National Aquaculture Development Plan

Draft (2024)

Committee on Environment of the National Science and Technology Council (NSTC) | Subcommittee on Aquaculture

National Aquaculture Development Plan, Overview

This National Aquaculture Development Plan (NADP) describes how federal agencies are advancing the contributions of aquaculture to support public health and nutrition, resilient communities, a strong economy, and a healthy planet. The NADP outlines federal activities in research and science, economic development, and regulatory efficiency that support using aquaculture for commercial, conservation, and restoration purposes. It builds on the work of federal and state agencies, Tribes and Indigenous communities, universities, and aquaculture stakeholders to design and implement cutting-edge scientific, technical, operational, and policy tools that generate significant benefits from aquaculture and aquatic products and minimize their negative impacts to people and the environment.

As defined in the National Aquaculture Act of 1980, aquaculture includes the cultivation of many different aquatic animal and plant species groups (e.g., finfish, bivalves, crustaceans, seaweeds, and other aquatic plants) in all aquatic environments (coastal, marine, brackish, and fresh water) and production systems (ponds, raceways, tanks, and net pens). Aquaculture has many applications:

- Food production
- Supporting recreational and commercial fisheries
- Providing ecosystem services
- Supporting fisheries for subsistence and those of Native American Indian Tribes and Alaska Native entities
- Conserving endangered and protected species
- Restoring habitats (e.g., oyster and coral reefs)
- Providing raw materials to produce biofuels, cosmetics, pharmaceuticals, and other industrial products

Aquaculture science is a multidimensional field that combines agriculture and aquatic ecosystem disciplines. Methods for cultivating aquatic organisms are diverse and complex, often requiring species-specific protocols for breeding, rearing, and harvesting in various environments, including ponds, rivers, lakes, and marine or land-based closed-containment systems that use tanks or raceways. Worldwide aquaculture includes more than 600 species,[1] including at least 46 that are produced domestically.[2]

[1] FAO. 2019. The State of the World's Aquatic Genetic Resources for Food and Agriculture. Rome (Italy): FAO. https://www.fao.org/documents/card/en/c/ca5256en

[2] USDA. 2017. The U.S. Country Report of the First State of the World's Aquatic Genetic Resources for Food and Agriculture. https://www.ars.usda.gov/news-events/news/research-news/2017/usda-agency-led-group-profiles-us-aquaculture-for-world-report/

Although emerging needs are noted, the federal actions outlined in this NADP describe current activities authorized by existing legislative authorities and that are funded through U.S. Congressional allocations.

About the National Aquaculture Development Plan (NADP)

The draft NADP is a product of the Subcommittee on Aquaculture (SCA), a statutory subcommittee that operates under the Committee on Environment of the National Science and Technology Council (NSTC) under the Office of Science and Technology Policy in the Executive Office of the President.[3] The SCA serves as the federal interagency coordinating group to increase the overall effectiveness and productivity of federal aquaculture research, regulation, technology transfer, and assistance programs. This interagency coordinating group has been in operation since before the National Aquaculture Act, which was enacted in 1980 and charged the U.S. Department of Agriculture (USDA), U.S. Department of Commerce (DOC), and U.S. Department of the Interior (DOI) with drafting a NADP, which was published in 1983.[4] While the National Aquaculture Act called for periodic updates of the NADP, a comprehensive update has not been completed until now. The original NADP drafted four decades ago does not capture the progress the U.S. aquaculture community has made to develop and adopt scientific advancements and sustainable aquaculture practices.

National Aquaculture Act of 1980

The National Aquaculture Act of 1980 states that "aquaculture has the potential for reducing the United States trade deficit in fisheries products, for augmenting existing commercial and recreational fisheries and for producing other renewable resources, thereby assisting the United States in meeting its future food needs and contributing to the solution of world resource problems. It is, therefore, in the national interest, and it is the national policy, to encourage the development of aquaculture in the United States."[5] The National Aquaculture Act is periodically reauthorized in the Farm Bill.

The NADP includes an overview chapter, three thematic plans (research planning, regulatory efficiency, and economic development), and progress reports on federal regulatory and scientific activities conducted after the issuance of the regulatory and research plans. During the past several years, the SCA drafted, invited public input on, and then published the first two thematic parts of the new NADP: a *National Strategic Plan for Aquaculture Research*[6] and the *Strategic*

[3] Previously known as the Interagency Working Group on Aquaculture (IWGA) and the Joint Subcommittee on Aquaculture (JSA). National Aquaculture Act of 1980 (Pub. L. 96-362. 94 Stat. 1198, 16 U.S.C. 2801, et seq.); the National Aquaculture Improvement Act of 1985 (Pub. L. 99-198, 99 Stat. 1641). The Department of Agriculture, Department of Commerce, The Department of Interior, and the White House Office of Science and Technology Policy co-chair the SCA. Members include the multiple agencies from the Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Health and Human Services, Department of the Interior, Department of State, Environmental Protection Agency, National Science Foundation, and the Office of Management and Budget.
[4] National Aquaculture Development Plan (1983). https://repository.library.noaa.gov/view/noaa/9341
[5] National Aquaculture Act of 1980, sect. (2)(c) (Pub. L. 96-362. 94 Stat. 1198, 16 U.S.C. 2801, et seq.), https://www.ars.usda.gov/SCA/National%20Aquaculture%20Act%20of%201980.pdf
[6] See the *National Strategic Plan for Aquaculture Research*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Research%20Plan_Final%20508%20compliant.pdf

