations) or modification/destruction of natural habitat modifies the suitability of these areas or alters the connectivity of populations across these regions.
    - Determine whether offshore wind infrastructure aggregates species-of-interest and/or their predators/prey, subsequently affecting spatial distribution, natural mortality, and productivity.
    - Produce species distribution models using results from oceanographic modeling identified in Research Focus 1.
- Determine if spatial closures to fishing activities within offshore wind farms alter the distribution and abundance patterns or the demographic structure of harvested populations.
- Assess how spatial variation or changes in biological rates and population characteristics will affect population estimates and uncertainty calculated by NMFS stock assessments for fisheries stocks and protected species.

Research Focus 4: *Socioeconomic Impacts to Fisheries & Fishing Communities*

Description

Offshore wind energy development will likely impact commercial, recreational, and tribal fishing activities, as well as communities for which fishing is part of their culture and economy. The impacts depend on whether areas with offshore wind energy infrastructure will be inaccessible to fishing, potential physiological and distributional impacts on target species, and how port and offshore wind energy infrastructure development affect the local labor supply and economy. Some of these research priorities can inform siting decisions and will be necessary to assess impacts to fisheries, while others will support NMFS in its mission area of managing productive, sustainable fisheries and resilient fishing communities alongside the emerging offshore wind energy sector.

Research Priorities

- Develop web portals for spatial revenue and fishing effort data for commercial and recreational fishing.
- Assess the distribution of different types of fishing effort, the potential redistribution of different types of fishing effort or changes to transit due to closed areas, and changes in fishing effort distribution and/or catch composition due to species distribution shifts.
- Improve and customize economic impact modeling tools to be useful for analysis of the impacts of offshore wind energy on the seafood industry, tourism, local labor, and regional welfare.
- Understand how port infrastructure development will affect different types of fishing activities.
- Evaluate strategies that decrease impacts on fisheries-related operations and assess the effectiveness of proposed mitigation efforts.
- Integrate NMFS' community vulnerability indices for the U.S. West Coast with the national NMFS Social Indicators for Coastal Communities,[3] and assess whether additional inputs would improve their relevance to offshore wind energy.
- Evaluate and describe the potential for offshore wind energy development to affect the cultural identity and fishing heritage of fishing communities.
- Understand how changes in stock assessment uncertainty may affect fisheries management decisions, as well as any resulting effects on fishery economics.
- Valuate nonmarket ecosystem services and existence values.

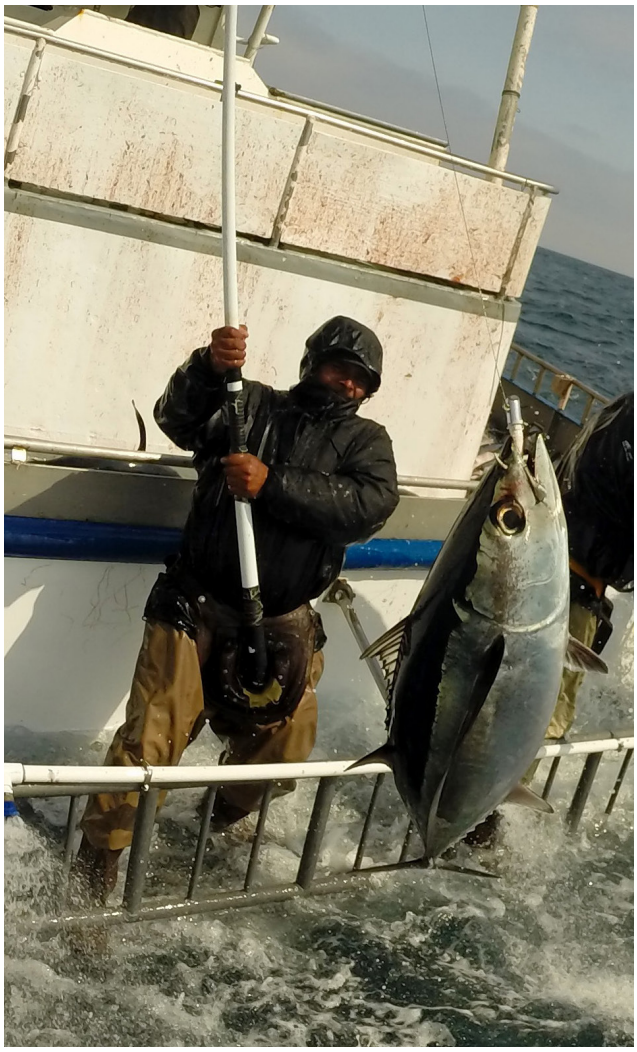
Research Focus 5:
Ecosystem & Climate Interactions

Description

The development of offshore wind energy will affect many ecosystem components, as described under the previous research foci. In addition, research priorities will be needed to synthesize the effects identified under other focus areas, to understand how impacts to individual ecosystem components might interact and result in compounding effects across the ecosystem, and to distinguish offshore wind energy impacts from climate variability and climate change. This research focus identifies areas of scientific need related to identifying and measuring the many indirect pathways through which offshore wind energy development may impact NMFS trust resources, fisheries, and the coastal communities that depend on these resources. These research priorities will help frame individual impacts into an ecosystem-based management framework and provide science advice capable of identifying trade-offs across multiple, often conflicting, objectives. This is important for understanding the interactions between offshore wind energy and other ocean-use sectors, such as fisheries.

