USA

Report on Groundfish Activities by the Northwest Fisheries Science Center in 2025

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Prepared for the
Canada-United States Groundfish Technical Committee

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1. Executive Summary

Groundfish research at the Northwest Fisheries Science Center (NWFSC) is conducted within the following Divisions: Conservation Biology, Fish Ecology, and Fisheries Resource Analysis and Monitoring. All Divisions work closely together to accomplish the mission of the NWFSC.

In 2025, the NWFSC conducted groundfish research following the NOAA Fisheries 2022-2025 Strategic Plan and Center priorities. This report includes summaries of six surveys conducted, 20 published research papers, 24 ongoing research projects, seven newly developed tools, seven stock assessments, and data management updates.

2. Surveys and Monitoring

West Coast Groundfish Bottom Trawl Survey
Contributed by Doug Draper, douglas.draper@noaa.gov.

The NWFSC conducted its twenty-seventh annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California in 2025. The objective of the 2025 survey was to provide information on the distribution and relative abundance of demersal species within this region at depths from 30 to 700 fathoms (ftm), encompassing all groundfish species of management concern (94+ species). Other biological information necessary to assess the status of groundfish stocks (e.g. length, weight, sex and age structures) was collected throughout the survey period.

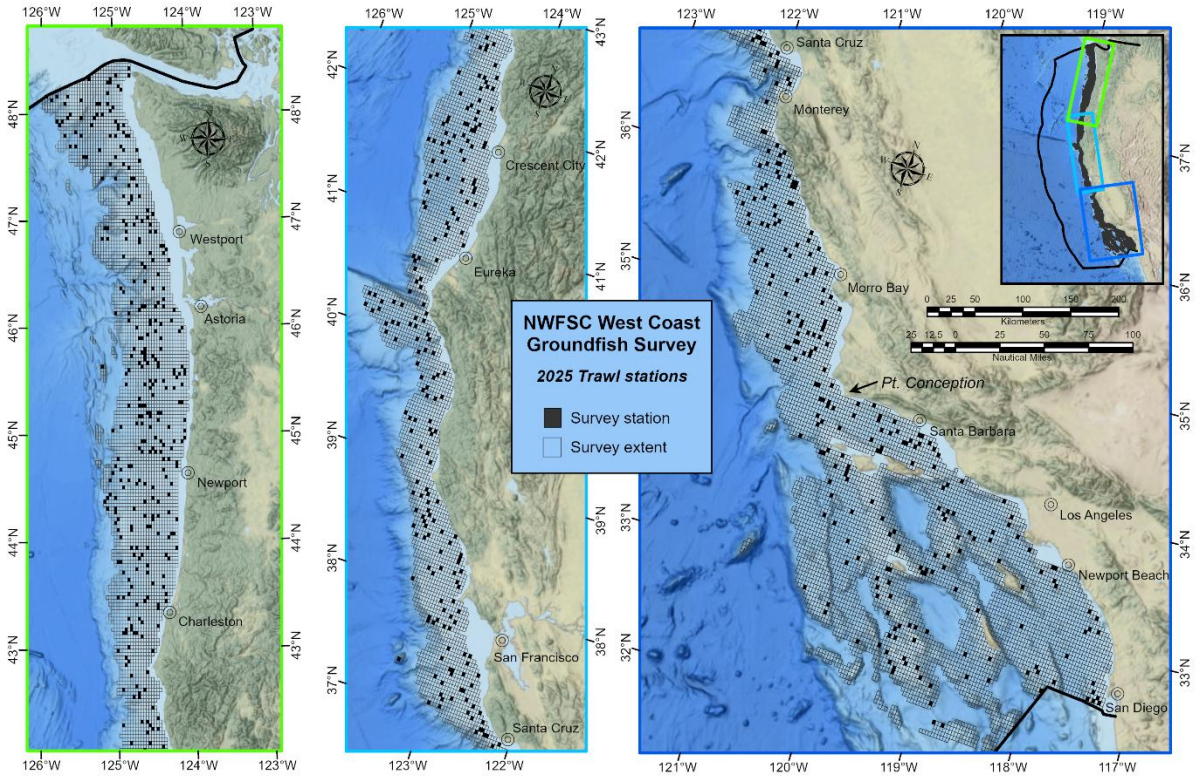

Figure 1. Summary of station locations for the 2025 NWFSC West Coast Groundfish Bottom Trawl Survey.

The NWFSC chartered four commercial fishing vessels to conduct the survey in 2025 using standardized trawl gear. F/V *Last Straw* and F/V *Excalibur* were contracted to survey the area from Cape Flattery, WA to the Mexican border in Southern California (Figure 1) during a first pass beginning May 12 and ending July 22. During the second pass, beginning August 18 and ending October 28, F/V *Noah's Ark* and F/V *Ms. Julie* were contracted for the survey. Pass 1 and Pass 2 were subdivided into 5 legs of 7-11 day duration. An experienced captain, two crew-members, a night watch and three scientists staffed each vessel; 29 scientists, including NOAA personnel, affiliates, collaborators and volunteers participated in the 2025 survey. The survey area was partitioned into ~12,000 adjacent cells of equal area (1.5 nm long. by 2.0 nm lat., Albers Equal Area projection) with each vessel assigned a primary subset of 188 randomly selected cells to sample. An Aberdeen-style net with a small mesh (1 1/2" stretch) liner in the codend was used for sampling. The survey followed a stratified random sampling scheme with 15-minute tows within 2 geographic strata (80% N of Pt. Conception, CA and 20% S) and 3 depth strata. The depth strata were: shallow (30-100 ftm), middle (100-300 ftm), and deep (300-700 ftm). The sample design consisted of 752 sampling locations, with a minimum of 30 tows per strata. In 2025 we completed 700 successful tows of 719 attempts, and identified 550 taxa of fish (n = 251) and invertebrates (n = 299). We collected information on length and sex for 69,943 specimens. We additionally collected otoliths and individual weights for 20,651 fish, 420 ovaries for histology and

fecundity research, 796 fin clip for genetics research, and 420 stomachs for diet and trophic analyses.

In 2025, we continued to utilize an updated back deck data collection system with improved software applications, and wireless networking. Programming used to gather data for the groundfish survey was rewritten so that the various components were fully integrated, updated to include multiple sensor streams, and enhanced to increase flexibility for data input from special projects and future undefined data sources. The changes in the back-deck programming, wheel house programming, and the data QA/QC process resulted in overall improvements to data collection efficiency and anticipated future decreases in time requirements for data to be made available to the Data Warehouse. Established NOAA national bottom trawl protocols were used throughout the survey. As in prior years, a series of special research projects were undertaken in cooperation with other NOAA groups and various Universities.

Southern California shelf rockfish hook-and-line survey
Contributed by John Harms, john.harms@noaa.gov.

In Fall 2025, NWFSC/FRAM conducted the 21st Southern California Shelf Rockfish Hook and Line Survey. This survey is a cooperative effort with Pacific States Marine Fisheries Commission (PSMFC) and the Southern California sportfishing industry and is aimed at developing a time series of abundance and biological data for structure-associated groundfish species including bocaccio (*Sebastes paucispinis*), bank rockfish (*S. rufus*), copper rockfish (*S. caurinus*), greenspotted rockfish (*S. chlorostictus*), cowcod (*S. levis*) blue rockfish (*S. mystinus*), speckled rockfish (*S. ovalis*), the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) and lingcod (*Ophiodon elongatus*) within the Southern California Bight.

The F/V *Aggressor* (Newport Beach, CA), F/V *Mirage* (Port Hueneme, CA), and F/V *Toronado* (Long Beach, CA) were each chartered for 14 days of at-sea research, with 14 biologists participating during the course of the survey. During the 2025 survey, the three vessels sampled all 201 of the survey's fixed sites which range from Point Arguello in the north to the US-Mexico EEZ boundary in the south and in a depth range of 20 – 125 ftm (37 – 229 m) (Figure 1). Sites are located inside and outside the two Cowcod Conservation Areas (CCAs) – two large spatial closures implemented in 2000 to help recover overfished rockfish species including cowcod (*S. levis*). The two CCAs have been partially opened in recent years to allow some sport and commercial fishing, subject to depth restrictions.

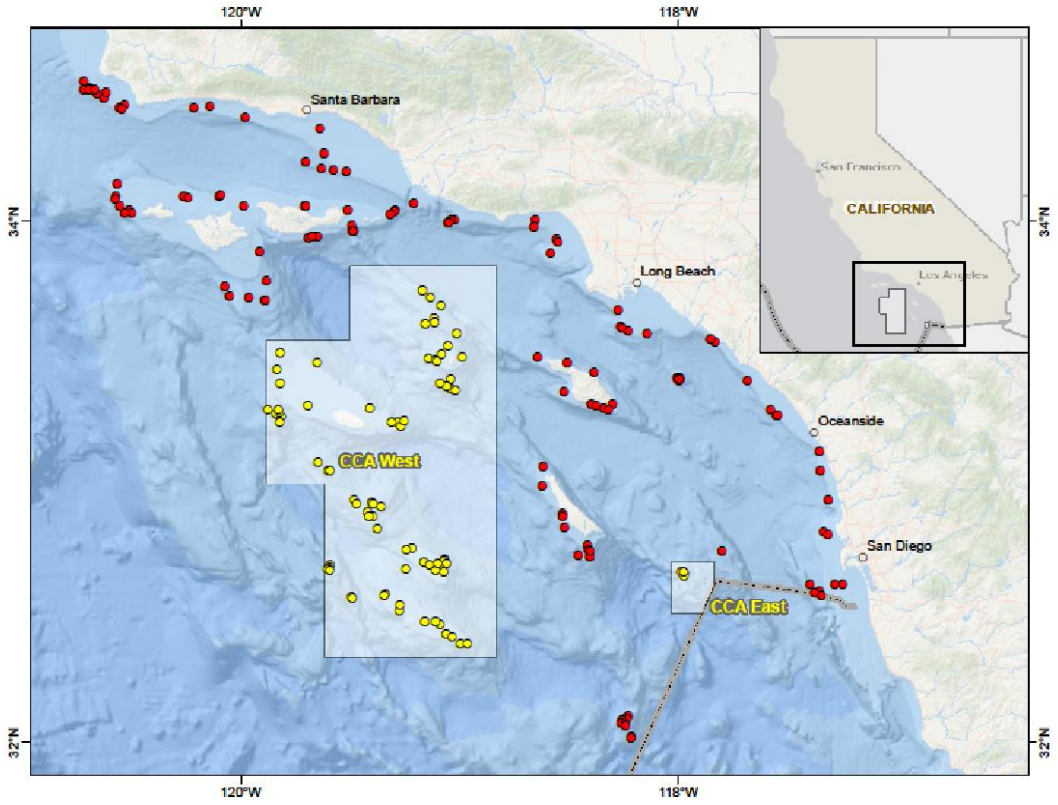

Figure 1. Sampling frame for the NWFSC Shelf Rockfish Hook and Line Survey.

The survey caught 7,763 individual fish and collected biological data and specimens from captured individuals including 7,708 sexed lengths and weights, 5,068 age structures, and 6,464 finclips. Approximately 73 whole or partial ovaries were collected from four different species to support the development of maturity curves and fecundity analysis. Approximately 15 individual fish were retained for use in species identification training for West Coast groundfish observers, a genetic voucher program conducted by the University of Washington, and for in-house meristic and morphometric analyses. Thirty-three specimens representing four species were retained to support a CalCOFI research effort aimed at studying potential impacts of the 2025 Palisades fire on local fish populations.

In 2025, the survey captured individuals from 42 unique taxa including the survey's first-ever capture of a bluebanded ronquil (*Rathbunella hypoplecta*). To date, the survey has encountered at least 73 unique fish and invertebrate species. The survey continued to descend (or release at surface) and tag all individuals captured at six sites located inside federal marine reserves. Since tagging began in 2016, approximately 1,942 individuals have been tagged and released, including 195 in 2025. Six individuals have been recaptured, either by the survey or by recreational anglers.

The survey also collects information to support ecosystem-level analyses by deploying an array of oceanographic sensors to generate full water column profiles of temperature, salinity, dissolved oxygen, turbidity, and fluorescence at each site. 2025 was the 8th year of using the HookLogger wireless electronic data collection system on board survey vessels. Developed by NWFSC personnel, this system networks two mobile tablet workstations on the back deck with a desktop

computer inside the galley with each machine writing to a common database using customized UI and networking software. HookLogger has eliminated the need for post-survey manual data entry and has improved data quality by integrating real-time validations and other error checking. In 2025, the survey continued to use a custom-designed camera system that captures an overhead photograph of each fish sampled for use in QA-QC and for developing a library of species-specific photographs to inform species identification via machine learning.

To date, information generated by the survey have informed 21 separate stock assessments representing 12 groundfish species and have helped monitor the rebuilding of formerly-overfished species such as bocaccio (*S. paucispinis*) and cowcod (*S. levis*). Survey data have been incorporated into at least 10 peer-reviewed publications.

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Prerecruit survey
Contributed by Brian Wells, brian.wells@noaa.gov.

During May and June of 2025, the Prerecruit survey operated a midwater trawl at 30 m headrope to collect and enumerate forage species, inclusive of juvenile groundfishes aboard the NOAA Ship Bell M Shimada. The survey operated from the coast of OR/CA to the WA/CAN border across ~7 transects oriented in to offshore. This work is in collaboration with the southern Rockfish Recruitment and Ecosystem Assessment Survey.

Rockfish dive surveys
Contributed by Nick Tolimieri, nick.tolimieri@noaa.gov, and Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Ole Shelton, Nick Tolimieri, Jameal Samhouri, Kelly Andrews, Greg Williams, Kinsey Frick
Divers from the NWFSC and National Marine Sanctuaries conduct annual dive surveys at five sites along the Washington Coast from Destruction Island to Neah Bay. The dives focus on kelp forest dynamics, especially groundfish abundance and rockfish recruitment. The most frequently observed groundfish species include black rockfish, copper rockfish, china rockfish, yellowtail rockfish, lingcod, greenlings, and cabazon. The survey observed strong recruitment of black rockfish in August 2025. This recruitment was the second highest observed since 2015 (2016 saw the highest recruitment in the time series). These data provide a recruitment index for the WA black rockfish assessment. The survey also recorded an increase in sunflower sea stars, which had been absent from the WA coast following the die-offs from sea star wasting syndrome in 2013-2014.

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Integrated Ecosystem Assessment of the California Current
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Investigators: Mary Hunsicker and numerous contributors from the NWFSC, SWFSC and partner institutions

An integrated ecosystem assessment (IEA) is a science support element for ecosystem-based management (EBM); the IEA process involves synthesizing and analyzing information through steps that include scoping, indicator development, risk analysis, and evaluating management strategies. The primary goal of the California Current IEA is to inform the implementation of EBM by melding diverse ecosystem components into a single, dynamic fabric that allows for coordinated evaluations of the status of the California Current ecosystem. We also aim to involve and inform a wide variety of stakeholders and agencies that rely on science support for EBM, and to integrate information collected by NOAA and other federal agencies, states, non-governmental organizations, and academic institutions. The essence of IEAs is to inform the management of a wide array of ocean-use sectors. As such, a successful California Current IEA must encompass a variety of management objectives, consider a wide-range of natural drivers and human activities, and forecast the delivery of ecosystem goods and services under a range of scenarios.

The California Current IEA team develops an ecosystem status report (ESR) of the California Current each year, which describes the status and trends of many ecosystem indicators, including some related to groundfish. The ESR is presented to the Pacific Fishery Management Council and developed into an annual tech memo. ESRs and tech memos can be found at www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-reports. Also, the California Current IEA team is conducting in-depth quantitative analysis of ecosystem indicators; assessing the risk posed by natural and anthropogenic stressors to key ecosystem resources and human wellbeing; and evaluating potential management strategies to determine which strategies are most effective in moving the ecosystem toward management goals and objectives, and to identify potential management tradeoffs. Many of these efforts also involve analyses related to groundfish, including the development of risk tables as part of groundfish stock assessments.

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Joint U.S.–Canada Pacific Hake Acoustic Trawl Survey/Integrated West Coast Pelagics Survey

Contributed by Julia Clemons, Julia.clemons@noaa.gov.

