frontiers | Frontiers for Young Minds

BIODIVERSITY
Published: 26 June 2024
doi: 10.3389/frym.2024.1331893

THE DIVERSITY OF SCIENCE BEHIND U.S. SEAFOOD

***Kristy Wallmo*[1*], *Danika Kleiber*[2], *David Tomberlin*[1], *Phoebe Woodworth-Jefcoats*[3] and *Thomas Oliver*[4]**

[1] *Division of Economics and Social Analysis, Office of Science and Technology, National Marine Fisheries Service, Silver Spring, MD, United States*

[2] *Social-Ecological and Economic Systems Program, Ecosystem Sciences Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, United States*

[3] *Pelagic Research Program, Ecosystem Sciences Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, United States*

[4] *Archipelagic Research Program, Ecosystem Sciences Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI, United States*

YOUNG REVIEWERS:

MS. BRINGEWATT'S SCIENCE CLASS

AGES: 13–14

JOY

AGE: 14

Since 2014, people have been eating more and more seafood like fish, shrimp, and plant-based seafood like seaweed. In the United States, seafood even features in some popular television shows such as *Wicked Tuna* and *Deadliest Catch*. But did you know that before you sit down to enjoy a seafood dinner, many types of scientists have been working together to answer questions like: "How many fish can we catch without taking too many?" and "How will catching one species affect other species in the ecosystem?". Scientists even study questions like: "How does catching fish and other types of seafood affect a community?". In this article, we will explore how fish, shrimp, clams, and other seafood resources are managed in the U.S., and why many different types of scientists are needed to make sure that these

resources can sustainably provide food, jobs, recreation, and cultural benefits to people who use them.

WHAT CAN SCIENCE DO FOR SEAFOOD?

Humans eat a lot of seafood. When you think of seafood, you might think of tuna salad, fish sticks, or shrimp, but seafood also includes things like octopus, clams, and even seaweed. In most countries, the amount of seafood eaten has increased during the last 50 years, in part due to expansions in aquaculture (farming fish instead of catching them in the wild) and increased access to seafood products. In the U.S., the average person went from eating 14 kg (31 pounds) of seafood in 1961 to almost 23 kg (50 pounds) in 2021 (Figure 1). That is over 8 million tons of seafood for the whole country in 2021! Seafood is big business, and it even features on popular reality TV shows like *Deadliest Catch* and *Wicked Tuna*. But catching the fish is only one part of the story. Behind the scenes, there are many kinds of scientists working to keep the seafood industry healthy and **sustainable**.

SUSTAINABLE

Describes humans and nature coexisting to support the current and future generations.

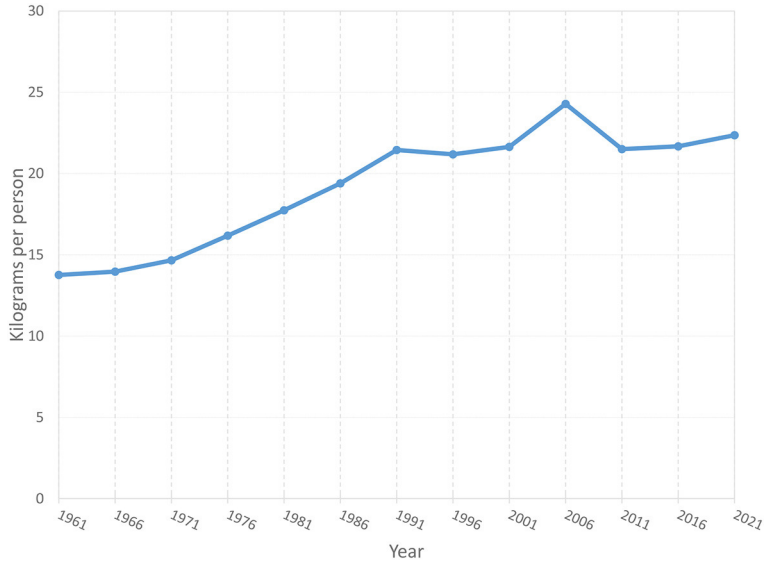

Figure 1

U.S. seafood consumption per person, 1961–2021. Data include all fish species and major seafood commodities, including crustaceans, cephalopods, and other mollusc species. You can see that seafood consumption has risen considerably since the 1960s (reprinted with permission from https://ourworldindata.org).

