Sound Science
Drives Sustainable Fisheries

Ocean Conservancy | Environmental Defense Fund

Fishing is an economic engine for coastal communities, a beloved pastime and essential to food security. But fisheries themselves are complex. To understand fisheries, managers need to know the behaviors and biology of the fish, the conditions of the environments they swim in, and the priorities and needs of the people and communities that depend on these resources.

In the U.S., the National Oceanic and Atmospheric Administration (NOAA) manages the nation's marine fisheries for their long-term sustainability under the Magnuson-Stevens Fishery Conservation and Management Act, with the goals of supporting coastal communities and stewarding healthy ecosystems. To do so, NOAA and its partners have built a world-class system of data collection, science and analysis that provides critical information about the past, present and likely future of our fisheries. This information is then used by fishery managers to make important decisions about how we manage our fisheries to balance our short-term priorities with the long-term needs of conservation and stability.

The success of the U.S. fishery management system depends on the interconnected science efforts by NOAA and its partners. To understand the status of fish, ecosystems and people, data are collected in dozens of ways, including through biological sampling, surveys of marine life, scientific studies and directly from fishermen. These data are used to produce analyses such as stock assessments, environmental modeling and forecasting, revenue and employment information, and community analyses. By asking and answering key questions, scientists and managers can make good decisions about how to manage these shared resources.

The table on the next page summarizes current efforts to address these key questions and describes how the science can be improved relative to timeliness, coverage, precision, integration and accessibility of data. These improvements would bolster confidence in the data, support more responsive management, and help managers balance the ecological, economic, and community benefits of our fisheries.

Information about the Fish

How much fishing has happened in the past to predict what is sustainable for the future?

Information about the Ecosystem

How do ecosystem conditions drive changes in fisheries and how can fishing impact changes to ecosystems?

Information about the People

How fishing impacts people and the economy, and how people and the economy impact fishing?

How do we fish sustainably?

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What information do we need to fish sustainably?