Scientists from the Northwest Fisheries Science Center, the Southwest Fisheries Science Center, and Fisheries and Oceans Canada conducted a 2025 Joint U.S.–Canada Pacific Hake Acoustic Trawl Survey/Integrated West Coast Pelagics Survey (IWCPS) aboard the NOAA Ship *Bell M. Shimada* and the CCGS *Sir John Franklin*. The *Shimada* surveyed between June 12 and September 9, collecting acoustic data from nine transects in the Southern California Bight (SCB) and 44 transects between Point Conception and the U.S.–Canada border. The *Franklin* surveyed between August 20 and September 9, collecting acoustic data from 38 transects between the U.S.–Canada border and Dixon Entrance. The *Shimada* dropped 13 of the 66 originally planned transects to make up for time lost due to equipment breakdowns, staffing issues, and weather. The *Franklin* did not drop any transects.

The *Shimada* observed adult (age 2+) Pacific hake on 37 transects, ranging from Cambria, California to the Strait of Juan de Fuca; adult hake were present consistently between San Francisco and Newport, with strongest sign observed along the King Range/Cape Mendocino area of Northern California to just south of Newport. Small amounts of adult hake were observed off Washington. While few adult hake were observed in the SCB, age-1 hake were

detected within the sheltered inshore waters and island lees of the SCB. The *Franklin* observed adult hake on only one transect, off southern Vancouver Island.

The 2025 biomass estimate of adult hake off the west coast of the United States and Canada totaled 0.652 million metric tons, including the approximately 0.005 million metric tons of observed biomass located in Canadian waters. The 2025 estimate was the smallest estimate in the time series since 1995, comparable to the previous low estimate from 2011, and represented a decrease of 0.26 mt (approximately 29%) from the 2023 biomass estimate. Age-2 hake dominated the observed biomass and numbers. The raw length-frequency distribution of hake in U.S. waters was characterized by a multimodal distribution, with age-1 hake centered on 25 cm and age-2+ hake displaying modes at 36 and 48 cm.

3. Research

PUBLISHED RESEARCH

Prioritizing qualitative, ecosystem-based risk assessments to maximize impact in single-species fishery management
Contributed by Kiva Oken, kiva.oken@noaa.gov and Abigail Golden, Abigail.golden@noaa.gov.

Citation: Abigail S. Golden, Megan Feddern, Kristin Marshall, Mary E. Hunsicker, Anne H. Beaudreau, Jameal Samhouri, Kiva L. Oken (2025) Prioritizing qualitative, ecosystem-based risk assessments to maximize impact in single-species fishery management. Ocean & Coastal Management, Volume 270, 107917, ISSN 0964-5691, https://doi.org/10.1016/j.ocecoaman.2025.107917.

Accelerating environmental changes are altering the landscape of risks associated with marine resource management. Risk assessment approaches are gaining traction as a way to incorporate qualitative ecosystem information into the marine fishery management process to evaluate and mitigate these risks. For instance, risk tables that distill complex, ecosystem-based information into qualitative advice can add flexibility to existing processes by providing a way to adjust risk tolerance in response to information about uncertainty and ecosystem trends that do not fit into more rigid decision making structures. However, their effectiveness depends strongly on the key factors of data availability, timing of risk table development, and management on-ramps. Where scientific capacity is constraining, targeting risk table development for situations where they can have the most potential risk mitigation benefit will be key. Here, we share lessons learned from developing a pilot risk table approach for groundfish management on the U.S. West Coast and make recommendations for prioritizing risk table development in light of data availability and management needs. We explore West Coast groundfish case studies to present general guidance for effective prioritization of risk tables in capacity-limited contexts. Key suggestions that offer support within and beyond the West Coast are: 1) identifying management on-ramps for risk tables before or alongside risk table development, 2) coordinating risk table development with management cycles where possible to take advantage of scientific capacity, and 3) tailoring risk table objectives based on the quantity and quality of ecosystem information and its level of inclusion in stock assessments.

Free Tools – not so "free"? The evolution, risks and costs of fishery stock assessment tools

Contributed by Jason Cope, Jason.cope@noaa.gov.

Citation: Dowling, N. A., C. M.Dichmont, A. E.Punt, et al. 2026. "Free Tools—Not So "Free"? The Evolution, Risks and Costs of Fishery Stock Assessment Tools." Fish and Fisheries1–21. https://doi.org/10.1111/faf.70076.

In fisheries stock assessment, free software tools have proliferated in recent years. These tools provide standardised, and, in many cases, well-tested and efficient ways to conduct and support stock assessments, making cutting edge expertise globally accessible. However, they come with considerable ongoing costs, beyond their conceptual development and coding. We seek to understand and analyse the process by which fisheries stock assessment tools have evolved, and identify the risks and challenges associated with their development, general use, and ongoing maintenance. We postulate on the development process and risk points for the endurance of fisheries science software tools, using theory related to volunteering. To confront our expectations with empirical evidence, we undertook a survey of stock assessment tool developers. Overwhelmingly, despite moderate institutional support, developers work beyond regular hours, especially when upscaling a tool to wider use, providing updates to the tool, and conducting maintenance activities. Notably, our expectation that tools with limited employer/institutional support do not survive was only partially supported - we found many tools persist despite limited support, primarily through substantial voluntary effort from developers. Future efforts for tool development should focus on i) better integrating tool development and maintenance into institutional frameworks; ii) better appreciating the motivation of and need for free tools; iii) as such, advocating for their development, and, particularly, ongoing maintenance, and iv) for these activities to become internalised and owned in an ongoing manner, as part of core business.

Leveraging transboundary science to support Northeast Pacific fisheries and protected species management

Contributed by Vlada Gertseva, vladlena.gertseva@noaa.gov.

Citation: Bridget E Ferriss, Brendan M Connors, Lisa G Crozier, Sean C Anderson, Jennifer L Boldt, Wei Cheng, Andrew M Edwards, Cameron Freshwater, Vladlena Gertseva, David D Huff, Mary E Hunsicker, Michael G Jacox, Jackie King, Kiva L Oken, M Angelica Peña, Lauren A Rogers, Christopher N Rooper, Tetjana Ross, Akash Sastri, Paul D Spencer, Wesley W Strasburger, Eric J Ward, Leveraging transboundary science to support Northeast Pacific fisheries and protected species management, *ICES Journal of Marine Science*, Volume 83, Issue 3, March 2026, fsag019, https://doi.org/10.1093/icesjms/fsag019.

Climate change is impacting marine ecosystems in increasingly rapid and unpredictable ways. The spatial extent of these impacts on marine fisheries and endangered and threatened species often spans regional and international boundaries. The transboundary nature of changing ocean conditions can challenge detection and anticipation of changes, and delay coordinated actions at the scales required to mitigate and respond. Here, we identify challenges and opportunities for transboundary science in the Northeast Pacific Ocean. Specifically, we aim to support the management of fisheries and protected species in response to a changing climate, while

highlighting successful efforts. Challenges include (1) limited coordination of monitoring surveys; (2) institutional, cultural, and technological barriers to the sharing of data and analytical tools; (3) incomplete understanding of relationships among oceanographic conditions, trophic interactions, population dynamics, and species' distributions; (4) limited availability of high-resolution Earth system model projections that can be linked to ecosystem and fishery responses; and (5) differing prioritization of ecosystem information and limited communication among nations. Three opportunities to overcome these challenges include (1) coordinated monitoring and sharing of data at a transboundary scale to detect and understand marine ecosystem responses to climate change; (2) common assessment frameworks and modeling approaches to improve understanding and projections of ecological responses to climate change; and (3) increased communication of ecosystem information to support management needs across jurisdictions, enhance the use of existing science products, and strengthen pathways for science to inform management of marine resources. We focus on examples of these opportunities drawn from our collective experience as government scientists working on Northeast Pacific Ocean ecosystems. We suggest that by strategically focusing on these opportunities, transboundary science worldwide can improve predictions of ecosystem responses to climate change and better support regional and international management of shared resources.

Mystery of the Disappearing Dogfish: Transboundary Analyses Reveal Steep Population Declines Across the Northeast Pacific With Little Evidence for Regional Redistribution
Contributed by Vlada Gertseva, vladlena.gertseva@noaa.gov.

Citation: Davidson, L.N., English, P.A., King, J., Grant, P.B., Taylor, I.G., Barnett, L.A., Gertseva, V., Tribuzio, C.A. and Anderson, S.C., 2026. Mystery of the disappearing dogfish: transboundary analyses reveal steep population declines across the Northeast Pacific with little evidence for regional redistribution. Fish and Fisheries, 27(1), pp.1-12. https://doi.org/10.1111/faf.70028.

Quantifying broad-scale population trends and distribution change is critical for effective management and conservation of marine species, particularly under climate change. However, fragmented regional survey data often hinder such efforts for transboundary populations. A prime example is Pacific Spiny Dogfish (*Squalus suckleyi*, Squalidae), a small shark with a remarkably slow life history and wide-ranging distribution. Dogfish are now caught incidentally but were heavily fished along the Pacific US–Canada coast ≈80 years ago. Reports on local population trends have conflicted along the coast, suggesting that movement between regions may be responsible. We fit spatiotemporal models integrating data from 10 surveys to synthesise trends in biomass, abundance, distribution and thermal niche for dogfish across their entire eastern Pacific Ocean range. Prior to 2003, Alaskan biomass increased through the 1990s whereas California to British Columbia indices were variable and imprecise. However, during 2003–2023, we found a coastwide 51% (95% CI: 38%–61%) decline in dogfish biomass with mature females and immature dogfish showing the largest proportional declines. Regionally, declines were steepest for the US West Coast (71%–85%) and Canada (58%–82%), while Alaska showed less severe declines (13%–54%). Off the US West Coast, dogfish shifted into deeper waters as temperatures in their habitat increased, but these patterns do not explain the coastwide declines. Our results suggest population declines are primarily driven by

reduced abundance rather than between-region movement, indicating elevated coastwide conservation concern and helping focus investigations of causal mechanisms.

Quantifying time-dependent climate and ecosystem relationships in the California Current System
Contributed by Megan Feddern, megan.feddern@noaa.gov.

Citation: Feddern, M. L., Ward, E. J., Litzow, M. A., Hunsicker, M. E., Jacox, M. G., Schroeder, I. D., et al. (2025). Quantifying time-dependent climate and ecosystem relationships in the California Current System. Geophysical Research Letters, 52, e2024GL113431. https://doi.org/10.1029/2024GL113431.

The northeast Pacific has recently experienced abnormal climate conditions, characterized by frequent and severe marine heatwaves, making it difficult to know how species will respond to the environment. We examined how relationships between marine fauna and environmental conditions have changed over the past decade compared to earlier time periods over the past 50+ years. We found that an important atmospheric system, known as the North Pacific High, has been weaker and located further north during the spring upwelling season from 2013 to 2023, when ocean temperatures have been exceptionally warm. This shift impacts weather patterns and ocean currents, which in turn affect marine life and ecosystems. Our research shows that indicators of basin-scale climate conditions do not track short-term trends in upwelling and marine fauna. This means that the relationships between large-scale climate and regional marine ecosystems are complex, making it difficult to predict how marine life will respond to current and future climate conditions without clearer mechanistic understanding.

Stage-Specific Indicators of Northern Yellowtail Rockfish (Sebastes flavidus) Recruitment in the California Current Ecosystem
Contributed by Megan Feddern, megan.feddern@noaa.gov.

Citation: Feddern, M. L., A. Darby, K. Oken, and N. Tolimieri. 2026. “Stage-Specific Indicators of Northern Yellowtail Rockfish (Sebastes flavidus) Recruitment in the California Current Ecosystem.” Fisheries Oceanography1–20. https://doi.org/10.1111/fog.70041.

Oceanographic and ecological conditions can be used to inform forecasts and decision-making for marine resources, but the dominant drivers of recruitment variability remain poorly understood for many fish stocks. We developed a conceptual life-history model of the oceanographic and ecological variables that influence the recruitment of yellowtail rockfish (Sebastes flavidus), a species with incomplete observations of young age classes in fisheries-dependent data and fisheries independent surveys. We generated 29 hypotheses including seven life stages, from preconditioning of females to benthic recruitment, specific to the northern stock (40°–48° N). Model-estimated recruitment deviations from the 2025 northern yellowtail rockfish assessment were used as the dependent variable in generalized additive models, with predictor variables drawn from regional and global ocean reanalysis and Ecosystem Status Reports for the California Current Ecosystem (CCE). Three variables explained 60% of the recruitment variability not accounted for by the stock–recruitment relationship in the assessment. Recruitment was maximized in years with intermediate timing of the spring upwelling transition, intermediate long-shore transport, and when La Niña conditions occurred

during the pelagic-juvenile stage. Overall we find La Niña/El Niño conditions to be a dominant driver of northern yellowtail recruitment. These results are an important development for the application of oceanographic and ecological indicators in stock assessments in the CCE, but remaining analytical challenges exist for broader operationalization.

Decade-scale spatio-temporal variability in maturity of Pacific hake, *Merluccius productus*, along the US West Coast

Contributed by Melissa Head, melissa.head@noaa.gov and Aaron Berger, aaron.berger@noaa.gov.

Citation: Head, M.A., Billings, A.A., Tuttle, V.J. et al. Decade-scale spatio-temporal variability in maturity of Pacific hake, Merluccius productus, along the US West Coast. Environ Biol Fish 108, 317–338 (2025). https://doi.org/10.1007/s10641-025-01671-1.

Pacific hake, *Merluccius productus*, is the most abundant groundfish in the California Current Large Marine Ecosystem and plays a vital role in predator–prey dynamics. Hake population dynamics are driven by large annual fluctuations in recruitment and intense levels of harvest. The sustainability of harvests relies on stock assessment models reflecting accurate population trends and life-history parameters, such as the size or age at maturity and the rate at which mature adults fail to spawn. We evaluated biological and functional maturity of Pacific hake from 2009 to 2021 using histological samples collected along the West Coast of North America. Maturity parameters were estimated using a standard asymptotic logistic curve and a more flexible cubic spline to evaluate reductions in functional maturity at older ages. We uncovered temporal variability in maturity across years (length and age at 50% functional maturity ranging from 29.89 to 37.89 cm and 1.93 to 3.24 years). There were also significant increases in functional maturity for fish north of Pt. Conception, CA (nearly 9 cm larger and 1 year older). Pacific hake were found to spawn batches throughout the year and along the entire US West Coast, extending previous reports of spawning occurring primarily in southern California from January to February. To support sustainable fisheries management, biological collections should provide data that allow for consideration of non-stationary life history parameters in stock assessments, such as spatio-temporal differences in maturity.

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The pragmatic sceptic: a practical approach for integrating environmental DNA into marine stock assessment and fisheries management

Contributed by Aaron Berger, aaron.berger@noaa.gov.

Citation: Baetscher, D.S., Omori, K.L., Goethel, D.R., Shelton, A.O., Berger, A.M., Ledger, K.J., Nichols, K.M. and Larson, W.A. (2025), The Pragmatic Sceptic: A Practical Approach for Integrating Environmental DNA Into Marine Stock Assessment and Fisheries Management. Fish Fish, 26: 809-824. https://doi.org/10.1111/faf.70001.

The ‘omics revolution’ has advanced scientific understanding of marine ecosystems and led to a rapid increase in data that can inform species' population structure, distribution, and abundance. Of the 'omics data types, environmental DNA (eDNA) may present the most cost-effective

opportunity for developing quantitative estimates of abundance trends, a key input for stock assessment models. However, eDNA has yet to be widely adopted for stock status determinations within regional fisheries management organisations. We review progress towards addressing key challenges that limited the application of eDNA in marine fisheries management, including advances in (1) the quantitative relationship between eDNA observations and species biomass, (2) reducing false-negative and false-positive detections, (3) defining the spatial scale of eDNA, (4) collecting biological data from eDNA surveys, (5) quantifying uncertainty in eDNA surveys, and (6) responding to scepticism of new survey methods. We use a case study with Pacific hake (Merluccius productus) to demonstrate the development of an eDNA index and its direct integration into an age-structured stock assessment model. Given the many ways in which the field of eDNA has matured, we propose that eDNA can meaningfully inform a range of fisheries management needs, and outline a roadmap for using eDNA in stock assessment models in data-limited to data-rich species. A primary impediment to operationalising eDNA as stock assessment model inputs is the lack of interdisciplinary research teams, including geneticists, ecological modellers, and stock assessment scientists, which are necessary to interpret methods and results across scientific disciplines and ensure data are used appropriately.