You might ask yourself why the seafood industry needs science. Well, not only do we need scientists, we need many different types of scientists working together to answer questions like: "How many fish can we catch without taking too many?" and "How will fishing rules impact people and their livelihoods and communities?". Scientists even address questions such as whether the "rules" of fishing are helping or hurting some people more than others. These kinds of questions often have very complex answers that depend on things like the type of fish, types of fishing methods, environmental factors (such as variations in the temperature of the ocean), and human **fishing communities**. In this article, we will explore how scientists from fields

FISHING COMMUNITIES

Places where fishers live, or a community based on a type of fishing gear, species fished for, shared values, or other factors.

like economics, sociology, anthropology, ecology, oceanography, and biology work together to address questions like these, which ultimately help maintain healthy seafood populations that provide food, jobs, recreation, and cultural benefits.

HOW ARE FISHERIES MANAGED IN THE U.S.?

FISHERY

An occupation, an industry, or a season for catching seafood, particularly fish and shellfish. Fishery can also refer to the location where seafood is caught, or the business of catching the species.

The term **fishery** refers to the business of catching seafood—it can refer to an occupation, an industry, or how, where, or when seafood is caught. In the U.S., fisheries that exist within 3 miles of the coastline are managed by the states closest to that fishery. For example, the Atlantic blue crab fishery in the Chesapeake Bay is managed by Virginia and Maryland. These states tell blue crab fishers how many crabs they can take during a certain period of time, or where they can set crab traps during certain seasons, or other rules that keep the fishery healthy. But most U.S. fisheries exist in areas called federal waters. Federal waters cover everything between 3 and 200 miles from the coastline. Fisheries in federal waters are managed by the federal and tribal governments, management councils, and commissions. These groups, along with scientists from other organizations, do research to help make and evaluate the rules for managing and maintaining healthy seafood species—from familiar species like tuna, cod, salmon, scallops, and crab, to some not-so-familiar species like the moonfish and tilefish (Figure 2). In total, the U.S. manages 492 different **fish stocks**, and about 86% of them are considered healthy and not overfished. In addition to keeping seafood populations healthy, fisheries management makes sure that the economic, social, and cultural benefits from fishing are sustainable, meaning that those benefits continue for everyone involved—fishers, fishing communities, and society. And of course, fisheries management works to make sure that other marine (ocean-living) animal populations and **ecosystems** are healthy and sustainable. To do all of these things successfully requires a lot of science from a variety of fields.

FISH STOCK

A group of fish of the same species that live in the same geographic area and mix enough to breed with each other when mature.

ECOSYSTEMS

A group of living organisms that live in and interact with each other in a specific environment.

BIOLOGY AND ECOLOGY

LIFE CYCLE

The sequence of biological changes that occurs as an organism develops from an egg into an adult, until its death.

Biology is the study of living organisms, and ecology is a branch of biology that studies the relationships of organisms to each other and their environments. In fisheries management, biology and ecology provide the building blocks for understanding the **life cycle** of a fish stock—how a group of fish of the same species spends their whole life. Biologists and ecologists help us understand how large the fish stock is and how it changes in response to changes in the environment or in response to people catching the fish. Because it would be impossible to count all the fish in a stock one by one, scientists take samples of fish in different areas over time. Information such as age, size, and sex of the fish in the sample is used to predict how many fish there are in a stock and how many can be harvested without causing the population

Figure 2

A variety of seafood species was harvested in the U.S. in 2021. Did you or your family eat any of these?