Plan to Enhance Regulatory Efficiency in Aquaculture.[7] The *Aquaculture Economic Development Plan*,[8] the third and final pillar of the draft NADP, was issued for public comment at the same time as the draft overview of the NADP. The three thematic plans describe the work of federal agencies to support commercial and conservation aquaculture. The three thematic strategic plans identify specific opportunities to support ongoing research, foster new partnerships, and increase both internal and external awareness of the benefits and risks of aquaculture.

The NADP describes how federal agencies are advancing the contributions of aquaculture to support public health and nutrition, resilient communities, a strong economy, and a healthy planet through research and science, economic development, and regulatory efficiency that support using aquaculture for commercial, conservation, and restoration purposes. It outlines collective work needed from federal and state agencies, Tribes, universities, and aquaculture stakeholders to design and implement cutting-edge scientific, technical, operational, and policy tools that generate significant and sustainable benefits from aquaculture while minimizing negative impacts to aquatic ecosystems and user conflicts.

NADP Policy Background

Domestic aquaculture production and uses of aquaculture techniques for conservation advance economic, social, and environmental priorities outlined in the Ocean Climate Action Plan;[9] the National Strategy on Hunger, Nutrition, and Health;[10] Administration priorities for agriculture and support for rural and Tribal communities,[11] and Executive Orders addressing climate change,[12] federal research and development supporting domestic manufacturing and jobs,[13] domestic manufacturing and supply chains,[14] food security,[15] and the resiliency of the U.S. seafood industry.[16]

Aquaculture provides opportunities to produce high-quality and nutritious food, good jobs, and economic development in rural, urban, and coastal areas. Aquaculture can be one of the most environmentally efficient ways to produce food; it optimizes the use of feed and space, has a low

[7] See the *Strategic Plan to Enhance Regulatory Efficiency in Aquaculture*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Regulatory%20Efficiency%20Plan_Final%20508%20compliant.pdf
[8] See the SCA Economic Development Task Force page: https://www.ars.usda.gov/sca/economictaskforce.html
[9] Ocean Policy Committee. 2023. Ocean Climate Action Plan. A report by the White House Ocean Policy Committee. https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf
[10] The White House. *Executive Summary: Biden-Harris Administration National Strategy on Hunger, Nutrition, and Health* (27 September 2022). https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/27/executive-summary-biden-harris-administration-national-strategy-on-hunger-nutrition-and-health/
[11] USDA Strategic Plan for Fiscal Years 2022 – 2026. https://www.usda.gov/sites/default/files/documents/usda-fy-2022-2026-strategic-plan.pdf
[12] Executive Order 13990 Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/
[13] Executive Over on Federal Research and Development in Support of Domestic Manufacturing and United States Jobs. https://www.whitehouse.gov/briefing-room/presidential-actions/2023/07/28/executive-order-on-federal-research-and-development-in-support-of-domestic-manufacturing-and-united-states-jobs/
[14] Executive Order on Supply Chains. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/24/executive-order-on-americas-supply-chains/
[15] The White House. *National Security Memo on Strengthening the Security and Resilience of the United States Food and Agriculture.* https://www.whitehouse.gov/briefing-room/presidential-actions/2022/11/10/national-security-memorandum-on-on-strengthening-the-security-and-resilience-of-united-states-food-and-agriculture/
[16] Executive Order 13921 Promoting American Seafood Competitiveness and Economic Growth. https://www.federalregister.gov/documents/2020/05/12/2020-10315/promoting-american-seafood-competitiveness-and-economic-growth

carbon footprint, and often supports ecosystem health.[17,18,19] In addition, expanded domestic aquaculture will be an essential element of food systems designed to reduce and mitigate the effects of climate change.[20,21] Aquaculture in the form of hatchery-reared seedstock or fingerlings is used by government agencies and their partners to conserve and restore more than 70 endangered or threatened species,[22] enhance commercial and recreational fisheries (e.g., Pacific salmon), restore ecologically important habitats (e.g., oyster and coral reefs), and mitigate climate change and other ecosystem stressors such as excess nutrients (e.g., oyster reef and marsh grass restoration). The term "conservation aquaculture" is used here to encompass the conservation, restoration, and enhancement uses of aquaculture. Climate change is driving the need for aquaculture-based actions by federal, state, and Tribal agencies and their partners as part of their biodiversity conservation strategies.