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Panmictic panacea? Demonstrating good practices for developing spatial stock assessments through application to Alaska sablefish (*Anoplopoma fimbria*)
Contributed by Aaron Berger, aaron.berger@noaa.gov.

Citation: Cheng, M.L.H., Marsh, C.A., Goethel, D.R., Hulson, P.-J.F., Echave, K., Williams, B.C., Berger, A.M. and Cunningham, C.J. (2025), Panmictic Panacea? Demonstrating Good Practices for Developing Spatial Stock Assessments Through Application to Alaska Sablefish (Anoplopoma fimbria). Fish Fish, 26: 825-847. https://doi.org/10.1111/faf.70002.

Marine species and associated fisheries demonstrate complex spatial dynamics driven by biological, ecosystem and socioeconomic factors and integrating these spatial dynamics into stock assessment models can improve fishery management advice. While preliminary good practices for developing spatial stock assessment models have been proposed, comprehensive demonstrations applying these practices remain limited. Drawing on these good practices, we provide an end-to-end demonstration of developing a spatial stock assessment using Alaska sablefish (*Anoplopoma fimbria*). Our demonstration emphasises the utility of high-resolution data analysis and conceptual models for informing key model structure decisions, the joint development of spatial and spatially-aggregated models to enhance understanding of population dynamics, and the need for further guidance on integrating tagging data and diagnostic tools in spatial assessments. Spatial models highlighted regional differences in sablefish biomass, recruitment and age structure, but total population estimates generally aligned with outputs from spatially aggregated models. Moreover, the spatial model identified ontogenetic movement patterns for this highly mobile species. Overall, the spatially aggregated model for Alaska sablefish is likely adequate for management advice, but periodic spatial model updates could offer insights into spatial dynamics and regional depletion levels. Thus, we recommend concomitant use of both models: spatially aggregated models for informing population-wide status, and spatial models for informing spatial fishery dynamics and local

depletion. The sablefish application represents one of the first implementations of a spatial stock assessment using recently proposed good practices, serving as a valuable guide for future practitioners by underscoring critical decision points and analyses to address them when developing spatial stock assessments.

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Course corrections responding to climate impacts produce divergent effects on population biomass and harvest in fisheries
Contributed by Aaron Berger, aaron.berger@noaa.gov.

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Climate change will alter ecological dynamics, affecting the relative abundance of species. A primary challenge is whether and how to modify natural resource management practices to address these changes. We explored a model of a harvested fish population experiencing climate-driven changes in demography, finding that climate impacts impose a choice between management strategies that favor fishery yield or population biomass but not both. When climate caused a population's carrying capacity to increase, or its productivity to decrease, a climate adaptive strategy relying upon this updated information maintained higher population biomass but produced similar or lower yield than fixed management pegged to historical conditions. In contrast, when climate caused a population's carrying capacity to decrease, or its productivity to increase, a climate adaptive strategy produced greater yield but maintained lower population biomass. Both strategies prevented a population from becoming overfished (too small to achieve maximum yield), but the fixed management strategy could impose more excessive annual harvest rates (overfishing). These insights suggest climate adaptive management may not always outperform a fixed strategy. Yet in U.S. fisheries we found routine assessment of population status modifies demographic parameters, implicitly shifting management reference points that affect fishery yield and population biomass. Participatory processes can illuminate these impacts, creating opportunities to co-develop weightings for conservation and harvest objectives.

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Hidden Markov mark-recapture modeling highlights transboundary exchange for northeast pacific sablefish
Contributed by Aaron Berger, aaron.berger@noaa.gov.

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Developing robust fisheries management advice requires understanding fish population distribution and movement in relation to harvesting and management boundaries. Traditional stock assessment models often assume homogeneous populations with negligible transboundary movement, an assumption that may lead to undesirable management outcomes when violated. We developed a hidden Markov movement model and fitted it to almost forty years (1979–2018) of conventional tagging data for northeast Pacific sablefish (*Anoplopoma fimbria*), a commercially valuable species distributed across the northeast Pacific. This is the first time that sablefish movement has been evaluated at this spatial scale and included transboundary migration. Estimated movement rates were then combined with stock assessment abundance estimates to quantify the magnitude of exchange between management regions. Several sensitivity analyses were conducted to evaluate the robustness of the model assumptions regarding size structure, time-at-liberty, size-transition and parameter uncertainty. Sablefish exhibited long-distance movements. Notably, British Columbia acted as a transition zone for sablefish movement between regions and a net recipient for sablefish abundance, receiving net immigration from both Alaska and the California Current, a pattern influenced by regional abundance differences. Differences in movement rates between size classes were modest, although larger sablefish in Alaska were more likely to move into British Columbia compared to smaller fish. Our findings, consistent with previous smaller-scale sablefish movement research, uniquely quantify the demographic exchange across management regions, highlighting a large contribution of sablefish from Alaska and the California Current to British Columbia. This study emphasizes the need to account for the transboundary nature of sablefish within assessment and management frameworks. Collaborative, international efforts in monitoring and data sharing will be essential for ensuring the sustainable harvest of transboundary stocks like sablefish.

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Applying information theory to increase the efficiency of life-history sampling in fisheries data

Contributed by Melissa Head, melissa.head@noaa.gov.

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Effective monitoring of fish populations is critical for understanding life-history traits such as maturation or growth, which directly impact population dynamics and fisheries management. Long-term monitoring efforts around the world are faced with rising survey costs and a more uncertain future, as environmental variability is projected to increase. Together, these pressures necessitate more efficient sampling designs. In this study, we use information theory (Fisher Information) to evaluate and optimize life-history sampling, focusing on how variation in fish growth or maturation can guide more informed sampling decisions. Fisher Information is closely related to variance, in that samples with higher information result in greater precision. Using life-history parameters from eight commercially important groundfish species assessed on the U.S. West Coast, we develop three case studies illustrating how sampling strategies can be improved using Fisher Information. The first example focuses on estimating maturity ogives in the absence of spatial and temporal variability; our second case study incorporates spatial and

temporal variation; and the third adds a second life-history trait (growth) to jointly optimize sampling for maturity. Our results indicate that for informing maturity ogives, Fisher Information is maximized at lengths near the inflection point, and that the range of most informative lengths can shift across space and time due to habitat or environmental variation. When both growth and maturation are considered, optimal sampling windows broaden for some species but remain narrow for others. Our simulation results also show that sampling fish in proportion to Fisher Information, rather than random sampling, can reduce sampling effort by more than 50 % while maintaining or improving the precision of parameter estimates. While the benefits of using Fisher Information are species specific, these findings suggest that adaptive sampling based on Fisher Information can substantially increase the efficiency and effectiveness of monitoring programs, especially under budgetary or logistical constraints.

A comparison of the biology and distribution of vermilion rockfish (*Sebastes miniatus*) and its cryptic pair, sunset rockfish (*S. crocotulus*) along the US West Coast
Contributed by John Harms, john.harms@noaa.gov.

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290. https://doi.org/10.1016/j.fishres.2025.107504.

The presence of cryptic species within exploited fisheries presents challenges for researchers and managers who must balance occasionally divergent commercial and conservation goals. These challenges may be exacerbated when the component taxa have different life histories and historical catches. We used advanced genomics techniques to separate an economically and ecologically important cryptic species pair, vermilion rockfish and sunset rockfish (Genus: Sebastes), into its constituent species. Over 30,000 tissue specimens were analyzed to clarify species-specific life history traits and improve the information available for research and management. Vermilion rockfish were observed from Canada to Mexico, generally in waters shallower than 130 m, while sunset rockfish were encountered from Point Arena, California to Mexico and were common in both shallow waters and offshore banks to at least 300 m. Sunset rockfish grew faster and reached larger maximum sizes, but vermilion rockfish exhibited older maximum ages. As a result of spatial and depth-based management which disproportionately protected deeper waters, vermilion rockfish have likely been subjected to greater commercial and recreational fishing pressure than sunset rockfish throughout most of the 21st century. Improved understanding of the unique life and catch histories of the two species may have implications for how this and other cryptic species pairs are assessed and managed in the future.

Continuing long-term shifts in larval fish phenology in the southern California Current ecosystem are matched by rapid advances in the north
Contributed by Brian Wells, brian.wells@noaa.gov.

Citation: Chen, K., Petrik, C.M., Asch, R.G., Thompson, A.R., and Auth, T.D. (2025) Continuing long-term shifts in larval fish phenology in the southern California Current ecosystem are matched by rapid advances in the north. Glob. Chang. Biol. 31:e70141. https://doi.org/10.1111/gcb.70141.

Changing environmental conditions are leading to shifts in the timing of seasonal events globally. In the ocean, environmental cues affecting larval fish (ichthyoplankton) abundance may not be synchronized with factors optimizing larval and juvenile survival, making the study of ichthyoplankton phenology in the context of a changing environment critical. In the southern California Current Ecosystem (CCE), a major eastern boundary current upwelling system, significant long-term shifts in larval fish phenology have been previously observed. To assess the stability of these estimates and extend them to the northern CCE, we evaluated multidecadal trends in ichthyoplankton abundance for 57 species from the California Cooperative Oceanic Fisheries Investigations (CalCOFI) and 25 species from the Newport Hydrographic Line (NH Line). We show that on average, larval fish phenology in the southern CCE has continued to advance with an estimated rate of -0.18 ± 0.05 day year-1 from 1951 to 2022, while phenology in the northern CCE has advanced at a rate of -0.48 ± 0.26 day year-1 from 1996 to 2023. Thirty-nine percent of species showed significant advancing phenology, 12% exhibited delayed phenology, and 49% showed no long-term linear change. A comparison analysis showed that species in these groups had similar rates of change between the two locations for the 1997–2017 period. Phenological shifts in the southern CCE tracked changes in the phenology of upper ocean temperature, zooplankton, and upwelling. These variables poorly explained shifts in the northern CCE, where short-term effects of the El Niño–Southern Oscillation and the 2014–2016 marine heatwave on ichthyoplankton phenology were observed for some species. This research highlights regional variability and continuing phenological shifts in one of the world's most productive marine ecosystems.

A tale of two heatwaves: variable daily growth and a broad diet enable neustonic larval cabezon to thrive during warm oceanic conditions
Contributed by Brian Wells, brian.wells@noaa.gov.

Citation: Wilson, M.N., Brodeur, R.D., Auth, T.D., Roegner, G.C., Morgan, C.A., Zeman, S.M., and Sponaugle, S. (2025) A tale of two heatwaves: variable daily growth and a broad diet enable neustonic larval cabezon to thrive during warm oceanic conditions. Front. Mar. Sci. 12:1569581. https://doi.org/10.3389/fmars.2025.1569581.

Effects of climate change on ocean ecosystem dynamics are widespread. Oceanographic conditions vital to biological communities have already shown changes, resulting in negative impacts on several of the world’s largest fisheries. The Northern California Current (NCC) is a highly productive system that supports many important fisheries. In addition to large-scale oceanographic forcing and seasonal up- and downwelling cycles, in the last decade, the NCC also experienced two distinct marine heatwaves (MHWs) that resulted in pervasive ecosystem alterations. The 2014–16 and 2019 MHWs had contrasting oceanic and atmospheric origins and different effects on ocean temperature, providing the opportunity to identify the mechanisms important to juvenile fish recruitment processes and how they may be differentially impacted by future warming scenarios. We utilized a five-year time series (2014, 2015, 2016, 2018, and 2019) of larval fish concentration, growth, and diet as a natural experiment to investigate the

impact of MHWs as well as two neutral years on cabezon (*Scorpaenicthys marmoratus*). Findings include the first published measurement of larval cabezon daily growth rates. Mean growth rates were higher during MHWs, suggesting that elevated temperatures did not pose a major growth or survival challenge. Cabezon's fast growth response to MHW conditions demonstrates that larval cabezon were able to sustain fast growth in warmer temperatures, and were not likely prey limited. Further, larval cabezon gut fullness did not differ significantly among years. Instead, differences in diet composition and prey quality varied with larval growth. Relative to slower-growing larvae, larval cabezon with high growth rates consumed larger prey items, including larval euphausiids and amphipods. Consistent with these patterns of larval growth, nearshore recruitment of juvenile cabezon was also high during MHW years. Our findings highlight the importance of phenological coupling, or matches in timing, between cabezon and euphausiid population dynamics in that larval cabezon exhibited fast growth when the timing of flexion was coupled with the euphausiid population transition to a larger, omnivorous larval stage. Results of this study suggest that larval cabezon's variable growth and broad diet coupled with selection for large, nutrient dense prey may be a source of resilience for its population dynamics.

Mapping the value of commercial fishing and potential costs of offshore wind energy on the U.S: West Coast: Towards an assessment of resource use tradeoffs
Contributed by Jameal Samhouri, jameal.samhouri@noaa.gov.

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The West Coast of the U.S. has a vast offshore wind energy (OWE) electricity generation potential with value on the order of billions of USD, and pressure is mounting to develop large OWE projects. However, this seascape has numerous existing resource extraction uses, including a multi-billion dollar commercial fishing industry, which create the potential for conflict. To date, spatially explicit comparisons of OWE and commercial fisheries value have not been done, but are essential for marine spatial planning and for investigating the tradeoffs of OWE development on existing marine uses. In this analysis, we generate maps of OWE levelized cost of energy and of total economic activity generated by the top eight commercial fishing targets that account for the vast majority (~84%) of landed revenue off the U.S. West Coast. We quantify spatial overlap between these two ocean uses and use multiobjective optimization to develop tradeoff frontiers to investigate implications for both sectors from established state goals or mandates for OWE power generation capacity. There are clear differences in the exposure of each fishery in their traditional fishing grounds as a function of differing OWE capacity goals and outcomes vary depending on whether OWE development goals are achieved at a state-by-state level or a region-wide level. Responsible siting of OWE projects includes careful consideration of existing commercial fishing activities, and responsible transition to renewable energies on the West Coast and elsewhere accounts for the socio-economic consequences of the total economic activity associated with each fishery.

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Skill Testing Oxygen Data for Distribution Modeling of Marine Species
Contributed by Eric Ward, eric.ward@noaa.gov.

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Spatial models that identify statistical relationships between environmental conditions and species distributional data are commonly used in fisheries research to evaluate habitat suitability and predict distributional shifts, such as those driven by changing ocean temperature and oxygen levels. However, a lack of environmental data—particularly dissolved oxygen—at the same temporal and spatial resolution as biological data can limit these analyses. We evaluate the ability to predict bottom dissolved oxygen via imputation and extrapolation and with biophysical oceanographic models in the northeastern Pacific Ocean (Aleutian Islands, Eastern Bering Sea, Gulf of Alaska, British Columbia, and California Current). Specifically, we measure predictive skill compared to in situ observations (measured concurrently with bottom trawl data) for (1) predictions from an empirical statistical model fit to integrated dissolved oxygen observations and (2) a commonly used dynamical oceanographic model estimate of oxygen, the Global Oceanographic Biogeochemistry Hindcast (GOBH). Lastly, we evaluate how estimation and interpretation of a species distribution model are impacted by the use of different oxygen data sources. For year-out cross-validation, we find that the empirical statistical model predicts bottom dissolved oxygen for fish catch sampling events with relatively high accuracy in only certain regions (California Current and British Columbia) (root mean squared error [RMSE] ~ 16–30 μmol kg−1). Prediction skill was more than two times lower in Alaska regions that did not have extensive data (around < 0.075 observations per square kilometer), and this approach would likely not provide sufficiently accurate oxygen values for SDMs in these regions. The Copernicus Global Oceanographic Biogeochemistry Hindcast had a substantially lower prediction skill than the integrated statistical predictions (RMSE ~30–90 μmol kg−1). When applied to species distribution models, the estimated dissolved oxygen thresholds differed by 20–50 μmol kg−1 when fit to different dissolved oxygen data sources. We focus on oxygen in the northeastern Pacific, yet our approach is generalizable to other variables and systems. We recommend increased attention to validating oceanographic models when operationalized to fisheries applications and evaluating the robustness of conclusions to environmental covariate data sources.

Spatiotemporal models reveal dynamic growth patterns in U.S. West Coast groundfish
Contributed by Eric Ward, eric.ward@noaa.gov.