Research Priorities

- Collaborate with interested tribal nations and other partners to develop methods to identify changes in ecosystem structure and function, including conceptual models and suites of ecosystem indicators across physical, biological, and human-dimension components.
- Identify and fill gaps in our understanding of trophic interactions across the food web, and use these new estimates to evaluate how impacts may cascade throughout the ecosystem.
- Develop frameworks for quantifying cumulative effects of multiple offshore wind farms on ecosystem processes and components.
- Develop risk assessment tools that can quantify changes in relevant ecosystem indicators and distinguish the effects due to offshore wind energy development from the effects of climate variability and change.



Research Focus 6: *Impacts to NMFS' Scientific Surveys*

Description

NMFS' scientific surveys are essential for sustainably managing our nation's fisheries, promoting the protection and recovery of marine mammals and endangered and threatened species, and conserving coastal and marine habitats and ecosystems for future generations. These surveys are critical to understanding the impacts of climate change on marine species and their habitats, marine ecosystems, and the human communities that rely on them. Consistent sampling designs and methods are essential to the surveys' value, allowing NMFS to examine the status and trends of managed species consistently through time. Four impacts to NMFS surveys from offshore wind energy development may occur:[4]

1. Preclusion of NMFS sampling platforms from wind development areas because of operational and safety limitations.
2. Impacts to the statistical design of surveys (random-stratified, fixed station, transect, opportunistic, and others) that are the basis for scientific assessments, advice, and analyses.
3. Alteration of benthic and pelagic habitats and airspace in and around wind energy developments, requiring new designs and methods to sample new habitats.
4. Reduced sampling productivity caused by navigation impacts of wind energy infrastructure on aerial and vessel surveys.

These impacts must be mitigated[5] to maintain the scientific integrity of NMFS' surveys and the scientific products that are produced with these survey data by NMFS, other federal and state agencies, academics, and other partners. On the U.S. East Coast, NMFS and BOEM developed a joint mitigation strategy to address impacts to NMFS' northeastern surveys, and a similar effort will be necessary on the U.S. West Coast.

Research Priorities

- Evaluate and quantify the impacts of proposed project-related wind development activities on scientific survey operations and provision of scientific advice to management.
- Evaluate or develop appropriate new statistical designs, sampling protocols, and methods while maintaining data-quality standards for the provision of management advice.
- Design and carry out necessary calibrations and analyses to integrate existing and new survey approaches by addressing both operational and analytical needs to ensure continuity, interoperability, precision, and accuracy of data products.
- Develop interim indices from existing datasets to partially bridge the gap in data availability between pre-construction and operational periods while new approaches are being identified, tested, or calibrated.

Overarching Scientific Challenges and Opportunities

The development of offshore wind energy along the U.S. West Coast presents experimental design, analytical, and logistical challenges that will affect how NMFS moves forward in developing scientific methodologies to address research questions across each of the science priorities identified in this plan. The challenges include:

- Enhancing and integrating regional data infrastructure across agencies to provide timely and equitable access to scientific data and research products, including agreeing upon open data architectures that can be used to assimilate and serve ecosystem data across multiple sources (e.g., government, academics, developers, contractors).
- Characterizing baseline conditions prior to offshore wind development.
- Developing research methods that can disentangle attributable effects of offshore wind energy development on ecosystem components from effects imposed by underlying climate variability and climate change or other influences.
- Developing research methods that can accommodate current and future scenarios of cumulative offshore wind energy development across multiple spatial scales and temporal horizons.
- Developing and implementing new monitoring technology that will minimize negative impacts to surveys and the mission-critical management actions they support.
- Providing unique expertise in fisheries, marine and anadromous species and their habitats, and the California Current Ecosystem, and building collaborations with partners that capitalize on that expertise.
- Funding to keep pace with the demands of decision-making timelines and the need for sound, trusted scientific information to inform offshore wind energy development.

Simultaneous with the identified scientific challenges, there are substantial scientific opportunities presented by the infrastructure that will be installed in the ocean because of offshore wind development. For the U.S. West Coast, this infrastructure is expected to consist of a systematic field of densely spaced floating platforms with life expectancies of 20+ years located across multiple regions of the coast, characteristics which lend themselves to monitoring and experimental sampling designs that have not been possible in the past:

- Using platforms for fine-resolution data collection that will help answer longstanding research questions.
- Engaging and collaborating with offshore wind energy industry partners before construction and operation plans are in place to design and integrate novel monitoring schemes and instrumentation with offshore infrastructure.
- Using offshore infrastructure to mitigate the loss of long-term survey sampling locations.
- Exploring opportunities for designing and implementing collaborative research and monitoring projects with tribal nations partners from the outset.