The Ocean Climate Action Plan cites several actions to "expand and decarbonize sustainable U.S. aquaculture production to enhance resilience of U.S. and global seafood to the impacts of climate change."[23] These include:

- Enable and support the expansion of climate-ready aquaculture operations using the best available information on current and future ocean and coastal ecosystem conditions to inform science-based planning for Aquaculture Opportunity Areas.
- Improve resource access to scale up seafood farming projects for Indigenous communities, Tribal Nations, and community-based organizations to increase access to climate-smart agriculture for food production and to build climate resilience.
- Reduce costs and timeframes for siting and permitting new and existing commercial-scale aquaculture operations through investments in Aquaculture Opportunity Areas and other key areas that support sustainable industry growth and inform effective management decisions.
- Expand research to better understand hatchery and out-planting best practices for protecting and restoring ocean and coastal habitats such as coral and oyster reefs and marsh grass habitats, as well as for important recreational, commercial, and endangered species (e.g., Pacific salmon).

In recent decades, U.S. wild-caught fisheries and aquaculture production have not kept up with growing U.S. seafood demand, so the national reliance on seafood imports has increased. Fifty percent of these imports are derived from aquaculture. The United States currently imports 65 to 70 percent of the seafood consumed domestically, deepening our nearly $17-billion seafood trade deficit.[24] Additionally, market and supply chain disruptions caused by the COVID-19

[17] Rust, MB. et al. 2014. Environmental performance of marine net-pen aquaculture in the United States. Fisheries 39(11): 508-524. https://www.tandfonline.com/doi/full/10.1080/03632415.2014.966818
[18] Froehlich, HE., et al. 2018. Comparative terrestrial feed and land use of an aquaculture-dominant world. PNAS 115(20): 5295-5300. https://www.pnas.org/content/115/20/5295
[19] Gephart, JA, et al. 2021. Environmental performance of blue foods. Nature 597: 360-365
[20] Costello et al. 2020. *The future of food from the sea*. High Level Panel for a Sustainable Ocean Economy. www.oceanpanel.org/future-food-sea
[21] Froehlich, HE, et al. 2021. Securing a sustainable future for US seafood in the wake of a global crisis. Marine Policy 124: 104328. https://www.sciencedirect.com/science/article/pii/S0308597X20309751
[22] US Fish and Wildlife Service. *2022 Fish and Aquatic Conservation Annual Report – Confluence: Connecting Partners and Conservation*. https://www.fws.gov/media/2022-fish-and-aquatic-conservation-annual-report
[23] Ocean Policy Committee. 2023. Ocean Climate Action Plan. A report by the White House Ocean Policy Committee. https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf
[24] National Marine Fisheries Service. 2022. Fisheries of the United States, 2020. U.S. Department of Commerce, NOAA Current Fisheries Statistics No. 2020.

pandemic highlight the need to expand options for domestic seafood supplies and jobs, particularly in hard-hit and underserved rural communities, and to reduce U.S. reliance on imported seafood.[25]

As aquaculture provides half the global seafood supply,[26] it is critical for providing food to the United States and the world. Therefore, it will be an essential part of a climate-resilient, sustainable food strategy.[27] The NADP will help inform a U.S. National Strategy for a Sustainable Ocean Economy, which is being developed as part of a 17-nation initiative in which each country will develop a plan for sustainably managing marine areas under their national jurisdiction.[28] The U.S. National Strategy will outline the vision, goals, and high-level actions needed for a robust, equitable, secure, sustainable ocean economy enabled by healthy, resilient ocean ecosystems, including sustainable aquaculture production practices and policies advanced in the NADP.

Benefits and Challenges, and Advances in Addressing Challenges

This is the first NADP to be published since the first one was published 40 years ago. During that time, global aquaculture production has substantially increased and now supplies half of the world's seafood.[29] The United States has ideal resources to become a world leader in the aquaculture production of fish, mollusks, crustaceans, and algae and in using aquaculture for conservation. These resources include:

- Ample available land
- A leading global supply of feed resources
- Expansive aquatic resources, including vast coastal and exclusive economic zones
- A rigorous environmental regulatory framework
- Advanced technology and scientific research
- One of the largest seafood markets in the world

Using aquaculture as a tool to produce food and to restore species and habitats can provide a variety of economic, social, and environmental benefits. Aquaculture can also pose risks, because it has the potential to create environmental damage, disrupt rather than complement existing economic activities, or be implemented with unsustainable social practices.[30,31,32,33]

[25] Love DC, et al. 2021. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. Glob Food Sec. 28: 100494. Doi:10.10116j.gfs.2020.100476.
[26] FAO 2022. State of the World Fisheries 2022. Rome (Italy): FAO. https://www.fao.org/publications/home/fao-flagship-publications/the-state-of-world-fisheries-and-aquaculture/en
[27] Costello et al. 2020. The future of food from the sea; Nature 588(7836): 95-100. Doi:10.1038/s41586-020-2016-y; Golden, CD., et al. 2021. Aquatic foods to nourish nations. Nature 598: 315-320.
[28] Federal Register. 2023. Request for Information; National Strategy for a Sustainable Ocean Economy. 88FR 42111, June 29, 2023.
[29] FAO 2022. State of the World Fisheries and Aquaculture 2022. Rome (Italy): FAO. https://www.fao.org/publications/home/fao-flagship-publications/the-state-of-world-fisheries-and-aquaculture/en;
[30] Stentiford GD, et al. 2020. Sustainable aquaculture through the One Health lens. Nature Food 1, 468-474. https://www.nature.com/articles/s43016-020-0127-5
[31] Clavelle T, et al. 2019. Interactions and management for the future of marine aquaculture and capture fisheries. Fish and Fisheries, 20(2): 368-388. https://onlinelibrary.wiley.com/doi/abs/10.1111/faf.12351
[32] Price, CS, Morris JA. 2013. Marine cage culture and the environment: twenty-first century science informing a sustainable industry. NOAA-NCOSS Technical Memorandum NOS-NCCOS-211. US Department of Commerce. https://www.noaa.gov/stories2013/pdfs/2013_PriceandMorris_MarineCageCultureandTheEnvironment(5).pdf
[33] Shumway, S. ed. 2011. Shellfish Aquaculture and the Environment. John Wiley and Sons. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470960967