Citation: Andrea N Odell, Kristin N Marshall, Eric J Ward, Kelli F Johnson, Marissa L Baskett, Spatiotemporal models reveal dynamic growth patterns in U.S. West Coast groundfish, *Transactions of the American Fisheries Society*, Volume 155, Issue 1, January 2026, Pages 76–89, https://doi.org/10.1093/tafafs/vnaf050.

Variability in somatic growth of marine fish can affect their reproductive potential and survival and, therefore, the productivity of a population. Understanding how growth might vary among species can improve predictions of population status and responses to environmental change.

Our objective was to characterize the variability in growth and body condition of groundfish species along the U.S. West Coast to support their monitoring and assessment. We used geostatistical models to estimate growth rate and body condition, two interrelated traits associated with somatic growth, across space and time for nine commercially important U.S. West Coast groundfish species. We fit generalized linear mixed models with Gaussian Markov random fields to biological data collected from annual bottom trawl surveys to estimate variability at a 4- × 4-km spatial resolution. Our models uncover spatiotemporal variability in growth rate and body condition in all nine groundfish species with limited trends shared among species with similar traits, suggesting a greater influence from niche partitioning acting on local scales. Such interspecific differences in growth rate and body condition also occurred at regional scales, with some species exhibiting positive responses while others declined. These findings reveal the dynamic nature of somatic growth among groundfish species and provide insight into potential mechanisms of its variability that could be considered within climate-enhanced assessments of population status for marine fish.

Elevated fish growth yet postponed maturation during intense marine heatwaves
Contributed by Claire Rosemond, claire.rosemond@noaa.gov.

Citation: Rosemond, R. Claire, Melissa A.Head, and Scott A.Heppell. 2025. “Elevated Fish Growth yet Postponed Maturation during Intense Marine Heatwaves.” Ecological Applications35(4): e70033. https://doi.org/10.1002/eap.70033

In the last decade, the northeast Pacific Ocean has experienced new climatic extremes with the occurrence of several marine heatwaves (MHWs), prolonged periods of warmer-than-normal ocean temperatures, likely as a result of anthropogenic climate change. The temperature-size rule is used to contextualize the impacts of climate change on fish maturity and growth, and predicts earlier maturation, faster growth of juveniles, and smaller adult body sizes with increasing temperatures. We investigated the temporal dynamics of fish reproductive development, maturity, and growth from 2014 to 2021, during intense and less intense MHW conditions. We estimated length and age at 50% maturity with histological sections of ovarian tissue samples collected from 644 female Black Rockfish (*Sebastes melanops*) caught off the Pacific Coast of the United States (42° N–49° N) and estimated von Bertalanffy growth function parameters with length-at-age data for a subset of 302 females. During intense MHWs, maturation was postponed, reproductive success was lower by a third, and parasite prevalence in ovaries was nominally higher. Younger females were larger at age during intense MHWs, and throughout the last decade, growth rate coefficients were higher than what is typically expected for slower-growing fishes, like rockfishes. The increase in juvenile growth during intense MHW conditions may be explained by the temperature-size rule, but our observation of postponed maturation contradicts theoretical predictions. Our work reveals that MHWs can induce shifts in fish growth and maturation, but that the temperature-size rule may not provide an adequate framework to predict how increasing temperatures associated with climate change may influence reproductive development and maturity for fishes with complex reproductive strategies. An understanding of how anomalous environmental conditions interact with fish life histories may help predict population vulnerability, which will be critical for future fisheries management under climate change.

eDNA reveals spatial differences in species composition of protected rockfishes

Contributed by John Harms, john.harms@noaa.gov.

Citation: Matthews, S.A., Scott, O.M., Everett, M.V., Shaffer, M.R., Andruszkiewicz Allan, E. Shelton, A.O., Williams, G.D., Wells, A., Nichols, K.M., Kelly, R.P. 2025. eDNA reveals spatial differences in species composition of protected rockfishes. PLos One. https://doi.org/10.1371/journal.pone.0337724

Rare species are difficult and time-consuming to detect, but environmental DNA (eDNA) methods can be used to increase data availability for monitoring and management. Here, we use the diverse rockfish species flock (genus *Sebastes*) to demonstrate the utility of eDNA as a tool for detecting rare and difficult to observe species in the marine environment. We describe the identification of a phylogenetically informative gene region for eDNA metabarcoding which uniquely identifies 93 of the 109 *Sebastes* species currently described. We then use this assay to differentiate rockfish communities in field samples collected from two sub-basins within Puget Sound in Washington, USA. Across three field sampling platforms, we found that sample collection location (distance from seafloor) has substantial impacts on rates of detection and on the diversity of species detected, likely reflecting the habitat preferences of the target species. This metabarcoding region provides an important tool for rockfish monitoring, both within Puget Sound and across the North Pacific. More generally, this work speaks to the usefulness of eDNA data as a tool for the conservation and management of rare and difficult-to-distinguish species.

IN REVIEW OR ONGOING RESEARCH

Escaping the net: Assessing midwater gear selectivity for the Joint United States and Canada Integrated Ecosystem and Pacific hake (*Merluccius productus*) Acoustic Trawl survey

Contributed by Sabrina Beyer, sabrina.beyer@noaa.gov.

Investigators: Sabrina G. Beyer, Julia E. Clemons, Alicia A. Billings, Stephen K. de Blois, Elizabeth M. Phillips, John E. Pohl, Rebecca E. Thomas, Amanda Vitale, and Stéphane Gauthier

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Acoustic trawl surveys use trawl catches to validate the species and size composition of fish aggregations detected acoustically. However, certain sizes of fish may be more likely to escape some trawls, which can bias the size and age distribution of the catch used to estimate biomass. To quantify size-selectivity, we studied 3 midwater trawls used for the United States and Canada joint survey of Pacific hake (*Merluccius productus*). The survey most recently used an Aleutian Wing Trawl (AWT) with different codend liners until 2023, then switched to a Multi-Function Trawl (MFT) in 2025. We assessed differences in catch rates and fish escapement in paired trawls of both net-types sampling the same aggregations and with recapture nets. Both net-types retained greater than 85% of hake longer than 30-cm (age 2+). In general, the MFT was more efficient than the AWT with near full retention of all fish sizes while a substantial fraction of small hake (age 0 to 1) escaped the AWT. A power analysis indicated a low

probability of detecting differences in escapement from the AWT with different codend liners. Gear selectivity information is important to improve the accuracy of fishery survey data and account for changes in sampling gear.

Evaluating fishery-independent surveys with stock vulnerability to support holistic management

Contributed by Jason Cope, jason.cope@noaa.gov.

Investigators: Derek G. Bolser, Lewis Barnett, Jason Cope

The consequences of mis-managing vulnerable stocks (i.e., those with low productivity and high susceptibility to collapse) are high and potentially permanent. To avoid negative outcomes, precautionary buffers can be coupled with reference points and more and better data can be provisioned to enhance stock assessments. Social and economic value typically determine sampling priorities, but high-profile stocks are not necessarily at the highest risk for collapse. So, we modified the Productivity-Susceptibility Analysis, a data-limited fishery assessment tool, to identify which stocks are most vulnerable to unpredicted stock collapse (due to overfishing, environmental stressors, or mis-management from lack of knowledge). We examined the vulnerability of 426 fish stocks or species within stock complexes that NOAA Fisheries assessed from 2005-2024 (excluding highly migratory and salmon stocks). We then examined patterns of vulnerability by taxonomy, area, and survey method. The most vulnerable stocks were demersal teleosts (e.g., Psychrolutids, Macrourids, Scorpaenids). On average, the Caribbean Sea, West Coast, and Pacific Islands contained the most vulnerable stocks that were not sampled by surveys. Visual surveys in Alaska sampled the most vulnerable stocks, followed by bottom trawl surveys in Alaska. Across all areas, bottom trawl surveys provided stock assessment information for nearly twice as many stocks as any other survey method on average. Many vulnerable stocks are not economically or socially valuable. Vulnerability, therefore, could be used as a supplement or alternative to economic and social importance to make more holistic decisions about sampling priorities in support of biodiversity conservation, ecosystem function, and fisheries objectives.

Evaluating the quality of von Bertalanffy growth estimates from data and databases

Contributed by Jason Cope, jason.cope@noaa.gov.

The 3-parameter von Bertalanffy growth equation is the most commonly used functional form to model the relationship between age and growth in fishes. The resultant growth parameters provide foundational information for a variety of analytical approaches used to assess population health. In particular, the asymptotic size (Linf, or the average maximum size of the population) parameter sets the baseline by which length data are assessed to interpret stock status from length composition data. Any mis-estimation of it can bias length-based stock assessments, as well as provide poor estimates of the growth coefficient parameter (k). In situations where data are readily available, collecting large individuals to help estimate Linf is achievable. But in more data-restricted situations, sample sizes may be low and or potentially biased when sampling a population that is already length truncated. It is not uncommon in large life history databases to see the Linf higher than the maximum reported size. I explore the issue of reliability in the Linf estimation when the maximum observed length is lower than the estimated Linf. Is this a reasonable result? Do we always expect species to obtain Linf, or is it

sometimes just a theoretical value? We will play with simulated data to see how well we can estimate Linf under a variety of Lmax<Linf conditions, and diagnose whether these experiments are getting at the above issues. If indeed certain Lmax<Linf situations are not reasonable, a warning for both data sets and database entries can be designed to avoid misapplying to certain stock assessment methods or using poorly estimated life history values.

Managing healthy fish stocks can be difficult: Stock status approaching unfished levels can lead to uncertain catch limits
Contributed by Jason Cope, jason.cope@noaa.gov.

Investigators: Jason M. Cope, Vladlena Gertseva, R. Claire Rosemond, Alison D. Whitman, Fabio P. Caltabellotta

This work explores how uncertainty in stock scale can change when the uncertainty in stock status includes an unfished condition. Uncertainty profiles for several groundfishes are explored to look for patterns in stock scale based on stock status. This work looks to help explain why it is difficult to set catch limits when the stock status is high.

These aren't the fish you're looking for: Differences in maximum age across latitude for west coast groundfish with emphasis on quillback rockfish
Contributed by Brian Langseth, brian.langseth@noaa.gov.

Investigators: B.J. Langseth, E. Ward, M.H. Monk

Empirical relationships are often used to derive a value for the natural mortality rate M in the absence of estimating M within a stock assessment. For U.S. west coast assessments, these relationships have historically been based on maximum age. This, however, presents a problem when estimates for maximum age are highly variable among limited age samples, or differ from samples collected in nearby areas or different time periods. Estimates of maximum age for quillback rockfish (*Sebastes maliger*) along the U.S. west coast differ by up to 38 years (range from 57 to 95 years) between their southern range in California and their northern extent in Alaska, leading to large uncertainty in the corresponding estimate of natural mortality, as well as population dynamics, for state-specific stock assessments. Using a new tool for analyzing data sampled across state, federal, and international agencies, we assess whether this range in maximum age is unique to quillback rockfish, suggesting this range may be due to differences in sampling or fishing intensity across the coast, or shared by other species, suggesting this range may be biological/environmentally driven. We explore circumstances that may lead to such situations and conclude by describing ways for selecting maximum age values that balance uncertainty in derived estimates of M.

Treatment of closed areas within fishery stock assessment methods: a mini review
Contributed by Brian Langseth, brian.langseth@noaa.gov.

Restrictions on where and when to fish are common fishery management measures that can reduce the effect of fishing pressure on fished populations. Spatial closures in the harvest of a fished species can complicate the stock assessment of that species. As the amount of area closures change over time, managers will need to better understand how to incorporate these

changes within stock assessments, yet the literature on the topic is disaggregated. This literature review provides managers information on ways closed areas have been incorporated within stock assessment methods. The findings indicate that closed areas have been incorporated across a continuum of stock assessment methods. When approaches have been compared, explicitly modeling the areas open and closed to fishing has generally performed best. Comparisons have only been done with model-based approaches, and less model intensive methods have not been compared to one another. Similarly, while the availability of fishery-independent surveys has been explored, the influence of limitation in all data, including fishery-dependent data, remains lacking. A review of stock assessment reports would build upon this manuscript's first step attempt to understand how closed areas are included in stock assessment methods, and is recommended for future work.

Quantifying potential impacts of reduced survey coverage on biomass and density estimates for stock assessment: a case study of U.S. West Coast wind energy areas
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Investigators: Kaitlyn A. O'Brien, Brian J. Langseth, Aaron M Berger, Kelly S. Andrews

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Growing competition among ocean use sectors (e.g., energy development, conservation, commercial fisheries) can lead to spatial conflicts that can restrict the domain of fishery-independent surveys. The loss of survey coverage presents challenges for marine resource management, particularly in estimating indices of abundance and biomass—key components of many stock assessments. This study used fishery-independent trawl data to evaluate the potential impacts of spatial closures of varying sizes, locations, shapes, and time-since-last sampling on biomass and density estimates, using U.S. West Coast offshore wind energy planning and designated areas as a case study. Spatiotemporal models were applied to simulate scenarios where survey access was restricted. Results indicate that these models can effectively interpolate abundance within closed areas when prior survey data exist. However, predictive performance declined exponentially in regions lacking historical observations, with accuracy influenced by species' life history characteristics. Model specification also played a key role as incorporating a mechanistic covariate (depth) reduced bias and uncertainty under the largest and most persistent closures. Density estimates were most sensitive to the location and shape of closures, rather than their size; designs incorporating survey corridors or irregular boundaries helped reduce estimation error. These findings underscore the need to anticipate and mitigate the effects of spatial closures to understand their influence on stock assessments as ocean use conflicts continue to grow.

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Comparing two model-based age prediction methods, DNA methylation and FT-NIR spectroscopy, for a temperate marine fish
Contributed by Laurel Lam, laurel.lam@noaa.gov.

Investigators: Lam, L., Helser, T.E., Berry, O., Jarman, S., Benson, I., Hsieh, B., Longo, G.C., McNeel, K.W., Basnett, B., Hamilton, S.L., Samhouri, J.F., Nichols, K.M.

Best practices for estimating fish ages for stock assessments relies on validated methods that have high accuracy and precision, and are scalable to large sample sizes. Traditional age estimation methods consisting of annual band counts may be inefficient in the face of growing stock assessment demands. Lingcod (*Ophiodon elongatus*), a commercially valuable finfish along the Pacific coast of North America, are traditionally aged using thin sections of fin rays, a process that is both labor intensive and costly in terms of materials, space, and personnel. However, emerging technologies that are potentially cheaper, faster, and comparable in accuracy and precision are showing promise. Here, we assessed the performance of two alternative, model-based methods for predicting lingcod age: DNA methylation and Fourier transform near infrared spectroscopy (FT-NIRS). Average coefficient of variation (ACV), percent agreement, and bias were calculated among the two alternative methods and compared to two traditional methods (fin ray and otolith band counts). Results demonstrated that ages estimated by DNA methylation and FT-NIRS have slightly higher ACV but are in close agreement (greater than 95% agreement within 2 years) with traditionally-estimated ages. Between the two alternative methods, the FT-NIRS model performed slightly better than the DNA methylation model, though there are advantages and disadvantages to each method that should be considered, including whether the animal will be sampled non-lethally or lethally. Considering the potential for scalability, increased efficiency, and reduced cost, these alternative methods have significant potential for use in estimating ages for large-scale stock assessments.

An exploration of space, time, and environmental relationships in groundfish reproduction
Contributed by Melissa Head, melissa.head@noaa.gov.

Investigators: Melissa A. Head, Eric J. Ward, Kristin Marshall, Kelli Johnson

Understanding how life history processes vary over space and time is essential for informing stock assessments, yet has been generally overlooked. Recent work in the California Current has demonstrated that a number of species exhibit variation in growth rates and maximum size, but less work has been done to understand variation in maturation. Using long term datasets collected by NOAA's Northwest Fisheries Science Center, we developed a series of models incorporating space and time to better understand reproductive variability in the region. Our analyses focused on seven commercially important groundfish species: Pacific Hake, lingcod, dover sole, petrale sole, sablefish, canary rockfish, yellowtail rockfish, and shortspine thornyhead, and for each species, we fit models that varied in their treatment of year effects and spatial structure. Results demonstrate strong support for spatial models across most species, with two distinct patterns emerging: species maturing faster in northern regions (sablefish, Dover sole, shortspine thornyhead), versus those maturing faster in southern regions (petrale sole, lingcod, Pacific Hake). Sablefish and dover sole showed the greatest differences between spatial and non-spatial models. Several environmental covariates were considered as predictors of this spatial change, and future work may expand to consider additional mechanisms of change.