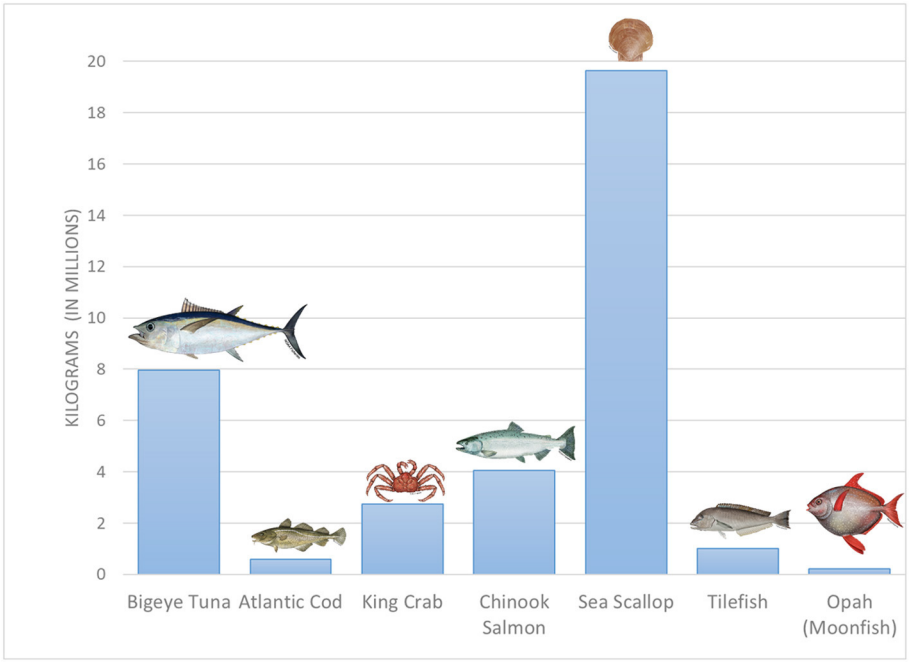

Figure 2

to become too small. In the same way, biology and ecology help scientists understand the life and habits of other marine animals like whales, dolphins, and sea turtles, so that fishers can avoid accidentally harming them. For example, scientists studying loggerhead sea turtles found that when fishers in the North Atlantic swordfish fishery used a certain type of fishing hook and bait (Figure 3), the number of loggerhead sea turtles that were accidentally caught went down [1]. This finding helped both the swordfish fishers, who must stop fishing if they accidentally catch too many turtles, and the population of loggerhead sea turtles.

OCEANOGRAPHY

Oceanography is the study of the ocean, including its temperature, salinity (how salty the water is), pH (a measure of acidity), tides, currents, and other physical, chemical, or biological characteristics. In fisheries management, oceanographers often examine how changes in ocean characteristics affect fish stocks, the ecosystems where fish live, and even patterns of behavior among fishers. Oceanographers might address questions like how climate patterns impact the ocean, and how this in turn may affect fish populations. The information that oceanographers collect can be used to improve stock assessment predictions and to help us better understand processes and relationships within larger ecosystems. For example, scientists studying an ecosystem off the U.S. West Coast found that it is important to include the effects of decreasing pH levels, or **ocean acidification**, in their predictions. They showed that if the ocean

OCEAN ACIDIFICATION

A reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere.