Information about the fish				Information about the ecosystem				Information about the people			
What do we need to know?											
How many fish are we catching? How many have we already caught?	**How healthy are the fish?**	**How does each fish stock reproduce and grow?**	**Where are the fish located?**	**How is fishing affecting non-targeted catch (i.e., bycatch) and impacting protected resources?**	**How is fishing impacting food webs and habitat?**	**How do ocean conditions affect the stock, and how will that change?**	**Do fish have enough food and healthy habitat?**	**Who is fishing?**	**How much does fishing contribute to the U.S. economy and what is the economic performance of the seafood industry?**	**How will decisions affect people, the economy, and fishing communities?**	**What is the value of fisheries and healthy marine ecosystems to society?**
What does this information tell us, and why is it important?											
How many fish were caught in the past; real time tracking to maximize season length and avoid overfishing	Changes in fish abundance and stock status over time tells about stock health and how many fish can be removed annually based on how much catch a stock can sustain	How quickly the stock grows, how long the stock would take to rebuild, and how many fish can be removed in the future	Where fishing pressure is likely to occur, who should manage the fish and on what scale, and if stocks are shifting to new regions	What the impacts of fishing are on other species; how to meet requirements to protect, conserve, and manage protected resources	What the impacts on food webs and habitat are so they can be minimized to support abundant fish populations and healthy ecosystems	Whether changes in fish abundance are due to fishing or environment; help account for current and future impacts (e.g., on recruitment, growth, and prey availability)	Trophic interactions help understanding of stock productivity; habitat surveys inform habitat availability for fish across life stages	What communities depend on fishing and the types of vessels; businesses involved to understand impacts of tradeoffs of decisions	Fisheries contributions to jobs, communities, and state economies; informs the goal of maximizing benefits to the nation	Economic models help understanding of the potential economic impacts, tradeoffs, and likely behavioral responses of proposed policies or actions	How fisheries provide value, including and beyond dollars and jobs; assessing the value of features and species not sold in markets informs societal benefits
What tools, analyses, or products do we use to understand this information?											
Catch reporting, estimation, and monitoring (current and historical)	Stock assessments and other indicators of abundance; management strategy evaluations to test harvest control rules	Biological information (e.g., age, growth, and reproduction)	Distribution maps define the range of the stock for science and management unit and define boundaries	Catch monitoring, protected resource surveys and stock assessments	Scientific surveys and food web models; defining and assessing impacts to essential fish habitat (EFH); habitat maps; studies on fishing gear impacts on habitat	Environmental data collection and reporting tools (e.g., ecosystem status reports); forecasts and projections of ocean conditions; scientific surveys; climate vulnerability assessments	Ecosystem surveys and reporting; plankton surveys and diet studies; suitable habitat as determined by EFH; monitoring of acute impacts to habitat (e.g., with water quality monitoring)	Which communities depend on fishing and the types of vessels and businesses involved to understand the impacts and tradeoffs of decisions	Commercial fishing revenue; employment; recreational fishing economics; subsistence studies; trade flows; industry costs and price trends; catch reporting; consumer preferences; individual quota data	Analyses of fishing effort changes; the distribution of impacts; connections among fisheries; non-fishing income; catch by port; intergenerational access; cultural importance; social vulnerability; impacts on related industries	Bioeconomic modeling; non-market valuation studies; consumer surveys; seafood consumption rates
What are the types of data that are collected?											
Number of trips taken by gear type; estimates of catch (numbers of fish and by weight); bycatch (fish and other species that are caught and released); discard estimates; release mortality	Catch composition, bycatch, and recruitment data; survey trends of abundance and specific abundance studies	Samples collected dockside and during scientific surveys for: size of fish, reproductive potential (gonads, number of eggs, seasonality of spawning, sex ratio of population); age (through ear bones); genetic data	Survey presence and absence data; genetic information; tagging and catch data	Catch composition and bycatch (including protected species); protected species abundance surveys	Trophic interactions, catch and bycatch, diet studies; seafloor type; nursery areas; spawning grounds; bathymetric maps	Environmental and oceanographic data and modeling (e.g., temperature, salinity, currents, and climatic cycles like El Niño); species traits, exposure, and sensitivity; shifting stock distributions; changes in abundance and productivity	Prey abundance and diversity over time and space; diet studies; seafloor type; nursery areas; spawning grounds; bathymetric maps; information about red tides, hypoxia, pollution and associated fish kills	Vessel type and size; registered owner and designated operator; licensed crew members; home port; fishing licenses and permits; fishing history; quota ownership; cooperative membership	Landings data (including port, catch, species, location, and price); recreational trips; subsistence use; trade data; port inspections; cost estimates (e.g., labor, fuel, quota); price elasticity; seafood product data	Landings data; bioeconomic modeling; price; costs; permit data; demographics; fishery diversification, participation and networks; household revenue; reliance on fishing; poverty and unemployment; non-fishing economic data (e.g., bait shops)	Estimates of how much value people place on non-market goods and features; seafood consumption estimates
How are the data collected?											
Commercial trip reports; recreational fishing and effort surveys; logbooks; fish landing receipts; observers; electronic monitoring systems; fishing licenses or permits; targeted surveys or studies	Scientific surveys; cooperative research; detailed surveys of fish density on specific habitats; genetic surveys (e.g., close kin mark recapture); catch per unit effort data	Biological sampling from dockside intercepts, scientific surveys, and through onboard observers	Scientific surveys and catch reporting and monitoring	Commercial trip reports, observers; recreational fishing surveys; protected resource surveys; reported sightings	Scientific surveys and studies; bycatch; trophic sampling (e.g., stomach contents); coastal habitat sampling	Scientific surveys; oceanographic and ecosystem observations; research studies; trophic sampling; acoustic trawl surveys; camera and trap data collection; climate forecasts (e.g., from the Changing Ecosystems and Fisheries Initiative)	Research cruises; coastal sampling; deep-sea and coral habitat surveys; water quality sampling; harmful algal bloom monitoring	Boat registration (state, U.S. Coast Guard); vessel trip reports; fish tickets; census reports; social science surveys; permit registries; fisheries participation surveys	Landings data (including port, species, and price); recreational trips; catch by area; subsistence use and cultural importance; trade data; port inspections; cost estimates (e.g., labor, fuel, ice, fishing quota); price elasticity; seafood product data; processor employment	Fish tickets; dealer reports; vessel trip reports; economic data collection programs; economic model outputs; industry surveys; recreational fishing surveys; census; social science surveys	Economic surveys and research; social science surveys; consumer surveys; processor surveys; modeling efforts
What is the opportunity to improve how we collect or estimate this information and how will the data be improved?											
Increasing sampling rates can improve precision of estimates (reduce uncertainty); **electronic reporting** can improve accuracy, timeliness, and efficiency; **electronic monitoring** can improve bycatch accounting; **increasing voluntary reporting by anglers** (e.g., through apps) can increase data availability	**Increasing survey days at sea, expanding biological sampling, and using new technologies** (e.g., saildrones, UAVs, and eDNA) can improve collection coverage and process data more efficiently; **increasing management strategy evaluations and climate-informed decisions** can improve harvest control rules; **improving habitat information for abundance studies** can improve accuracy	**Increasing sampling and faster processing** can improve precision, accuracy, and timeliness; **increasing capacity for seasonal-to-decadal forecasting** can improve stock assessments, management strategy evaluations, and rebuilding; **using forecasts** can improve reference point ranges	**Using eDNA and specialized surveys, and increasing survey frequency and area** can improve precision accuracy and timeliness; **establishing a one-stop reporting mechanism** can reduce redundancy and improve timeliness and transparency	**Electronic monitoring** can improve bycatch accounting; **increasing surveys and observer coverage, collecting higher resolution data, and using eDNA** can reduce uncertainty; **linking catch, biological, habitat, climate, protected species, economic, and social data** can improve integration and interoperability	**Expanding ecosystem modeling capacity** improves assessment of cumulative impacts (e.g., from fishing, climate, habitat change, and competing ocean uses); **higher resolution habitat mapping** provides more precise spatial management; **collecting data in season and tracking indicators** can improve dynamic management	**Higher resolution data, use of Ecosystem and Socioeconomic Profiles, and integrating real-time ocean data and population dynamics into stock assessments** offer better forecasts and reduce uncertainty; **standardizing data and collection methods** produces comparable risk metrics; **creating scientifically rigorous data collection partnerships with industry** can increase information	**Expanding diet studies and integrating diet data into ecosystem models** projects future productivity of stocks for more responsive management; **higher resolution habitat mapping** provides more precise spatial management; **using fishermen feedback and cooperative research** allows for faster response	**National vessel registry** would improve ability to track participation across regions and allow managers to better understand opportunities for resilience; **access to data from population surveys** can increase understanding of well-being of fishing community members	**Electronic reporting** can improve accuracy, timeliness, and efficiency; **crew employment surveys** can improve employment estimates; **increasing surveys** can improve accuracy of data; **expansion of economic data collection** can support economic analyses, increase understanding of industry costs, and improve employment data	**Increasing or expanding social and economic surveys** can improve understanding of non-fishing income as part of vulnerability and resilience; **increasing seafood supply chain data** can strengthen understanding of impacts from climate, markets, imports, labor, infrastructure, and disasters	**Increasing or expanding social and economic surveys** can improve understanding of how people feel about fisheries and marine ecosystems and consumer values and priorities