Modeling temporal and spatial trends in Pacific Hake maturity at age
Contributed by Melissa Head, melissa.head@noaa.gov.

Investigators: Kelli F. Johnson, Eric J. Ward, Melissa A. Head, Kristin N. Marshall

Effective management and conservation of marine species requires capturing variability in space and time that drives population dynamics. Biological processes affected by changing environments are particularly important when marine species experience extreme events such as marine heat waves. Some models that estimate the status of marine fish populations account for changing conditions using time-varying parameters (such as selectivity and mortality) and, to a lesser extent, spatial structure but few include mechanistic, environmental drivers. We illustrate a novel approach for developing temperature-driven spatiotemporal variation in fish maturation rates and contrast them with status quo maturation rates in the assessment of Pacific Hake (Merluccius productus). Temporal variation was greater than spatial variation, and spatiotemporal variation in maturation is driven by increased temperatures leading to younger age at maturity. Notable exceptions were 2016 and 2019, years with higher than average ocean temperatures but older age at maturity, which led to a concave response to temperature. Management quantities calculated from the assessment of Pacific Hake revealed sensitivities to the day of year used to predict maturation rates.

Improving Reproductive Ecology Information for Pacific Hake (*Merluccius productus*)
Contributed by Melissa Head, melissa.head@noaa.gov.

Investigators: Sabrina Beyer and Melissa A. Head

The fishery for Pacific hake (*Merluccius productus*) is economically important and is one of the largest fisheries, by volume, along the U.S. West Coast (Grandin et al., 2024; Steiner, Post, and Chen, 2025). The life history traits of Pacific hake, such as growth and maturation, are highly dynamic in response to their environment. For example, variability in maturation rates at age are correlated with changing ocean temperature (Head et al., 2025). Because of this plasticity, it is important to better understand the reproductive characteristics of the stock to improve information for stock assessments. Specifically, the current assessment model does not explicitly model egg production (batch fecundity and spawning frequency), which in other hake species, has been shown to be size-dependent and important to population dynamics (Macchi et al., 2023).

An Age-structured Bioeconomic Model for Evaluating Harvest Strategies to Maximize Revenue from Large Sablefish Recruitment Pulses
Contributed by Dan Holland, dan.holland@noaa.gov.

Investigators: Daniel S. Holland (Northwest Fisheries Science Center) and Emily Sellinger (NOAA Affiliate, ECS Tech)

We are developing a dynamic bioeconomic model to evaluate harvest strategies for sablefish parameterized directly from the 2025 stock assessment and using size specific prices based on a hedonic price model. The objective is to evaluate whether more conservative harvest strategies will generate higher revenues by changing the distribution of catch to larger more valuable fish.

Reproductive biology and early life history inform steepness and the productivity of rockfishes (*Sebastes spp.*, Scorpaenidae) in the California Current

Contributed by Sabrina Beyer, sabrina.beyer@noaa.gov.

Investigators: Sabrina G. Beyer (NWFSC), John C. Field (SWFSC), and Marc Mangel (UCSC emeritus)

Steepness, a parameter derived from the spawner-recruit relationship, is widely used in fishery stock assessments to scale the productivity of a population. Steepness is a highly influential parameter, but it is often unknown *a priori* and is typically difficult to estimate. Attempts to statistically estimate steepness, either within stock assessments or through meta-analyses, often lead to implausible results. We move beyond steepness as a statistical concept to emphasize that steepness is determined by life history traits and the early life survival of offspring of a population. We return to the original derivation of spawner-recruit relationships, and model recruitment to the population as a function of total egg production, rather than using spawning biomass as a proxy. We then demonstrate how to calculate steepness based on biology through a case study of rockfishes (*Sebastes* spp., Scorpaenidae) in the California Current, where steepness has been notoriously difficult to estimate. We leverage a wealth of reproductive ecology and early life history information (empirical data and associated life history parameters) to compute steepness values for four species of rockfishes, in order to illustrate how steepness varies by species based on differences in their life histories. We also show the sensitivity of steepness to the different life history traits. We conclude that the steepness of a spawner recruit-relationship is a real biological parameter and can be meaningfully informed with life history parameters and early life survival.

Decreased coastal productivity and associated transport dynamics expand the distribution of juvenile Pacific hake

Contributed by Brian Wells, brian.wells@noaa.gov.

Investigators: Wells, BK, DD Huff, JA Santora, TD Auth, JC Field, ME Hunsicker, TL Rogers, JJ Bizzarro, AM Berger, KM Sukuma, ID Schroeder, and RR Miller

The California Current Large Marine Ecosystem (CCLME) is an eastern boundary upwelling system characterized by dynamic and sometimes synchronous productivity across biogeographic domains. We investigated the relative influence of environmental preconditioning, transport processes, habitat compression, retention, and Pacific hake (Merluccius productus) spawning stock biomass (SSB) on the regional distribution and potential ecological role of Age-0 Pacific hake, the most abundant finfish in the system. Using a 24-year (2001-2024) dataset of Age-0 Pacific hake collections and a generalized additive modeling framework, we characterized the relationships between Age-0 biomass and abundance across the southern, central, and northern CCLME and biophysical drivers. In the southern and northern CCLME, Age-0 biomass (grams per unit effort) and abundance (number per unit effort) were significantly related to SSB, compressed cool-water habitat (impinged by offshore waters), and onshore current strength following the late-winter spawning events. Generally, northward of the primary spawning areas, Age-0 Pacific hake biomass and abundance were increasingly driven by density-independent processes. Northern models were complex but generally argued that, beyond SSB, onshore and northward transport in the mixed layer were positively related to the presence of juveniles. Central CCLME Age-0 biomass and abundance were positively associated with increased California Undercurrent and onshore current strength. Weak late-

winter preconditioning, a greater extent of cooler upwelled surface waters, and lower observed juvenile abundances were associated with greater abundances of Age-1 fish later. Generally, literature supports that a high abundance of Age-0 Pacific hake in the north is associated with a low abundance of alternative forage taxa. These findings support an argument that Age-0 Pacific hake may act as an environmentally-dependent supplemental forage source, potentially offering a compensatory buffer against weak upwelling and reduced biomass of local forage communities in the central and northern CCLME. This connectivity highlights an important mechanism for natural coastwide mitigation of poor productivity conditions, providing a novel perspective on the function of synchronization across this large marine ecosystem.

A new look at oceanographic drivers of petrale sole recruitment in the California Current Ecosystem and its impact on stock assessment

Contributed by Nick Tolimieri, nick.tolimieri@noaa.gov and Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Nick Tolimieri, Vladlena Gertseva, and Ian G. Taylor

Stock assessments provide key scientific input for managing fisheries. Age-structure information is important for these assessments because it provides the foundation for estimating recruitment, which impacts estimates of future spawning biomass and other assessment parameters that inform management. For some species, like petrale sole (*Eopsetta jordani*), the younger cohorts are poorly sampled, which leads to uncertainty in estimates of recent recruitment. We used recruitment deviations from the most recent petrale sole stock assessment for and oceanographic indicators derived from the GLORYS oceanographic model to develop an environmental index of recruitment and then tested the impact of including the index in the assessment using Stock Synthesis. Quadratic relationships for degree days during the larval stage and long-shore transport during the pelagic juvenile states explained 66% of the variation recruitment deviations for 1993-2018 (the training period). We then included the index predicting the 2019-2022 (forecast period) recruitment deviations in the assessment model and compared the output to the 2023 base model without this index. Including the index captured recent recruitment variability and provided information for better model precision and near-term forecasting, leading to more accurate estimates of recruitment, spawning biomass, and projected catch in recent years—assessment parameters that inform management decisions.

Switching bait to balance fisheries management and fishing opportunities

Contributed by Kelly Andrews, kelly.andrews@noaa.gov and Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Kelly S. Andrews, Jennifer G.L. Heibult, Joseph K. Gaydos, Daniel M. Tonnes

Successful fisheries management is a balance between conservation and sustainable use of ecosystem services. In 2010, recreational fishing for ‘bottomfish’ species was prohibited in waters deeper than 36.6m to reduce mortality and bycatch of ESA-listed rockfish species (*Sebastes*) in Puget Sound, WA, USA. In cooperation with the recreational fishing community, we investigated how different bait types influenced catch rates of targeted species and rockfish bycatch in recreational groundfish fisheries. We used two complementary approaches: a voluntary sampling program with recreational fishing charter captains and a structured

experimental study. Both studies found that using frozen/thawed bait resulted in the highest rockfish bycatch rates. The experimental study showed that using live, large bait significantly reduced rockfish bycatch (83–98% lower) and maintained targeted species catch rates. These findings offer a potential "win-win-win" scenario to reduce rockfish bycatch, allow for expanded fishing opportunities, and encourage collaborative conservation efforts with the recreational fishing community.

For more information, please contact Kelly Andrews at NOAA's Northwest Fisheries Science Center, kelly.andrews@noaa.gov.

The cost of marine spatial closures: Economic impacts of new ocean-use sectors on West Coast trawl fisheries
Contributed by Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Katrina Munsterman, Paul Carvalho, Lisa Pfeiffer, Abigail Golden, Jameal F. Samhouri, and Kelly S. Andrews

Emerging sectors of ocean use, such as offshore aquaculture, deep-sea mining, wind and other renewable energy technologies, have the potential to strengthen food, energy and supply chain systems, yet this progress may come at a cost to existing ocean users, particularly commercial fisheries. In the United States, access to offshore wind energy areas to fishing could be limited due to concerns regarding navigation, physical obstruction, gear loss, and safety. These concerns are more severe for large vessels and vessels using trawling gear that are unable to maneuver within wind arrays. On the US West Coast, groundfish bottom trawl vessels will likely be unable to fish within wind arrays, creating large marine spatial closures. Here, we integrated 10 years of groundfish revenue, landings, logbook, and vessel movement data into a discrete choice modeling framework to understand the drivers of fisher behavior across US West Coast ports. We then applied a welfare analysis to estimate changes in vessel profit imposed by closure scenarios. Following simulated closures based on previously identified areas for offshore wind energy development, vessels redistributed their effort to the boundaries of closure areas, with vessels from some ports shifting to nearshore waters. Our models project that vessels whose fishing footprints overlap most with potential closure areas face the steepest penalties, with average profit losses of 25-50% per trip. These findings provide a framework for estimating the compensation required to mitigate the economic impacts of wind energy development.

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Course corrections responding to climate impacts produce divergent effects on population biomass and harvest in fisheries
Contributed by Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Jameal F. Samhouri, A. Raine Detmer, Kristin N. Marshall, Adrian C. Stier, Aaron Berger, Owen R. Liu, A. Ole Shelton

Climate change will alter ecological dynamics, affecting the relative abundance of species. A primary challenge is whether and how to modify natural resource management practices to address these changes. We explored a model of a harvested fish population experiencing climate-driven changes in demography, finding that climate impacts impose a choice between management strategies that favor fishery yield or population biomass but not both. When climate caused a population's carrying capacity to increase, or its productivity to decrease, a climate adaptive strategy relying upon this updated information maintained higher population biomass but produced similar or lower yield than fixed management pegged to historical conditions. In contrast, when climate caused a population's carrying capacity to decrease, or its productivity to increase, a climate adaptive strategy produced greater yield but maintained lower population biomass. Both strategies prevented a population from becoming overfished (too small to achieve maximum yield), but the fixed management strategy could impose more excessive annual harvest rates (overfishing). These insights suggest climate adaptive management may not always outperform a fixed strategy. Yet in U.S. fisheries we found routine assessment of population status modifies demographic parameters, implicitly shifting management reference points that affect fishery yield and population biomass. Participatory processes can illuminate these impacts, creating opportunities to co-develop weightings for conservation and harvest objectives.

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Correlating ocean conditions with bycatch: deploying bathythermograph sensors in the at-sea hake fishery
Contributed by Christa Conway, christa.conway@noaa.gov.

To expand on recent research correlating salmon (*Oncorhynchus* spp.) bycatch and remotely-sensed sea surface temperatures in the at-sea Pacific hake (*Merluccius productus*) fishery (Sabal et al., 2023), the At-Sea Hake Observer Program is deploying bathythermograph sensors in the Pacific hake fishery, off the U.S. West Coast. This research provides data to study the relationships between depth, temperature at depth, and bycatch of salmon in particular as well as other species. This study is initially targeting the at-sea hake catcher processor fleet, with potential future plans to expand data collection to other sectors of the fleet.

Persistent Bycatch Cold and Hot Spots in Irish and U.S. Trawl Fisheries
Contributed by Christa Conway, christa.conway@noaa.gov.

Fisheries managers and industry members need to make decisions to optimize wanted catch while minimizing unwanted catch. Catch data provide the foundation for these decisions, but can be costly to collect. Fishery managers must balance the expenses of data collection with the value those data provide. Whether considering decreasing or increasing monitoring rates, fishery managers are attempting to solve a well-established conundrum: what rate of monitoring maximizes the usefulness of these data? In this research, we analyze data sets from census-monitored fisheries to help answer this question when considering spatial management.

Developing Multi-Stream Bayesian Time Series Models for Rare Bycatch Event Estimation

Contributed by Christa Conway, christa.conway@noaa.gov.

Video review rates in the electronically-monitored catch share fisheries using bottom trawl and pot gear were reduces to ~10% of hauls per trip in 2024. At the same time, scientific WCGOP observers continued to monitor ~20-30% of trips in the sector. This resulted in independent but overlapping sampling frames. In order to estimate total bycatch based on the full suite of all available monitoring data, we developed a special case of the Bayesian time series model previously used for marine mammal, seabird, and sea turtle bycatch estimation. This model utilizes three streams of data: (1) observed hauls, (2) video reviewed hauls, and (3) observed and video reviewed hauls.

Increasing spatial approximation complexity can degrade prediction quality in distribution models
Contributed by Eric Ward, eric.ward@noaa.gov.

Investigators: Ward, EJ and SC Anderson.

Preprint: bioRxiv 2025.11.14.688354; doi: https://doi.org/10.1101/2025.11.14.688354

Spatial and spatiotemporal models are increasingly critical for understanding species distributions, tracking population change, and informing conservation decisions. However, the reliability of spatial predictions depends on often-overlooked modelling choices, including the spatial resolution used to approximate underlying processes. Using long term monitoring data from the West Coast Groundfish Bottom Trawl survey in the California Current ecosystem, we investigated how spatial model complexity affects the quality of ecological predictions and derived indices used for management. We fit spatial and spatiotemporal models of ocean temperature and fish biomass density for 27 commercially important species using varying levels of spatial resolution. We evaluated both in-sample and out-of-sample prediction, and effects on area-weighted biomass indices. Counter to common assumptions, increasing spatial approximation resolution did not universally improve predictions. Our case studies demonstrate that for many datasets, out-of-sample prediction quality peaked at intermediate spatial resolutions and declined at the finest scales. Through simulation testing, we found this pattern was strongest when spatial patterning had a small range and high spatial variance, and observation error was low. For most species, spatial resolution had a minimal effect on biomass trend estimates used in management, but for several commercially important rockfish species, resolution choices substantially affected both the scale and uncertainty of population indices. Our findings demonstrate that spatial model specification can substantially affect ecological inference, with direct implications for management and conservation planning. We provide practical guidance for ecologists on selecting appropriate spatial complexity through cross-validation. When out-of-sample prediction is a focus, appropriate approximation complexity should improve both parameter estimation accuracy and derived quantities.

Integrated West Coast Pelagics Survey net selectivity
Contributed by Julia Clemons, julia.clemons@noaa.gov.

The FRAM/FEAT team continued with net selectivity testing during a research leg at the end of the Integrated West Coast Pelagics Survey (IWCPS) aboard the NOAA Ship *Bell M. Shimada*.