Federal agencies and their partners are working to expand efforts to address challenges to commercial aquaculture and the uses of aquaculture for conservation and enhancement. For example, a 2020 series of listening sessions entitled "Aquaculture is Agriculture" provided stakeholders an opportunity to communicate 35 recommendations on how to strengthen domestic aquaculture.[34] The benefits and challenges posed by commercial and conservation aquaculture, along with notable advances in addressing these challenges contributed by federal agency actions, are outlined below.

Federal agencies are working with each other, state agencies, Tribes, and industry to improve the coordination, timeliness, and functioning of the federal aquaculture regulatory system. In addition, federal partnerships with industry, state, and academic partners on aquaculture science and on research and development have produced notable advancements in the sustainability and efficiency of commercial aquaculture production.[35] The use of aquaculture as a tool or technique for conservation, restoration, or enhancement of species and habitats has also been refined during the past 40 years. Government agencies and their partners use hatchery-reared stock to conserve and restore endangered or threatened species, enhance commercial and recreational fisheries, restore ecologically important habitats (e.g., oyster reefs), and mitigate climate change and other ecosystem stressors such as excess nutrients (e.g., oyster reef and marsh grass restoration).

While the overview to the NADP outlines the benefits and challenges, as well as advances made in commercial and conservation aquaculture separately, these two parts of aquaculture overlap and are interdependent. For example, developing hatchery infrastructure and aquatic health management practices for conservation aquaculture benefits the recovery of threatened and endangered aquatic species and creates production technologies and scientific understanding that are transferrable to the commercial aquaculture sector—and vice-versa.

The benefits of commercial aquaculture include:

- ***Nutrition:*** Seafood is one of the best sources of nutrients essential for human well-being; studies show beneficial associations with infant brain development and other health benefits.[36] U.S. federal dietary guidelines recommend an increase in annual seafood consumption from 19.2 pounds per capita to 26 pounds per capita.[37]
- ***Business, jobs, and community resilience:*** U.S. aquaculture produces $1.5 billion in annual farmgate sales, or 20 percent of U.S. seafood production by value. This supports direct and indirect activities up and down the value chain (equipment, feeds, fish health services, transportation, food service, retail/supermarkets). For instance, the United States

[34] Aquaculture is Agriculture: USDA's Role in Supporting Farmers of Fish, Shellfish, and Aquatic Plants. https://www.usda.gov/sites/default/files/documents/aquaculture-agriculture-colloquim.pdf

[35] See the *Strategic Plan to Enhance Regulatory Efficiency in Aquaculture*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Regulatory%20Efficiency%20Plan_Final%20508%20compliant.pdf; Tucker and Hargreaves, eds. 2008. Environmental Best Management Practices for Aquaculture. Ames (IA): Wiley-Blackwell; Shumway, S.E. Ed. 2011. Shellfish aquaculture and the environment. Ames (IA): Wiley-Blackwell.

[36] Gephart JA et al. 2020. Scenarios for global aquaculture and its role in human nutrition. Rev Fish Sci Aquac. 29(1):122-138; Hibblen JR et al. 2019. Relationships between seafood consumption during pregnancy and childhood and neurocognitive development: Two systematic reviews. Prostaglandins Leukot Esst FattyAcids. 151:14-36. Doi:10.1016/j.plefa.2019.10.002; Love DC et al. 2017. Fisheries, food, and health in the USA: The importance of aligning fisheries and health policies. Agric Food Secur. 6:16 doi: 10.1186/s400066-017-0093-9

[37] USDA and U/S Department of Health and Human Services. 2020. Dietary Guidelines for Americans, 2020-2025. 9th Edition. https://www.dietaryguidelines.gov/sites/default/files/2021-03/Dietary_Guidelines_for_Americans-2020-2025.pdf

is a major producer of agricultural fish and shrimp feed ingredients (e.g., soy) that are exported around the world.

- ***Food security:*** The high U.S. reliance on seafood imports was recently identified by the Department of Homeland Security as a key national economic and food supply vulnerability, and the growth of domestic aquaculture was recommended as one of six key national priorities to support domestic food system resilience.[38]
- ***Equity, environmental justice, and social effects:*** Aquaculture offers opportunities for jobs, professional development, and investments not historically available in underserved and underrepresented rural and coastal communities.
- ***Climate resilience:*** Aquaculture can be used as a tool to adapt to climate changes. For example, hatchery and larval reading methods can be adjusted to improve animal survival through the most vulnerable parts of a life cycle. In addition, organisms can be selectively bred for adaptation to changing climate conditions, and site and species selections can be made to improve long-term resilience.