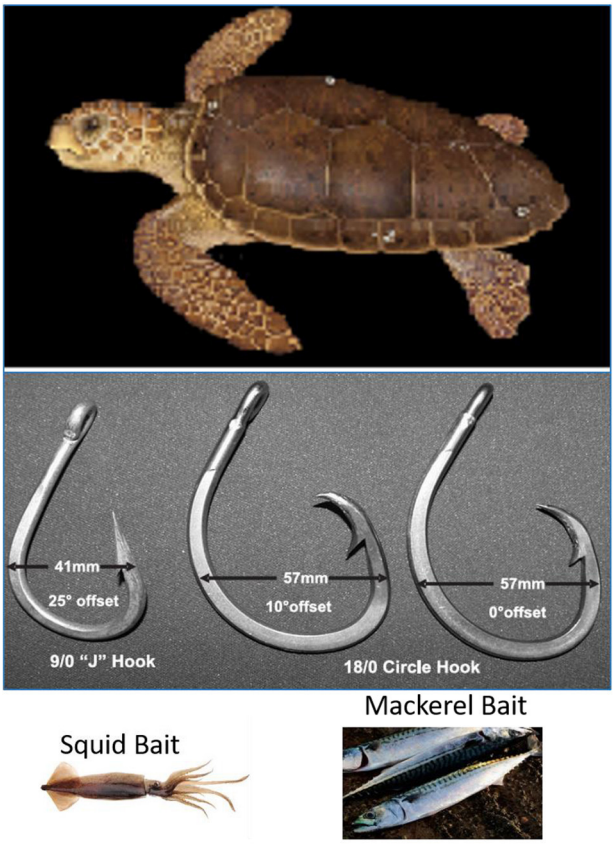

Figure 3

Biology and ecology can help people understand the life and habits of other ocean animals, so that fishers can take precautions to avoid catching or harming them by accident. For example, fewer loggerhead sea turtles were accidentally caught by fishermen fishing with circle hooks and mackerel bait compared to "J" hooks and squid bait.

becomes more acidic, the population size of three different species would decrease and fishers would have to catch fewer of them [2]. This research can help fishery managers set appropriate rules to promote sustainable fishing.

ECONOMICS

Economics is the study of how people and societies use resources for various purposes, or more broadly, the study of decision making. Money is associated with economics because the benefits and costs of decisions are often measured in dollars or other currencies. In fisheries management, economists often look at the costs and benefits of "rules" called management options, so that they can choose the ones that keep enough fish in the water while still supporting fishing communities. Sometimes these options include closing certain areas to fishing so that the number of fish increases or requiring fishers to use certain types of fishing gear that do less damage to marine ecosystems. For example, economists found that fishers in Hawaii would lose less money if fisheries management closed fishing areas in the Eastern Pacific rather than closing fishing areas in the Western and Central Pacific [3]. Understanding the costs and benefits of specific

management options can help fisheries managers choose the rule that has the most benefits for fishers, while still making sure that fish stocks and marine ecosystems are healthy.

SOCIOLOGY AND ANTHROPOLOGY

Sociology and anthropology are sciences that study human behavior, human cultures, and other aspects of human societies. In fisheries management, sociologists and anthropologists do research to understand the people and fishing communities who depend on the ocean for food, jobs, or their way of living. These scientists might examine things that are hard to measure, like how the ocean and fish are important to a community's culture, spirituality, or religion. Sociologists and anthropologists might also study things like how many jobs in a fishing community might be affected if a new fishing rule is put in place, or whether the regulation will affect some groups more than others. For example, researchers working in Alaska found that rules designed to increase Native Alaskan participation in fisheries did not work as they were intended to, and were able to suggest different strategies to improve fishing access for Alaska Natives [4]. This research can help fisheries management understand what might and might not help fisheries become more balanced, and ultimately improve the success of fisheries management for everyone. Anthropologists and sociologists have conducted many interviews with fishers and fishing community members, with some interviews dating back to 1895! You can read these interviews and more at Voices from the Fisheries.

This article described just some of the ways that different types of science are used in U.S. fisheries management—there are many more examples and even other types of science, like computer science and genetics, involved in managing fisheries. As fisheries management evolves to meet the changing needs of society and our changing environment, good science from many fields will be needed as well. So if you think you would like a career that helps maintain healthy and sustainable marine environments and all the benefits they provide, you know that there are many relevant fields of science to choose from. And the next time you enjoy a delicious meal of fish or shrimp or any of the other 400+ stocks that are managed in the U.S., remember that a lot of science was involved before that seafood was caught and put on your plate!

ACKNOWLEDGMENTS

The authors would like to thank our young reviewer A. Wesch for their help in preparing this manuscript for submission.