The research leg aimed to resample aggregations of age-1 hake and areas where age-1 and age-2+ hake had mingled earlier during the IWCPS. Between September 19–28, 2025 nine acoustic transects, previously completed during the IWCPS, were resampled in part (six off central California and three off southern Oregon). Eleven midwater trawls using an Aleutian Wing Trawl (AWT) with recapture ("pocket") nets attached were successfully conducted. Pacific hake was the dominant species in the catch composition, accounting for 94% of the catch by weight. The raw length-frequency distribution of hake caught during this leg was characterized by a bimodal distribution, with a much stronger major mode of age-1 hake centered on 28 cm and a much smaller, weaker mode of age-2+ hake at 38-39 cm. The pattern of escapement from different sections of the AWT showed more hake being recaptured in pocket nets closer to the codend.

Incorporating fishery-dependent data into stock assessment abundance indices
Contributed by Kiva Oken, kiva.oken@noaa.gov and Christa Conway, christa.conway@noaa.gov.

We are working on fishery-dependent CPUE indices for species that are difficult to sample with bottom trawl surveys, such as midwater rockfish. The work includes both statistical method development on preferential sampling to account for the non-random nature of the observations, and direct engagement with the fishing industry to better understand fishing effort decisions. More generally, an emergent need is better information on relative trends in abundance for these species. This could be achieved through fishery CPUE (described above), leveraging and analyzing existing acoustic data, or considering additional covariates for bottom trawl survey standardization that account for variation in the availability of semi-pelagic species to the survey (i.e., drivers of vertical distribution and habitat use).

TOOL DEVELOPMENT

Stock Assessment Continuum Tool (https://github.com/shcaba/SS-DL-tool)
Contributed by Jason Cope, jason.cope@noaa.gov.

The Stock Assessment Continuum Tool uses Stock Synthesis (SS3) (Methot and Wetzel 2013) to implement a variety of assessment configurations. This tool was initially built to implement several standard data-limited assessment methods within the SS3 modeling framework. Now, it has been expanded to be able to implement more complex and data-rich configurations. The tool builds Stock Synthesis input files for provided data and life history information. Under a unified framework, additional data and SS3 options can be added as it becomes available, either within the tool itself, if that feature would be useful to the wider community of stock assessment scientists, or options can be changed directly in the Stock Synthesis input. It produces full plots and tables for each model run via the r4ss package and additional screen output for straightforward interpretation. This tool is in active development and keeps up with the newest Stock Synthesis 3 version.

Stock Assessment Learning Tool (https://github.com/shcaba/Stock-Assessment-Learning-Tool)
Contributed by Jason Cope, jason.cope@noaa.gov.

A variety of interactive applications to learn about stock assessment inputs and outputs. The current version has 11 learning modules currently that covers topics such as life history theory, selectivity, sampling and uncertainty issues, information content of length and age data, indicators, references points, and stock assessment types and interpretation. The tool is hosted at the following website: https://connect.fisheries.noaa.gov/SALT/

The Natural Mortality Tool (https://github.com/shcaba/Natural-Mortality-Tool)
Contributed by Jason Cope, jason.cope@noaa.gov.

The Natural Mortality tool offers an accessible way to estimate natural mortality from a variety of life history information. The tool also offers a means to include uncertainty and combine multiple estimators into a non-parametric distribution. The tool can be launched directly from this site: https://connect.fisheries.noaa.gov/natural-mortality-tool/

***surveyjoin*: a standardized database of scientific trawl surveys in the Northeast Pacific Ocean**
Contributed by Eric Ward, eric.ward@noaa.gov.

Citation: Ward EJ, English PA, Rooper CN, Ferriss BE, Whitmire CE, Wetzel CR, Barnett LAK, Anderson SC, Thorson JT, Johnson KF, Indivero J, Markowitz EH. 2025. *surveyjoin*: a standardized database of scientific trawl surveys in the Northeast Pacific Ocean. *PeerJ* 13:e19964 https://doi.org/10.7717/peerj.19964

Fisheries management faces significant hurdles from political and ecological complexities, often exacerbated by shifting species distributions. Effective oversight requires integrating data across geographic boundaries, yet inconsistent formats and regional governance frequently hinder these efforts. To bridge these gaps, we introduce surveyjoin, an R package and standardized database for Northeast Pacific bottom trawl surveys. This resource integrates over 3.3 million observations from 14 NOAA and Fisheries and Oceans Canada surveys, spanning from Alaska to California (1980s–present). By standardizing variables like catch-per-unit-effort (CPUE) and bottom temperature, the package enables seamless transboundary analysis.
We demonstrate the utility of surveyjoin through three case studies:

1. Pacific Hake: Developing a coastwide geostatistical biomass index.
2. Community Structure: Identifying spatial breakpoints in groundfish assemblages and life histories.
3. Sablefish: Utilizing spatially varying coefficient models to detect regional biomass trends.

By providing a scalable framework for shared marine resources, surveyjoin fosters transparency and collaboration. It represents a vital step toward data-driven, international management of ecosystems under dynamic environmental conditions.

Pacific Survey Explorer
Contributed by Eric Ward, eric.ward@noaa.gov.

Investigators: Our team consists of scientists from the NWFSC (Chantel Wetzel, Kiva Oken, Kelli Johnson, Eric Ward), AFSC (Bridget Ferriss, Margaret Siple, Lewis Barnett, Jim Thorson,

Em Markowitz), DFO (Philina English, Chris Rooper, Sean Anderson), and UW (Julia Indivero, Tim Essignton).

While data - joining efforts like `surveyjoin` **https://doi.org/10.7717/peerj.19964** aim to make data accessible, a limitation of those efforts is that data is only accessible to end users comfortable in doing data queries or wrangling data themselves. To broaden the number of end users and make trawl survey data in the NE Pacific even more accessible, we worked with 2 summer interns during summer - fall 2025 to build the Pacific Survey Explorer (https://connect.fisheries.noaa.gov/pacific-survey-explorer/). This Shiny app currently displays design based indices, maps from recent surveys, and biological traits (growth, maximum size). The user interface has improved so that individual plots, or the raw data underlying them, may be saved as PDFs.

sdmTMB software
Contributed by Eric Ward, eric.ward@noaa.gov.

Citation: Anderson SC, Ward EJ, English PA, Barnett LAK, Thorson JT (2025). “sdmTMB: An R Package for Fast, Flexible, and User-Friendly Generalized Linear Mixed Effects Models with Spatial and Spatiotemporal Random Fields.” *Journal of Statistical Software*, 115(2), 1–46. doi:10.18637/jss.v115.i02.

Geostatistical spatial or spatiotemporal data are common across scientific fields. However, appropriate models to analyze these data, such as generalized linear mixed effects models (GLMMs) with Gaussian Markov random fields (GMRFs), are computationally intensive and challenging for many users to implement. Here, we introduce the R package sdmTMB, which extends the flexible interface familiar to users of lme4, glmmTMB, and mgcv to include spatial and spatiotemporal latent GMRFs using the stochastic partial differential equation (SPDE) approach. SPDE matrices are constructed with fmesher, and estimation is conducted via maximum marginal likelihood with TMB or via Bayesian inference with tmbstan and rstan. We describe the model and explore case studies that illustrate sdmTMB's flexibility in implementing penalized smoothers, non-stationary processes (time-varying and spatially varying coefficients), hurdle models, cross-validation, and anisotropy (directionally dependent spatial correlation). Finally, we compare the functionality, speed, and interfaces of related software, demonstrating that sdmTMB can be an order of magnitude faster than R-INLA. We hope sdmTMB will help open this useful class of models to more geostatistical analysts.

Survey sampling protocol review tool (https://github.com/rclairer/survey_data_prioritization)
Contributed by Claire Rosemond, claire.rosemond@noaa.gov.

This tool facilitates collaborative review of the NOAA NWFSC FRAM FRS survey sampling protocols and data collection targets designed to support stock assessments and research. The data are from the NOAA NWFSC West Coast Groundfish Bottom Trawl Survey (WCGBTS) and NOAA NWFSC Hook and Line Survey (HKLS). The data are filtered to include the species and stock areas currently included (or considered for inclusion) in the PFMC Fishery Management Plan.
Launch the tool directly from this site: https://connect.fisheries.noaa.gov/survey-sampling-protocol-review/

4. Stock Assessments and Management by Species/Group

Status of the yellowtail rockfish stock off the U.S. West Coast north of 40°10′ in 2025
Contributed by Kiva Oken, kiva.oken@noaa.gov.

Citation: Oken, K.L., I.G. Taylor, M.L. Feddern, A.D. Whitman, F.P. Caltabellotta. Status of the yellowtail rockfish stock off the U.S. West Coast north of 40°10′ in 2025. Pacific Fishery Management Council, Portland, Oregon. 175 p. https://www.pcouncil.org/documents/2026/01/status-of-the-yellowtail-rockfish-stock-off-the-u-s-west-coast-north-of-40-10-in-2025.pdf/

The U.S. Yellowtail Rockfish (*Sebastes flavidus*) stock north of 40°10' was assessed in a two-sex integrated model in stock synthesis using catch data (1889-2024), age data (1972-2024), length data (1972-2024), age-at-length data (2003-2024), and four fishery-independent indices. The indices included two bottom trawl surveys (1980-2004 and 2003-2024), a combined hook and line survey conducted in Oregon and Washington (2010-2024), and a recruitment survey based on standardized monitoring units for the recruitment of fish (2014-2024). Yellowtail rockfish is primarily harvested in the shoreside commercial fishery, with the bulk of recent catches using midwater trawl gear. It is also caught at lower rates in the recreational sector and in the at-sea hake fishery. While females grow to larger sizes, all data sources tend to observe more old males than old females. This dynamic was modeled by estimating sex-specific natural mortality rates and sex-specific selectivity for the recreational fleet.

At the start of 2025, the estimated stock status is 63% of unfished spawning output, which is above the target of 40%. The stock is not overfished and overfishing is not occurring. Catches increased substantially beginning in 2017 with the rapid development of the midwater trawl fishery, and have averaged around 3000 mt. This increase has been sustainable; the model's estimates of recent exploitation rates are below the proxy target. The recruitment index was elevated in 2021, indicating the possibility of a strong year class entering the fishery soon. This potential is included in the assessment forecast.

Status of the Rougheye and Blackspotted Rockfishes stock off the U.S. West Coast in 2025
Contributed by Jason Cope, jason.cope@noaa.gov and Vlada Gertseva, vladlena.gertseva@noaa.gov.

Citation: Cope, J.M., V. Gertseva, R.C. Rosemond, A.D. Whitman, and F.P. Caltabellotta. (2025) Status of the Rougheye and Blackspotted Rockfishes stock off the U.S. West Coast in 2025. Pacific Fishery Management Council. 356 pp. https://www.pcouncil.org/documents/2026/01/status-of-yelloweye-rockfish-off-the-u-s-west-coast-in-2025.pdf/

Rougheye (*Sebastes aleutianus*) and Blackspotted (*Sebastes melanostictus*) rockfishes (RE/BS) range from northern California up to and throughout Alaska and into Japan. They greatly overlap in latitude and depth (shallower than 100 m to at least 439 m), and are generally

considered slope rockfish, with an ontogenetic shift from shallower to deeper waters as they age. RE/BS are often associated with structure, such as hard, rocky bottoms and steep habitats. They are rarely found on the deep flats.

This assessment reports the status of the RE/BS that reside in the waters off California, Oregon, and Washington from the U.S.-Canadian border in the north to the U.S.-Mexico border in the south.

The historical reconstruction of landings for RE/BS suggests that non-trawl (largely hook-and-line gear) fisheries have caught RE/BS since the end of the 19th century. The bottom trawl fishery developed in the 1930s and 1940s, and trawl landings for RE/BS first peaked in the 1960s and 1970s, when the foreign trawl fleet was targeting Pacific Ocean perch. The declaration of the Exclusive Economic Zone (established in 1977) resulted in the buildup of a domestic fleet and landings increased rapidly into the late 1980s and early 1990s (generally > 300 mt with a peak of 745mt in 1995). Subsequently, landings declined in the late 1990s, with catches under 250 metric tons in the last two decades. The contribution of mid-water trawl catches gradually grew over the past 15 years, and now they represent the majority of the trawl removals. Since RE/BS are marketable, discarding has been low historically. However, management restrictions (e.g., trip limits) resulted in increased discarding. Trawl rationalization was introduced in 2011, and since then very little discarding of RE/BS has occurred. RE/BS also has long been bycaught in the fishery for the coastal population of Pacific Hake, which is almost exclusively conducted with mid-water trawl.

This assessment estimates that the stock of RE/BS off the continental U.S. Pacific Coast is currently at 87 percent of its unexploited level, which is above the target of 40 percent of unfished spawning output. The time series of total mortality catch (landings plus discards) and estimated depletion for of the RE/BS are presented in Figure 1. While the stock complex is above the relative stock status target, the stock scale remains highly uncertain. While the high stock status and increased stock scale support higher sustainable total yield estimates than previously recorded, the high uncertainty is a strong consideration when setting sustainable catch limits.

Uncertainty in this assessment model is explicitly captured in the asymptotic confidence intervals reported throughout this assessment for key parameters and management quantities. Uncertainty associated with alternative model configurations and fixed parameters were evaluated through a variety of sensitivity runs and likelihood profile analysis. Uncertainty in natural mortality was used to define alternate states of nature in the decision table, bracketing the base model results.

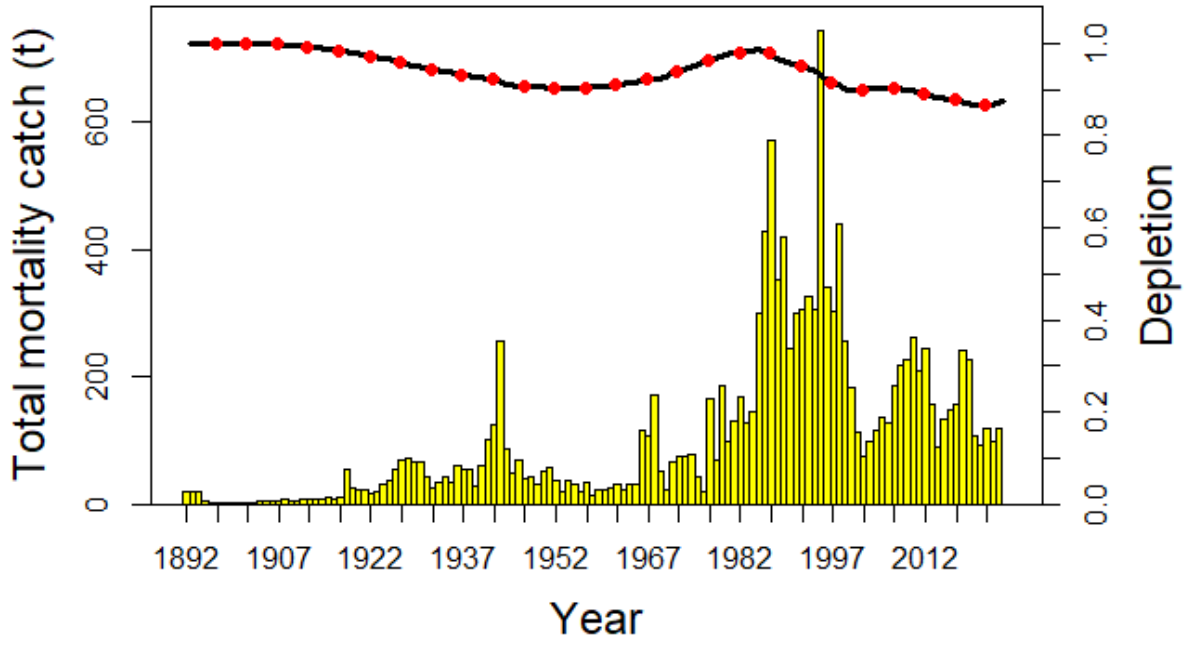

Figure 1. The time series of total mortality catch (bars) and estimated depletion (line) for Rougheye and Blackspotted rockfishes complex.

For more information on the Rougheye and Blackspotted rockfishes assessment, contact Jason Cope at Jason.Cope@noaa.gov and Vladlena Gertseva at Vladlena.Gertseva@noaa.gov.

Status of sablefish (*Anoplopoma fimbria*) off the U.S. West Coast in 2025
Contributed by Chantel Wetzel, chantel.wetzel@noaa.gov.