The challenges of commercial aquaculture include:

- ***Pathogens and parasites:*** Pathogens and parasites present in aquatic environments can transfer between wild and cultured populations, causing mortality events and production losses. Changes in aquatic temperature, acidification, and food webs caused by climate change can stress aquatic organisms, increasing the risks of disease outbreaks caused by pathogens or parasites. In some cases, disease outbreaks in aquaculture can transfer pathogens and parasites to wild stocks. Advances in aquatic health management practices, drugs and other therapeutants, and genetics are needed to reduce risks of disease outbreaks in farmed aquatic animals and potential transfer effects on wild stocks.[39]
- ***Feed:*** As feed can amount to up to 70 percent of the cost of raising fish or crustaceans (fed aquaculture), the availability and nutritional composition of feedstuffs are critical to a sustainable expansion of aquaculture and hatchery rearing of species for restoration or enhancement. Some finfish and shrimp aquaculture production relies on the use of fish meal and fish oil from wild fish to provide essential nutrients for fed species. With limits to the harvest of wild fish, the aquaculture industry is turning to other feed ingredients such as fish processing trimmings, agricultural products, and other ingredients to meet the feed needs of a growing industry.[40] [41]
- ***Environmental effects:*** Waste discharge, interactions with wild populations, and potential entanglement with endangered or threatened species are among the potential

[38] U.S. Department of Homeland Security. Threats to Food and Agricultural Resources (2021). https://www.dhs.gov/sites/default/files/publications/threats_to_food_and_agriculture_resources.pdf

[39] See the *National Strategic Plan for Aquaculture Research*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Research%20Plan_Final%20508%20compliant.pdf

[40] Barrows, FT, et. al. 2008. Report of the plan products in aquafeed strategic planning workshop: An integrated interdisciplinary research roadmap for increasing utilization of plant feedstuffs in diets for carnivorous fish. Rev. Fish Sci. 16: 449-455. Rust, M.B., et al. 2011. The Future of Aquafeeds. NOAA/USDA Alternative Feeds Initiative. NOAA Technical Memorandum NMFS F/SPO-124.

[41] See the *National Strategic Plan for Aquaculture Research*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Research%20Plan_Final%20508%20compliant.pdf

negative environmental effects of aquaculture.[42] Additional refinement of science-based approaches to siting, engineering design, and management of aquaculture facilities along with effective government regulation and monitoring are required to reduce and minimize environmental effects and risks.[43]

- ***User conflicts, social license, and regulatory costs:*** Several documented constraints—including regulatory costs, a complicated regulatory system, potential environmental and social effects, and competing and conflicting uses of land and public waters—have limited the development of U.S. commercial aquaculture.[44] Actions noted in the research, regulatory, and economic development thematic plans of the NADP aim to alleviate these constraints and to address the potential negative social and economic effects of aquaculture.
- ***Climate change:*** As noted above, aquaculture will be an important component of food systems designed to mitigate the effects of climate change.[45] Aquaculture production can also be negatively affected by changes in climate, as warmer waters may cause stress in animals or serve as vectors for pathogens causing mortalities. More frequent and extreme storm events may damage aquaculture operations and working waterfronts.

Advances in commercial aquaculture include:

- Producing fish feeds made from non-traditional ingredients, which has decoupled the growth of fed aquaculture (fish and shrimp) from dependence on fish meal and fish oil derived from small pelagic fish known as forage fish:[46] Feeds for carnivorous fishes such as salmonids are now produced using fish processing trimmings, soy, algae, insect meal, and other ingredients; this replaces fish meal and oil while maintaining successful production metrics.
- The split-pond production system for catfish, which uses 20 percent of a pond for fish grow-outs and the remaining 80 percent for oxygen production and waste treatment: These allocations increase feeding efficiencies and improve water quality.[47] In addition, reproductive technologies have facilitated the use of hybrid catfish that exhibit improved performance in these systems over purebred strains.
- USDA and NOAA collaborations with universities and private companies to develop regional oyster strains better adapted to local conditions and stresses caused by climate change: This research will help support the expanding raw bar market that spurred the rapid expansion of oyster farming.
- Scientific developments that have contributed to domestic and global aquaculture production advances: These advances include pest and pathogen resistant or tolerant fish