Feasibility/Scalability

The Northwest and Southwest Fisheries Science Centers and the West Coast Regional Office have staff with considerable expertise in ecosystem monitoring, oceanography, ecological and socioeconomic modeling, spatial analysis, risk assessment, management strategy evaluations, social science, and species-specific subject matter who will lead research projects for each of these priorities. Carrying out these research priorities will require significant increases in scientific funding and staff. Results of this research can provide guidance to managers for siting decisions, lease requirements, mitigation strategies, and regulatory consultations and authorizations, as well as uncover unanticipated questions and challenges. This plan will be considered adaptive and iterative.

Each of the research priorities identified should, to the extent possible, be adaptable to multiple spatial and temporal scales. An adaptable experimental or modeling framework will allow state and federal regulatory agencies to make necessary jurisdictional decisions and provide insights on the effects of floating offshore wind energy development to other regions of the United States and across the world. The breadth of natural and social science expertise necessary to carry out these ecosystem- and climate-integrated priorities will make it imperative for NMFS staff to develop and work with a large collaborative, cross-disciplinary team. NOAA's California Current Integrated Ecosystem Assessment is a well established, interdisciplinary science and management framework advancing the goals of ecosystem-based management that can provide a network of scientific expertise and a framework for developing the necessary ecosystem approaches identified across most of the research priorities.[6]

Partners, Outreach, and Communication

In order to carry out these research priorities, NMFS will work with existing and new partners. We will need to rely on regional expertise, indigenous knowledge, local knowledge, and resources across a wide range of disciplines from other federal and state agencies, tribal nations, the Pacific Fishery Management Council, the Pacific States Marine Fisheries Commission, academia, the offshore wind energy industry, fisheries, and numerous other parties.

Direct engagement and codevelopment of research with partners, including tribal nations, will be essential to ensure the results of our science are management-ready. We will seek to prioritize research necessary to uphold our federal responsibilities for tribal nations' trust and treaty resources. When applicable, we will undertake active engagement with tribal nations and others in the development of specific research goals and questions across the research foci. Incorporating local, traditional ecological, and indigenous knowledge will increase the value of the science and the breadth of scenarios it can be applied to in the decision-making process.[7] The results from these research priorities will be shared across diverse audiences that include BOEM and other federal and state agencies, management partners, industry, and nonscientific communities.

NMFS will collaborate with BOEM and the Department of Energy, who are also funding and undertaking research to address information needs for offshore wind development, given their respective roles. NMFS and BOEM have already begun collaborating on several U.S.West Coast studies. We are also looking forward to potential regional collaborations with federal and state agencies, tribes, academia, NGOs, and others.

Endnotes

[1] White House Fact Sheet, 29 March 2021 (https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/).

[2] Executive Order 14112 (https://www.federalregister.gov/documents/2023/12/11/2023-27318/reforming-federal-funding-and-support-for-tribal-nations-to-better-embrace-our-trust).

[3] See https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities.

[4] Hare, J. A., B. J. Blythe, K. H. Ford, S. Godfrey-McKee, B. R. Hooker, B. M. Jensen, A. Lipsky, C. Nachman, L. Pfeiffer, M. Rasser, and K. Renshaw. 2022. NOAA Fisheries and BOEM Federal Survey Mitigation Strategy—Northeast U.S. Region. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NE-292. DOI: 10.25923/jqse-x746

[5] According to the Council on Environmental Quality (CEQ), *mitigation* includes: Avoiding an impact by not taking a certain action or parts of an action; minimizing an impact by limiting the degree or magnitude of the action and its implementation; rectifying an impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating an impact over time, through preservation and maintenance operations during the life of the action; and compensating for an impact by replacing or providing substitute resources or environments (https://www.govinfo.gov/content/pkg/CFR-2013-title40-vol34/pdf/CFR-2013-title40-vol34-sec1508-20.pdf). NOAA's Mitigation Policy for Trust Resources incorporates CEQ's mitigation definition (https://www.noaa.gov/organization/administration/noaa-administrative-orders-chapter-216-program-management/nao-216-123-noaa-mitigation-policy-for-trust-resources).

[6] See https://www.integratedecosystemassessment.noaa.gov/regions/california-current.

[7] See https://www.noaa.gov/sites/default/files/2021-11/19-065933-Traditional-Knowledge-in-Decision-Making-Document-Signed.pdf and https://www.whitehouse.gov/wp-content/uploads/2021/11/111521-OSTP-CEQ-ITEK-Memo.pdf.

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