Opportunities for improving the science to support fisheries management include:

- Increasing biological, habitat, ecosystem, protected species, economic, and social data collection and strengthening fishery-independent surveys
- Integrating climate and ocean information into assessments and management advice
- Modernizing collection systems, such as expanding electronic reporting and monitoring and developing interoperable data systems across regions
- Increasing collaboration by improving co-production, transparency, and feedback with fishermen, communities, Tribes, managers, and other partners

NOAA Budget Considerations

Many parts of the NOAA budget support fisheries-relevant data collection and use.

- Within the Fisheries Science and Management line of the NOAA Fisheries budget, three lines encompass many of the data collection efforts that help managers answer key questions about fisheries: Fisheries Data Collections, Surveys and Assessments; Fisheries and Ecosystem Science Programs and Services; and Observers and Training.
- More broadly, other parts of NOAA, from the Office of Oceanic and Atmospheric Research (NOAA Research) to the Office of Marine and Aviation Operations (OMAO), are critical to provide infrastructure and analysis—from running NOAA's fleet of ships for surveys to generating oceanographic forecasts—that are needed to support sustainable fisheries.

Glossary

Bycatch – the catch of non-targeted species, including fish and other animals, that are discarded.

Ecosystem Status Report (ESR) – a scientific compilation and synthesis of ecological indicators designed to support fishery management; typically produced by NOAA Fisheries for a specific region on an annual basis, the ESR includes quantitative updated information on the physical, biological, environmental, economic and social conditions of coastal and marine ecosystems.

Electronic Monitoring (EM) – the use of cameras to record catch on board vessels.

Environmental DNA (eDNA) – a valuable tool that can enhance fish stock assessments by providing a non-invasive, cost-effective and scalable way to monitor fish populations by collecting genetic material shed by organisms into the surrounding environment.

Management Strategy Evaluation (MSE) – a simulation approach to test options for marine management, monitoring and assessment against simulated ecosystem and fishery dynamics, MSE has become a key method to evaluate trade-offs among management objectives.

Overfishing – a harvest or fishing mortality rate that is too high for long-term sustainability of the stock.

Observer – a professionally trained scientific technician to observe catch on fishing vessels while at sea.

Stock Assessment – scientific efforts that involve data collection, data processing and mathematical modeling to estimate the health and size of a fish stock, measure how fishing affects the stock, and project harvest levels that achieve the largest sustainable long-term yield.

Surveys – an all-encompassing term, surveys are consistent data collection efforts that can provide data on topics like fish stock abundance, ecosystem state, and community well-being.

Trophic Interactions – the feeding relationships and food acquisition behaviors of organisms that facilitate the transfer of energy and nutrients throughout an ecosystem and link species into a complex web of connections where one organism feeds upon another.

Vulnerability Assessments – identify what species, habitats or communities may be most vulnerable based on their exposure to projected changes in the environment based on their characteristics; can help identify areas where additional research and action are needed to reduce risks.