REFERENCES

1. Watson, J. W., Epperly, S. P., Shah, A. K., and Foster, D. G. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Can. J. Fish. Aquat. Sci.* 62:968–81. doi: 10.1139/f05-004
2. Kaplan, I. C., Levin, P. S., Burden, M., and Fulton, E. A. 2010. Fishing catch shares in the face of global change: a framework for integrating cumulative impacts and single species management. *Can. J. Fish. Aquat. Sci.* 67:1968–82. doi: 10.1139/F10-118
3. Chan, H. L., and Pan, M. 2021. Fishing trip cost modeling using generalized linear model and machine learning methods – A case study with longline fisheries in the Pacific and an application in regulatory impact analysis. *PLoS ONE* 16:1–23. doi: 10.1371/journal.pone.0257027
4. Richmond, L. 2013. Incorporating indigenous rights and environmental justice into fishery management: comparing policy challenges and potentials from Alaska and Hawai'i. *Environm. Manage*. 52:1071–84. doi: 10.1007/s00267-013-0021-0

SUBMITTED: 01 November 2023; **ACCEPTED:** 12 June 2024;
PUBLISHED ONLINE: 26 June 2024.

EDITOR: Hervé Claustre, Centre National de la Recherche Scientifique (CNRS), France

SCIENCE MENTORS: Maila Hallare and Emily Chen

CITATION: Wallmo K, Kleiber D, Tomberlin D, Woodworth-Jefcoats P and Oliver T (2024) The Diversity of Science Behind U.S. Seafood. Front. Young Minds 12:1331893. doi: 10.3389/frym.2024.1331893

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

MS. BRINGEWATT'S SCIENCE CLASS , AGES: 13–14

We are a class of 8th grade scientists who have been exploring the theme of water on our planet and the many ways water is connected to various science disciplines and current research efforts.

JOY, AGE: 14

Joy spends her days reading, playing board games, and snuggling with her dog Mabel. She hopes to explore her love of biology when she starts high school next year and has big plans to study veterinary medicine abroad after graduation. In addition to school, Joy loves playing both the viola and piano.

AUTHORS

KRISTY WALLMO

Dr. Kristy Wallmo has worked for NOAA Fisheries for over 20 years, conducting research to help us understand economic values, economic impacts, and trade-offs associated with alternative policies and conditions of marine resources. She is especially interested in exploring avenues for integrating ecosystem service values into fisheries management. One of the many things she enjoys about her job is the opportunity to talk with different people about their attitudes and opinions about the marine environment. *kristy.wallmo@noaa.gov

DANIKA KLEIBER

Dr. Danika Kleiber is a Social Scientist at the National Marine Fisheries Service Pacific Island Fisheries Science Center in Honolulu. Throughout her career she has woven together her background in gender and development and behavioral ecology, which has led to a specialization in applied equity approaches to fisheries research and management.

DAVID TOMBERLIN

Dr. David Tomberlin is an economist with the National Marine Fisheries Service, the federal government agency that manages the ocean fisheries of the United States. His main professional activities are collecting and analyzing data, writing research papers, and serving as a member of scientific and management groups. David's current interests include coastal habitat management and Southeast Asian fisheries. He has graduate degrees in agricultural and natural resource economics and an undergraduate degree in English literature.

PHOEBE WOODWORTH-JEFCOATS

Dr. Phoebe Woodworth-Jefcoats is a research oceanographer. She studies the North Pacific Ocean, its food webs, and its fisheries. She is especially interested in the effects of climate change. Her favorite part of her job is using data to create images that help her understand what is happening beneath the ocean's surface. Phoebe works at the NOAA Fisheries Pacific Islands Fisheries Science Center. She holds degrees in meteorology, physical oceanography, and marine biology.

THOMAS OLIVER

Dr. Thomas Oliver is a Research Ecologist at the Pacific Island Fisheries Science Center who mostly studies coral reefs and what we can do to make sure that these special ecosystems are managed sustainably. He also advises the Western Pacific Fisheries Management Council on the best ways to keep our fisheries productive and sustainable across the US Pacific.