[42] Gephart, JA, et al. 2021. Environmental performance of blue foods. Nature 597: 360-365; Price CS, and Morris JA. 2013. Marine cage culture and the environment: twenty-first century science informing a sustainable industry. NOAA Technical Memorandum NOS-NCCOS-164. Washington (DC): NOAA; Shumway SE, ed. 2011. Shellfish aquaculture and the environment. Ames (IA): Wiley-Blackwell.
[43] Naylor et al. 2021. A 20-year retrospective review of global aquaculture. Nature 591(551-563).
[44] National Research Council. 1992. Marine aquaculture: Opportunities for growth. Washington (DC): National Academy Press; U.S. Commission on Ocean Policy. 2004. An ocean blueprint for the 21st Century, U.S. Commission on Ocean Policy. Washington CDC): U.S. Ocean Commission; Engle CR, Stone NM. 2013. Competitiveness of U.S. aquaculture within current U.S. regulatory framework. Aquac Econ Manag. 17(3):251-290; Rubino, MC. 2022. Policy considerations for Marine Aquaculture in the United States. Rev Fish Sci & Aquac
[45] Costello et al. 2020. The future of food from the sea. Nature 588(7836):95-100.
[46] Barrows, FT, et. al. 2008. Report of the plan products in aquafeed strategic planning workshop: An integrated interdisciplinary research roadmap for increasing utilization of plant feedstuffs in diets for carnivorous fish. Rev. Fish Sci. 16: 449-455. Rust, M.B., et al. 2011. The Future of Aquafeeds. NOAA/USDA Alternative Feeds Initiative. NOAA Technical Memorandum NMFS F/SPO-124.
[47] Kumar, G. et al. 2016. Costs and risks of catfish split-pond systems. J of the World Aquac Soc. 47(3): 327-340. Cheatham M. et al. 2023. Economic risk of commercial catfish production practices. Aquac Econ & Mang. https://doi.org/10.1080/13657305.2023.2181463

and shellfish populations; enhanced pond, recirculating, and offshore production designs and systems; and performance improvements resulting from genetic selection and aquatic animal health science.[48]

- Significant improvements in the environmental performance of aquaculture in recent years in the United States to optimize the use of land, feed, and water and produce protein with a small environmental footprint: Advances in site selection and siting tools, efficient feeds, aquatic health management (which greatly reduces the need for therapeutants), escape prevention, and research on gear types to prevent entanglement of other marine life have all contributed to improved environmental practices that meet federal and state performance standards.[49]

The benefits of conservation aquaculture include:

- ***Commercial fisheries***: Hatchery stock is used to supplement the commercial catch of Pacific salmon species. Salmon hatcheries provide an average of 34 percent of the total common-property harvest of the salmon caught in Alaska,[50] and around 70 to 90 percent of the catch in the Pacific Northwest (California, Oregon, and Washington).[51]
- ***Recreational fisheries***: The National Fish Hatchery System supports recreational fisheries by directly stocking sport fish into public waterways. This stocking supports $1.2 billion in economic output annually, provides 12,000 jobs, and generates $88 million in federal tax revenue. For example, U.S. freshwater lakes and rivers stocked with trout fingerlings from state and private hatcheries provide recreational opportunities for millions of anglers.
- ***Recovery of threatened and endangered species***: The National Fish Hatchery System operated by the U.S. Fish and Wildlife Service (FWS) propagates 46 species of fish and 27 species of mollusks listed under the Endangered Species Act.[52] Propagation activities are conducted in accordance with recovery plans and range from providing genetic refuge in a captive environment (e.g., delta smelt and woundfin) to integrated stocking programs that provide demographic and genetic support to natural populations (e.g., razorback sucker, Gila trout, and pallid sturgeon). The National Oceanic and Atmospheric Administration (NOAA) also works FWS and other partners to restore endangered and threatened marine and anadromous species such as white abalone, certain coral species, Atlantic salmon, and several Pacific salmon species.

[48] See the *National Strategic Plan for Aquaculture Research*: https://www.ars.usda.gov/sca/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Research%20Plan_Final%20508%20compliant.pdf

[49] Gephart, JA, et al. 2021. Environmental performance of blue foods. Nature 597: 360-365; Asplin I. et al. 2020. Working group on environmental interaction of aquaculture. ICES Scientific Reports 2(112). Copenhagen (Denmark): International Council for the Exploration of the sea. Doi:10.17895/ices.pub.7619.; Price CS, and Morris JA. 2013. Marine cage culture and the environment: twenty-first century science informing a sustainable industry. NOAA Technical Memorandum NOS-NCCOS-164. Washington (DC): NOAA; Shumway SE,. ed. 2011. Shellfish aquaculture and the environment. Ames (IA): Wiley-Blackwell;.Price CS, et al. 2017. Protected species and marine aquaculture interactions. NOAA Technical Memorandum. NOAA NCCOS 211. Washington (DC): NOAA.

[50] Evenson DF et al. 2018 Salmon hatcheries in Alaska: a review of the implementation of plans, permits, and policies designed to provide protection for wild stocks. Special publication No. 18-12. Alaska Department of Fish and Game.