Citation: Wetzel, C.R., A.M. Berger, C. Barnes, J.A. Zahner, N. Tolimieri, E.J. Ward, and M. Head. 2025. Status of sablefish (Anoplopoma fimbria) off the U.S. West Coast in 2025. Pacific Fisheries Management Council, Portland, Oregon.

The 2025 stock assessment of sablefish off the U.S. West Coast estimates that the population is currently healthy and is neither overfished nor subject to overfishing. Spawning biomass has shown signs of stability or growth in recent years, largely supported by several strong year-classes that have entered the fishery. The stock is estimated to be at 33.9% of its unfished equilibrium level. While this is above the minimum stock size threshold of 25%, it remains below the management target of 40% and is currently categorized within the precautionary zone. The population of spawning output at the start of 2025 is estimated to be 74,409 metric tons (mt) and the 95% asymptotic confidence interval for this estimate ranges from 59,331 to 89,486 mt. The stock is currently experiencing a rapid increase in spawning output, which is projected to reach the 40% management target by 2027. This positive trajectory is primarily driven by several exceptionally strong recruitment cohorts from 2016, 2020, 2021, and 2023 that are beginning to mature and enter the spawning population.

The assessment utilizes a primary integrated statistical catch-at-age model developed in the Stock Synthesis (SS3) framework. This model is configured as a single-area, two-sex model that spans the U.S. West Coast from the Mexican border to the Canadian border. A defining feature of the 2025 model structure is its transition to an empirical weight-at-age approach; rather than assuming a static growth curve, to account for significant fluctuations in growth rates over time.

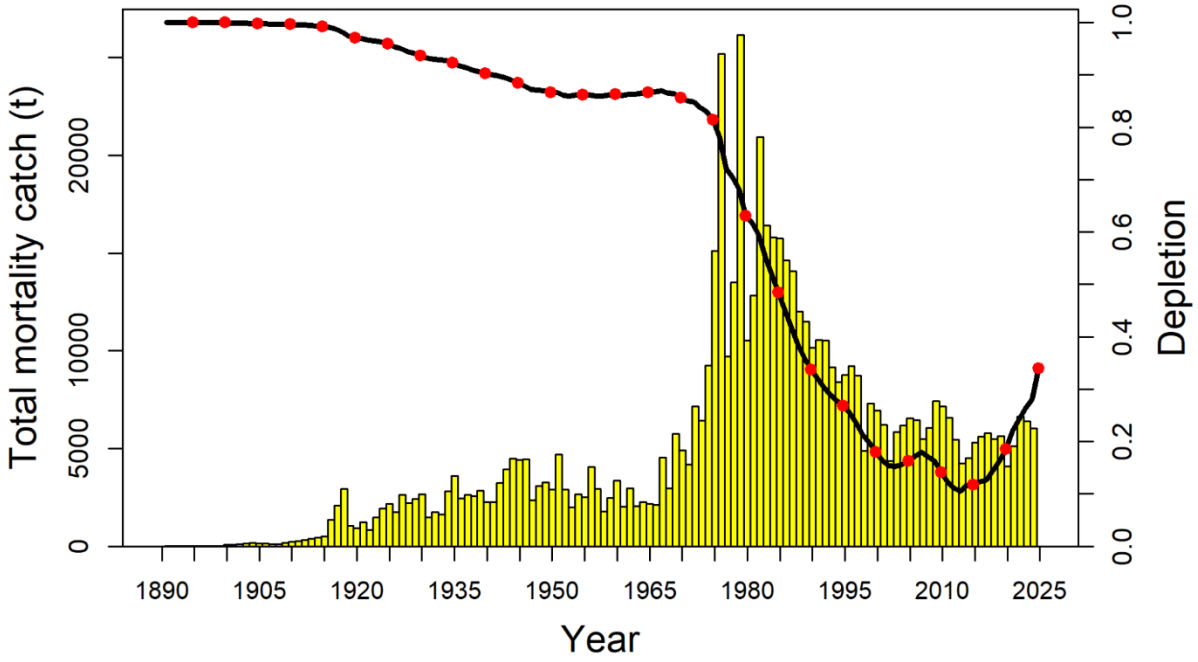

Figure 1. The time series of total mortality catch (bars) and estimated depletion (line, spawning biomass relative to unfished spawning biomass) for sablefish off the U.S. West Coast.

For more information, please contact Chantel Wetzel at Chantel.Wetzel@noaa.gov.

Status of widow rockfish stock off the U.S. West Coast in 2025
Contributed by Vlada Gertseva, vladlena.gertseva@noaa.gov.

Citation: Kinneen, M., Goodman, M. C., Sulc, A., Balstad, L., Diaz, R., Randrup, K., Patrone, W., Spencer, L., Morell, A., Rovellini, A., Dedrick, A., Grunloh, N., Bargas, M., Hopkins, S., Gersteva, V., Oken, K., Taylor, I., Haltuch, M., & Hamel, O. (2025) Status of widow rockfish stock off the U.S. West Coast in 2025. Pacific Fishery Management Council, Portland, Oregon.

Widow rockfish (*Sebastes entomelas*) inhabit water depths of 25–370 m from northern Baja California, Mexico, to Southeastern Alaska. This is an assessment of widow rockfish that reside in the waters off California, Oregon, and Washington, from the U.S.-Canada border in the north to the U.S. – Mexico border in the south.

Historically, fisheries have caught widow rockfish since the turn of the 20th century. Landings in the trawl fishery are estimated to have increased into the 1940s and remained relatively constant and small (below 1,000 mt per year) throughout the 1950s and into the 1960s,

before catches increased from a foreign trawl fleet in the 1970s, with a peak at almost 5,000 mt in 1967. Catches by a midwater trawl fleet increased rapidly in the late 1970s following the discovery that widow rockfish form large aggregations at night. Total landings of widow rockfish peaked in the early 1980s, increasing from approximately 1,000 metric tons (mt) in 1978 to over 25,000 mt in 1981. The large landings in the early 1980s were curtailed with trip limits beginning in 1982, which resulted in a decline in landings throughout the 1980s and 1990s, following sequential reductions in the trip limits. From 2000 to 2003, landings of widow rockfish dropped from over 4,000 mt to about 40 mt and remained low through 2016. Landings increased rapidly following the quota share reallocation in 2017, and have been near or above 10,000 mt in all years between 2018 and 2024. Midwater trawl gears targeting rockfish and bycatch in the Pacific hake/whiting (*Merluccius productus*) fisheries account for the majority of the recent catch.

This assessment estimates that the stock of widow rockfish off the continental U.S. Pacific Coast is currently at 50 percent of its unexploited level, which is above the target of 40 percent of unfished spawning output. The time series of total mortality catch (landings plus discards) and estimated depletion for of the widow rockfish are presented in Figure 1.

Uncertainty in this assessment model is explicitly captured in the asymptotic confidence intervals reported throughout this assessment for key parameters and management quantities. Uncertainty associated with alternative model configurations and fixed parameters were evaluated through a variety of sensitivity runs and likelihood profile analysis. Uncertainty in natural mortality and stock-recruit steepness was used to define alternate states of nature in the decision table, bracketing the base model results.

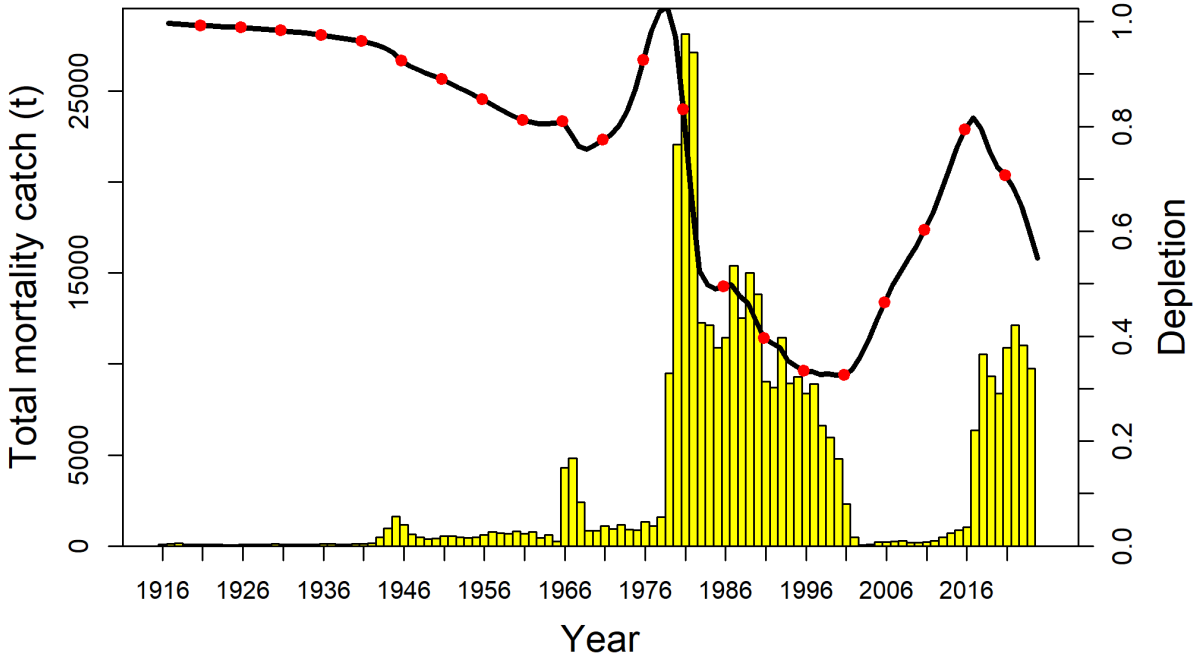

Figure 1. The time series of total mortality catch (bars) and estimated depletion (line) for widow rockfish.

For more information on the widow rockfish assessment, contact Ian Taylor at Ian.Taylor@noaa.gov and Vladlena Gertseva at Vladlena.Gertseva@noaa.gov.

Status of Yelloweye Rockfish off the U.S. West Coast in 2025
Contributed by Vlada Gertseva, vladlena.gertseva@noaa.gov.

Citation: Johnston, M. A., Rosemond, R. C., Whitman, A., Perl, E., Barros, M., Champagnat, J., Schamp, A., Schiano, S., Prior Caltabellotta, F., Gertseva, V., Taylor, I., Oken, K. and Berger, A. (2025) Status of Yelloweye rockfish off the U.S. West Coast in 2025. Pacific Fishery Management Council. 147 pp. https://www.pcouncil.org/documents/2026/01/status-of-yelloweye-rockfish-off-the-u-s-west-coast-in-2025.pdf/

Yelloweye Rockfish are found from the Gulf of Alaska to northern Baja California in Mexico across the northeastern Pacific Ocean. Their core distribution is from southeast Alaska to central California on the west coast of the United States. This assessment reports the status of Yelloweye Rockfish (*Sebastes ruberrimus*) off the U.S. West Coast using data through 2024. Yelloweye rockfish have historically been a prized catch in both commercial and recreational fisheries. Commercially, they have been caught by trawl and hook-and-line gear types. They have generally yielded a higher price than other rockfish and have largely been retained when encountered. Catches of yelloweye rockfish increased gradually throughout the first half of the 20th century, with a brief peak around World War II due to increased demand. The largest removals of the species occurred in the 1980s and 1990s and reached 552 mt in 1982. After 2002 (when yelloweye were declared overfished), total catches have been maintained at much lower levels. However, as other rockfish stocks have rebuilt and yelloweye rockfish has progressed under its rebuilding plan, catches have slowly increased in recent years, primarily in the Oregon-Washington non-trawl fleet and the recreational fleets.

This assessment estimates that the stock of yelloweye rockfish off the continental U.S. Pacific Coast is currently at 40.1 percent of its unexploited level, at the target of 40 percent of unfished spawning output. The time series of total mortality catch (landings plus discards) and estimated depletion for of the yelloweye rockfish are presented in Figure 1.

Uncertainty in this assessment model is explicitly captured in the asymptotic confidence intervals reported throughout this assessment for key parameters and management quantities. Uncertainty associated with alternative model configurations and fixed parameters were evaluated through a variety of sensitivity runs and likelihood profile analysis. Uncertainty in natural mortality was used to define alternate states of nature in the decision table, bracketing the base model results.

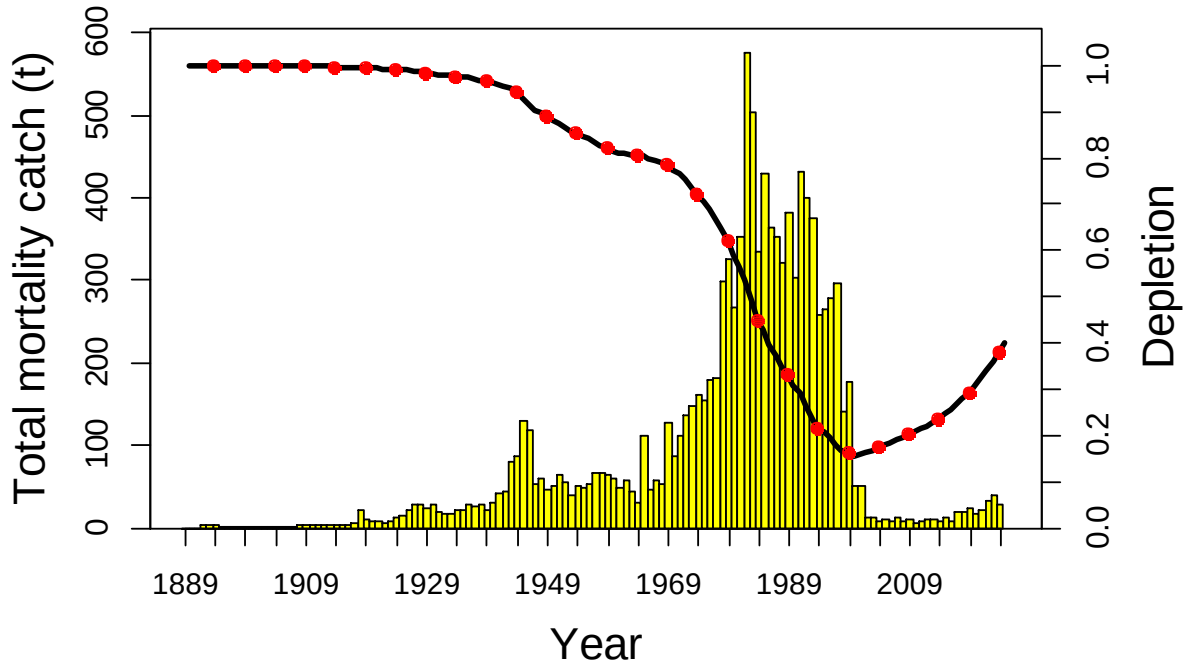

Figure 1. The time series of total mortality catch (bars) and estimated depletion (line) for yelloweye rockfish.

For more information on the yelloweye rockfish assessment, contact Vladlena Gertseva at Vladlena.Gertseva@noaa.gov and Claire Rosemond at Claire.Rosemond@noaa.gov.

Status of quillback rockfish in U.S. Waters off California in 2025
Contributed by Brian Langseth, brian.langseth@noaa.gov.

Citation: Langseth, B.J., M.H. Monk, J.H. Coates, 2025. Status of quillback rockfish in U.S. Waters off California in 2025. PFMC, Portland, OR. 210 pp.

This assessment reports the status of quillback rockfish (*Sebastes maligar*) in U.S. waters off the California coast using data through 2024. Quillback rockfish are a demersal, relatively nearshore rockfish found from southern California to the Gulf of Alaska. Quillback rockfish off the coast of California is defined as a stock by the Pacific Fishery Management Council (PFMC). The California stock of quillback rockfish was declared overfished in 2023 based on the results of a 2021 stock assessment. This assessment incorporates updated life history information using data from quillback rockfish collected in waters off California, along with additional information from fishery dependent and independent sources.

Quillback rockfish off the coast of California are caught in both the recreational and commercial fisheries (Figure 1 – bars). Recreational removals are the largest source of fishing mortality and represent approximately 70 percent of the total removals of quillback rockfish across all years. Recreational removals slowly increased from the 1960s to 1980, varied around lower amounts through 2015 with the exception of two years of exceptionally large catches in 1984 and 1993, and increased up to 2022. The majority of the commercial landings for quillback rockfish

occurred between 1990 and 2008, due to the development of the live fish fishery, with a small increase from 2016 to 2022.

Relative spawning output declined steadily from the first modeled year until 1998, with the exception of a slight increase around 1991, and then increased due to two above average recruitment events that occurred in 1993 and 1994 (Figure 1 – line). Relative spawning output increased from 1998 to 2006 before steadily declining until 2023, after which it has increased. The 2025 relative spawning output was 43.5 precent, which is above the management target of 40 percent. Due to the results of this assessment, the California stock of quillback rockfish is no longer considered to be overfished.

The primary uncertainty for the California quillback rockfish assessment was in parameter estimates influencing population productivity, particularly natural mortality and the growth parameter K, and the influence of age data on estimates of recruitment. Despite additional California-specific data, there is still uncertainty in these values. Future assessments would benefit from increased collection and reading of age samples as part of regular sampling program efforts.

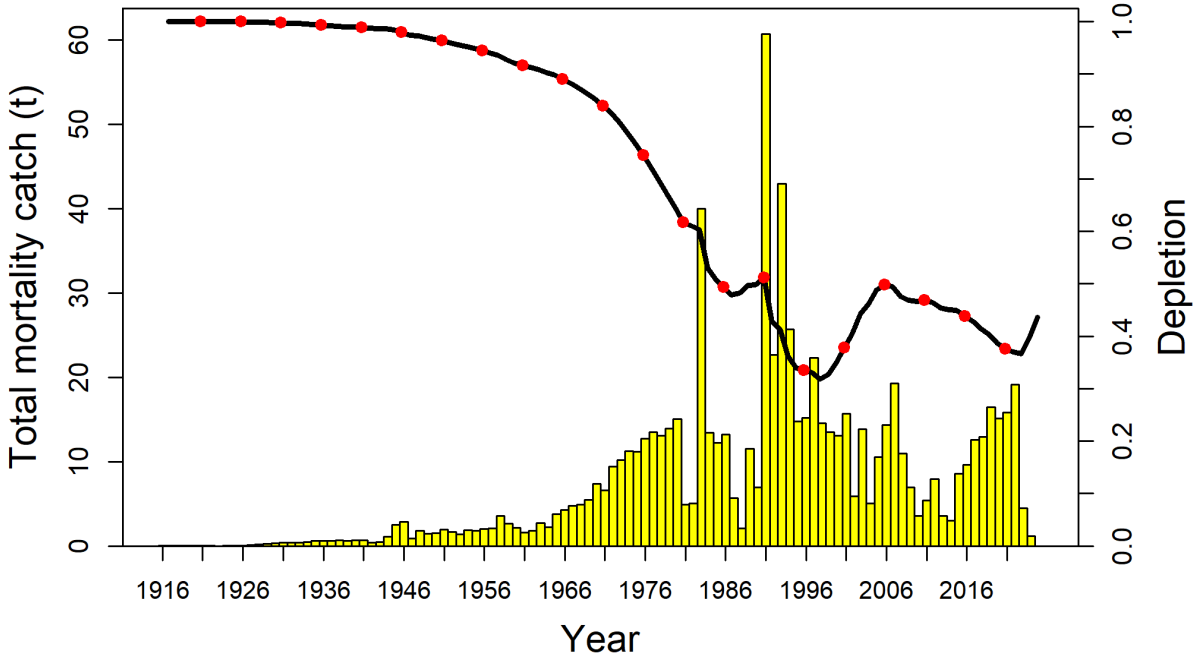

Figure 1. Total catch (bars) and depletion (line: relative to average unexploited equilibrium spawning output) for quillback rockfish in California, 1916 - 2024.

For more information, please contact Brian Langseth at brian.langseth@noaa.gov

Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2025
Contributed by Aaron Berger, aaron.berger@noaa.gov.

Investigators: K. Johnson, A. Edwards, A. Berger, C. Grandin, C. Wetzel

This stock assessment reported the collaborative efforts of the official U.S. and Canadian Joint Technical Committee members in accordance with the Agreement between the government of the U.S. and the government of Canada to assess the status of the coastal Pacific Hake (or Pacific whiting, *Merluccius productus*) resource off the west coast of the U.S. and Canada for 2025. Coast-wide fishery landings of Pacific hake averaged 242 thousand mt from 1966 to 2024, with a low of 90 thousand mt in 1980 and a peak of 441 thousand mt in 2017. Prior to 1966 the total removals were negligible relative to the modern fishery. Recent coast-wide landings from 2020–2024 have all been above the long-term average, except in 2024 when it was 171 thousand mt, with U.S. and Canadian catches averaging 251 thousand mt and 42 thousand mt during that period, respectively. In the 2024 catch, the 2021 cohort was represented the most (37%), followed by the 2020 cohort (17%) and then the 2016 (10%) cohorts. The Agreement between the U.S. and Canada establishes U.S. and Canadian shares of the coast-wide TAC at 73.88% and 26.12%, respectively.

The assessment model is fit to an acoustic survey index of biomass, annual commercial catch data, and age-composition data from the survey and commercial fisheries. Data for 2024 were included for each data set and minor changes to pre-2024 data were made as necessary. In addition, continued use of a model-based approach was used to develop the input weight-at-age matrix, and time-varying temperature-dependent maturity was used again to better inform fecundity. The assessment used Bayesian methods to incorporate prior information on four key parameters (natural mortality, M, steepness of the stock-recruitment relationship, h, and two Dirichlet data weighting parameters for fishery and survey age compositions) and integrate over parameter uncertainty to provide results that can be probabilistically interpreted. The exploration of uncertainty was not limited to parameter uncertainty as structural uncertainty was investigated through sensitivity analyses. Pacific Hake displays the highest degree of recruitment variability of any west coast groundfish stock, resulting in large and rapid changes in stock biomass. This volatility, coupled with a dynamic fishery, which potentially targets strong cohorts resulting in time-varying selectivity, and little data to inform recent recruitment, will, in most circumstances, continue to result in highly uncertain estimates of current stock status and even less-certain projections of future stock trajectory. Uncertainty in the results of this assessment is largely a function of the potentially above-average 2021 and 2020 year-classes, the lack of information about recruitment in 2023, 2024, and in forecasts, uncertain selectivity, and uncertainty about historical equilibrium conditions prior to or in the absence of fishing. Short-term forecasts are very uncertain because recruitment is a main source of uncertainty in the projections.

Estimates from the 2025 base model indicate that since the 1960s, Pacific Hake female spawning biomass has ranged from well below to near unfished equilibrium biomass. The stock was estimated to have been below the unfished equilibrium in the 1960s before increasing rapidly to above unfished equilibrium in the mid-1970s and mid-1980s, followed by steady decline through the 1990s to a low in 1999. This long period of decline was followed by a brief peak in 2002 as the large 1999 year-class matured and subsequently supported the fishery for several years. Estimated female spawning biomass declined to a time-series low of 0.601 million mt in 2009 because of low recruitment between 2000 and 2007, along with a declining 1999 year-class. Spawning biomass estimates peaked again in 2014 due to a very large 2010 year-class and an above-average 2008 year-class. The subsequent decline from 2014 to 2016

is primarily from the 2010 year-class surpassing the age at which gains in weight from growth are greater than the loss in weight from mortality (growth-mortality transition). The 2014 year-class is estimated to be large, though not as large as the 1999- and 2010-year classes, increasing the biomass through 2018. The estimated biomass declined from 2018 to 2022 due to the 2014- and 2016-year classes moving through the growth-mortality transition during a period of high catches. The increase in female spawning biomass from 2022 to 2025 is due to the expected above average 2020 and 2021 cohorts entering maturity and the recent declining trend in catch. The 2025 female spawning biomass is estimated to be 67% of the unfished equilibrium level (B_0) with a 95% posterior credibility interval ranging from 29% to 157%. The median estimated 2025 female spawning biomass is 1.223 million Mt. Uncertainty in current stock status is considerable, largely due to the lack of information about recent recruitment.

The fishing intensity on the Pacific Hake stock is estimated to have been below $F_{SPR=40\%}$ in all years. Over the last five years, fishing intensity was the highest in 2019 at 86.6%, dropped in 2020 to 68.9%, increased through 2021 and 2022 to 70.8% and 73.9% respectively, then dropped in 2023 and 2024 (66.2% and 66.6%, respectively). The official coastwide total catch target adopted by the U.S. and Canada has not been exceeded since 2002. Recent catch and levels of depletion are presented in Figure 1.

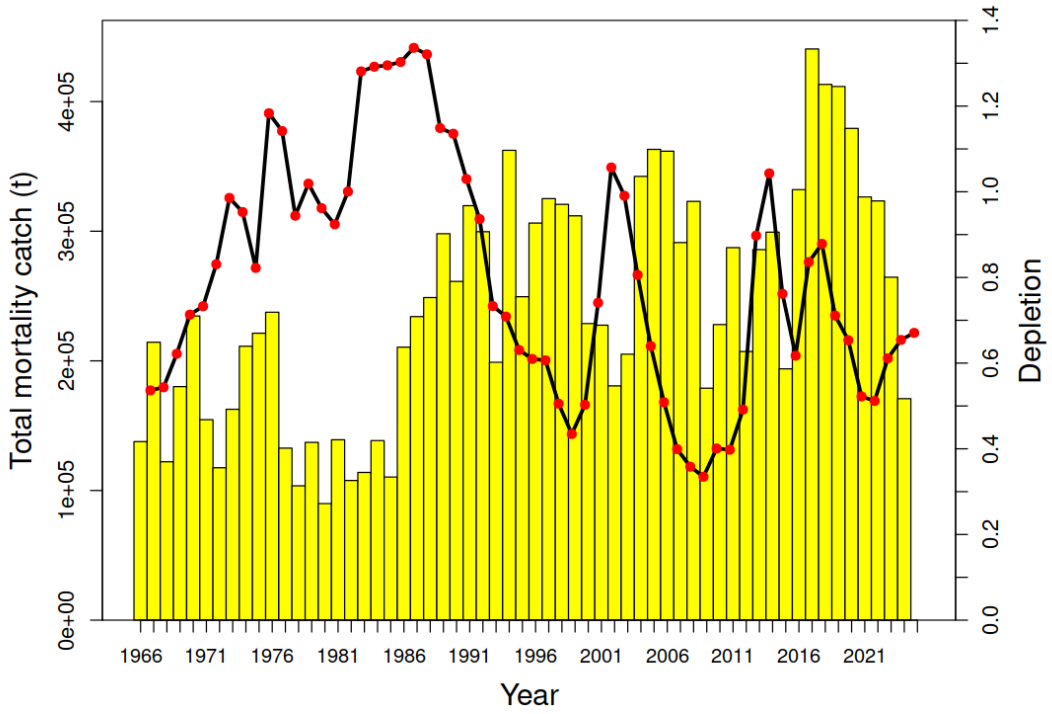

Figure 1. Total catch (mt; bars) and depletion (relative to average unexploited equilibrium level; line) for Pacific hake, 1966-2024.

For more information, please contact Aaron Berger at Aaron.Berger@noaa.gov or Chantel Wetzel Chantel.Wetzel@noaa.gov.

5. Reserves

Mapping the footprint of trawl rockfish conservation area (RCA) closures on the US West Coast
Contributed by Jameal Samhouri, jameal.samhouri@noaa.gov.

Investigators: Feist BE, Whitmire CE, Mangin T, Carbó Mestre P, Liu OR, Black B, Cohn L, Hanshew G, Molitor C, Gaines SD

Marine protected areas (MPAs) are used globally to conserve and restore marine resources, including fisheries. On the West Coast of the US, one type of MPA, rockfish conservation areas (RCAs), has been integral to managing the recovery and sustainability of multiple rockfish (*Sebastes* spp.) stocks since 2002. RCAs are season- and depth-specific closures to specified gear, such as bottom trawls; their goal has been to minimize incidental catch of several rockfish species that were declared overfished in the late 1990s and early 2000s. Quantifying how RCAs affect fish stocks depends upon comparing fish distributions and fishing activity within and outside these areas. However, detailed geospatial time series of these spatially and temporally dynamic closure areas do not exist, even though their boundaries are clearly defined in regulatory documents. As a result, resource managers have been unable to fully understand how closures affect fish populations, fishing activity and the efficacy of RCAs. We developed a methodology for converting over 20 years of RCA closure boundaries, defined in regulatory documents, into a geospatial data layer time-series of the exact boundaries used by fishers to adhere to RCA regulations. We then overlaid those layers with species distribution and habitat suitability probability models for species targeted by RCA protections to examine patterns of spatio-temporal overlap. We found that the total area of RCAs varied over time and that the boundary descriptions were challenging to convert into definitive maps. We also found that closure areas generally aligned well with species distribution and corresponding habitat suitability for the seven species that were originally declared overfished at the onset of the RCA process. These results suggest that while successful recovery of rockfish stocks relies on the synergistic effects of numerous regulatory actions, the RCAs likely play an important role.

For more information please contact Blake Feist at NOAA's Northwest Fisheries Science Center, blake.feist@noaa.gov.

6. Data Management

Contributed by Jim Fellows, james.fellows@noaa.gov.

Over the past two years, the NWFSC West Coast Groundfish Bottom Trawl Survey team has successfully completed a comprehensive review and consolidation of its database architecture, transitioning fully from legacy on-premise servers to Amazon Web Services (AWS). By utilizing AWS Relational Database Service (RDS), the program has stayed in front of NOAA Fisheries' push into the cloud as part of the Agency's Data Modernization Efforts. Our cloud migration has also allowed the team to leverage cloud-native tools such as S3 and AWS Lambda (serverless functions) to modernize and automate data management workflows.

The 2025 survey season marked a major operational milestone with the first deployment of a real-time data submission application. Using Starlink satellite internet, scientists were able to transmit data files directly to the cloud while at sea. These uploads automatically triggered serverless functions that ingested and processed the files into the production database in near real-time. This new pipeline has significantly accelerated data delivery timelines and eliminated multiple manual intervention and data collection steps typically required after the conclusion of a survey season.

7. Upcoming Work, Emerging Needs, and Challenges

UPCOMING WORK

Contributed by Brian Wells, brian.wells@noaa.gov.

- Going forward we intend to continue a coastwide perspective with collaborators at SWFSC, OSU, UW, UCSC, and MBARI. In doing so, we can study the system at the scales at which is works – from basin to individual fish.

Contributed by Christa Conway, christa.conway@noaa.gov.

- The creation of an interactive data visualization tool to improve accessibility of bycatch estimates across time and sectors.
- Krill ecology in the California current.
- Improving Estimates of Fishery Impacts on Marine Mammals by Incorporating Industry-Reported Interactions. This work will explore the potential to further improve multi-data stream Bayesian time series models by incorporating self-reported takes of marine mammals, seabirds, and sea turtles.

Contributed by Jim Fellows, james.fellows@noaa.gov.

- Public Data Catalog: In 2026, we plan to expand our automated cloud pipeline and roll out a rebuilt data catalog and access platform to improve data delivery, interoperability, and visibility for stock assessors, scientists, industry partners, and the public. This service will continue to build on our cloud architecture by providing both programmatic and interactive data access at the end of our sea-to-shore data pipeline.
- Modernized Wheelhouse Software: In preparation for 2027, we plan to deploy and test a new and improved wheelhouse data collection application to replace our legacy system. The app will use a modern local-first software stack, improve data quality in real-time, and continue to modernize our end-to-end data collection lifecycle by integrating more closely with our cloud database.

Contributed by Julia Clemons, julia.clemons@noaa.gov.

- In September 2026, the NWFSC acoustics team will conduct a 20-day gear trial of the Multifunction Trawl (MFT) aboard the NOAA Ship *Reuben Lasker*. This research leg aims to adapt midwater MFT fishing methods for the *Lasker* and develop new catch-processing workflows necessitated by its shorter back deck and unique sorting table and wet lab configuration compared to the *Shimada*. The acoustics team will conduct trawls using the MFT, equipped with pocket nets, for additional closed pocket net trawls. In

addition, up to seven days of an Intervessel Calibration (IVC) will be conducted between the *Lasker* and the CCGS *Sir John Franklin* to compare acoustic backscatter data collected by both vessels from fish sign that daytime trawling has verified is Pacific hake.

8. Other Publications

Publications are listed in the Research section.

9. Agency Contact List

Staff directory: https://www.fisheries.noaa.gov/staff-directory/northwest-fisheries-science-center-staff-directory