[51] Knapp, G, Roheim, CA, Anderson JL. 2007. The Great Salmon Run: Competition between Wild and Farmed Salmon. Washington (DC): TRAFFIC North America World Wildlife Fund; Marine Fisheries Advisory Committee. 2020. A Vision for Salmon and Steelhead: Goals to Restore Thriving Salmon and Steelhead to the Columbia River Basin. Phase 2 report of the Columbia Basin Partnership Task Force of NOAA's Marine Fisheries Advisory Committee. https://www.fisheries.noaa.gov/vision-salmon-and-steelhead-goals-restore-thriving-salmon-and-steelhead-columbia-river-basin

[52] 2022 Fish and Aquatic Conservation Annual Report – Confluence: Connecting Partners and Conservation. https://www.fws.gov/media/2022-fish-and-aquatic-conservation-annual-report

- ***Mitigation**:* Dams and other infrastructure projects can reduce habitat connectivity and alter ecosystems, resulting in negative impacts on recreational and commercial fisheries and imperiled nongame populations. Captive propagation and release are used to mitigate the negative impacts of federal infrastructure projects on inland and anadromous fishes.
- ***Subsistence fisheries**:* The FWS stocks cultured fish on Tribal lands, and this fulfills Tribal trust responsibilities by supporting subsistence fisheries and food sovereignty for 60 Tribes. The National Broodstock Program also provides eggs to support Tribal hatchery programs, which enables Tribes to conduct conservation aquaculture.
- ***Habitat restoration:*** Oyster spat, corals, and marsh grass produced in hatcheries and nurseries are used to restore oyster and coral reefs and marsh habitat around the United States.[53] The restored habitats provide a variety of ecological services (e.g., fisheries spawning and nursery habitat, water quality improvements, and nutrient and carbon sequestration) and coastal storm water protection.

The challenges of conservation aquaculture include:

- ***Environmental effects of hatchery produced stock:*** While hatchery stock can be an important component of species recovery and restoration plans or can supplement important commercial and recreational stocks, the release of hatchery stock comes with environmental risks.[54] For example, scientists have long been aware that release of salmon species to supplement wild stock to meet commercial, recreational, Tribal, or endangered species needs may negatively affect the survival of remaining stocks of wild salmon (by interbreeding with or outcompeting wild salmon for food). Although a variety of protocols based on scientific research are in place to guide hatchery programs and to separate wild from hatchery stock, additional research is required to reduce the genetic risks.[55]
- ***Climate change:*** Climate changes may put additional stress on endangered and threatened aquatic species, putting additional demands on species conservation and restoration programs.
- ***Habitat restoration:*** While a variety of federal, state, and private efforts are underway around the country to restore habitats with hatchery stock, the need for habitat restoration may greatly exceed the current resources available to these hatchery-based restoration efforts.

Advances in conservation aquaculture:

- Advances in using public hatcheries to restore threatened and endangered aquatic species such as trout, Pacific and Atlantic salmon species, white abalone, corals, and other species: Genetics protocols for hatchery-reared stock used to restore endangered stocks have been refined to reduce potential negative effects of releasing hatchery-raised stocks

[53] Bricker SB et al. 2017. Role of shellfish aquaculture in the reduction of eutrophication in an urban estuary. Environ Sci Technol. 52(1):173-183; Theraukauf SJ et al. 2022. Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: pathways, synthesis and next steps. Rev Aquacult. 14(1):54-72.
[54] Lorenzen, K., Leber, K. M., & Blankenship, H. L. (2010). Responsible approach to marine stock enhancement: an update. *Reviews in Fisheries Science*, *18*(2), 189-210.
[55] Al-Chokhachy, R., Heki, L., Loux, T., & Peka, R. (2020). Return of a giant: coordinated conservation leads to the first wild reproduction of Lahontan Cutthroat Trout in the Truckee River in nearly a century. *Fisheries*, *45*(2), 63-73.

on stocks spawned in the wild. These efforts by public hatcheries include developing and adopting genetic techniques to facilitate pedigree-based genetic management programs, which minimizes inbreeding risks and maximizes genetic diversity and effective population sizes in rare populations.[56] For example, the use of advanced pedigree-based genetic management approaches, like those used in the Atlantic Salmon and Lahontan Cutthroat Trout recovery programs, is assisting conservation aquaculture programs to reduce genetic risks.[57]

- The FWS release of 124 million fish from 70 species into public waterways in 2022,[58] in addition to 1 billion individuals of more than 77 species released by state agencies supported by federal grants: These fish support the recovery of ESA-listed species and restoration of at-risk sport fishes, help mitigate the impacts of infrastructure projects on aquatic habitats, provide commercial and recreational fishing opportunities, and support Tribal harvests.
- The FWS Aquatic Animal Drug Approval Partnership program has facilitated the Food and Drug Administration approval of multiple drugs for use in aquaculture.[59] In addition, the FWS Fish Technology Centers have conducted extensive applied aquaculture research to support captive propagation.

THEMATIC STRATEGIC PLANS

National Strategic Plan for Aquaculture Research

This strategic plan serves to communicate federal priorities for research and technology development that will facilitate responsible expansion of domestic aquaculture. This plan will be foundational for supporting a science-based industry that increases seafood availability, creates jobs, and provides economic and recreational opportunities while providing for the restoration and promotion of healthy aquatic ecosystems. Federal aquaculture research programs are for the benefit of the American people, inclusive of current and future generations. This plan identifies critical objectives for the following strategic goals that will support U.S. aquaculture development through federal agency and interagency research, science, and technology coordination over a 5-year term: (1) Develop Economic Growth through Aquaculture; (2) Improve Aquaculture Production Technologies and Inform Decision-making; and (3) Uphold Animal Well-Being, Product Safety, and Nutritional Value. These strategic goals will guide Federal agencies, with public and private sector partners, in building an interagency collaborative and multidisciplinary research framework to address the Nation's aquaculture priorities. Agency activities related to this plan are subject to the availability of appropriations and must be consistent with domestic and international legal obligations.

[56] Fisch KM, et al. 2015. Fish hatchery genetic management techniques: Integrating theory with implementation. N American J of Aquac. 77(3):343-357. O'Reilly, P.T. and Kozfkay, C.C., 2014. Use of microsatellite data and pedigree information in the genetic management of two long-term salmon conservation programs. *Reviews in fish biology and fisheries*, *24*, pp.819-848.
[57] O'Reilly, P. T., & Kozfkay, C. C. (2014). Use of microsatellite data and pedigree information in the genetic management of two long-term salmon conservation programs. *Reviews in fish biology and fisheries*, *24*, 819-848.
[58] 2022 Fish and Aquatic Conservation Annual Report – Confluence: Connecting Partners and Conservation. U.S. Fish and Wildlife Service. https://www.fws.gov/media/2022-fish-and-aquatic-conservation-annual-report
[59] Aquatic Animal Drug Approval Partnership Program. U.S. Fish and Wildlife Service. https://www.fws.gov/program/aquatic-animal-health/aquatic-animal-drug-approval-partnership

Strategic Plan to Enhance Regulatory Efficiency in Aquaculture

This strategic plan outlines actions that federal agencies plan to take within their existing statutory authorities and budgetary resources to improve efficiency, predictability, and timeliness, and reduce the costs of reviewing, approving, monitoring, and enforcing permits and other regulatory requirements for marine commercial aquaculture ventures. The plan describes key interagency and federal-state issues concerning aquaculture regulation, as well as science and technology needs to facilitate more efficient state and federal aquaculture management actions. The following strategic goals will help federal agencies build an interagency collaborative regulatory framework to meet the Nation's aquaculture priorities through coordination with the NSTC: (1) Improve Efficiencies in Aquaculture Permitting and Authorization Programs; (2) Implement a National Approach to Aquatic Animal Health Management of Aquaculture; and (3) Refine, Develop, and Disseminate Tools for Aquaculture Regulatory Management. These goals will also ensure aquaculture facilities continue to meet all applicable environmental, public health, and other federal requirements. This plan outlines objectives under each goal that federal agencies have identified as feasible to implement over the next few years. These proposed actions are intended to be undertaken in the context of environmental stewardship, human health, and other federal requirements.

Strategic Plan for Aquaculture Economic Development

This strategic plan outlines actions that federal agencies can take within their existing statutory authorities and budgetary resources to support a robust, resilient, globally competitive, and environmentally sustainable domestic aquaculture sector. Effective implementation of this plan will require a significant amount of public-private collaboration with a diverse set of stakeholders. The plan supports both the viability and expansion of existing aquaculture operations and encourages new entrants by addressing needs across the seafood supply chain and diverse production systems. The proposed actions serve as points of intersection between climate-smart food production, private-public partnerships, blue economy, community resilience and health, workforce development, working waterfronts, urban and rural development, and seafood supply chains.

The aquaculture industry encompasses a broad variety of practices, species, and operational structures, so this plan offers a number of approaches that acknowledge and support this diversity. There is no one-size-fits-all approach to aquaculture development; therefore this plan includes a wide range of actions tailored to the specialized needs of diverse aquaculture operations to assist in industry growth. This plan outlines four strategic goals to guide interagency collaborative efforts, coordinated through the SCA, to meet the nation's aquaculture priorities: (1) Encourage Industry Investment; (2) Support Infrastructure and Workforce Development; (3) Expand Market Opportunities for U.S. Aquaculture Products; and (4) Support Aquaculture Communications and Literacy. The plan outlines objectives under each goal that federal agencies have identified to implement over the next five years. Numerous federal and non-federal programs have mission areas that intersect with the goals and objectives of this plan. Some programs and initiatives are specific to aquaculture, but many others have a broader scope for which aquaculture entities are relevant and eligible. Effective implementation of this plan will require coordinated efforts among existing and new federal and non-federal partners, including states and the private sector.

Appendix I: Highlights of Federal Agency Accomplishments in Recent Years

Much interagency collaboration and work has been accomplished since the last iteration of the National Aquaculture Development Plan (NADP) in 1984. The NSTC Subcommittee on Aquaculture (SCA) and/or subsets of the participating agencies contributed to, for example, the development of effluent guidelines for aquaculture, a federal blueprint for alternative feeds research, and a national aquatic animal health plan. During the past decade, interagency coordination through the SCA has led to significant contributions that are advancing U.S. aquaculture development and use, and connecting federal agency work to the aquaculture farming and restoration communities, and allied stakeholders. Since the establishment of the Science Planning, Regulatory Efficiency, and Economic Development task forces, federal partners have continued to foster internal and external relationships to better coordinate the use of federal resources and capacity for supporting the aquaculture industry and the uses of aquaculture for species and habitat conservation. Several of these accomplishments are noted below.

Strategic Plan to Enhance Regulatory Efficiency in Aquaculture

The NADP charges the Regulatory Task Force with fostering improvements in the efficiency, reliability, and timeliness of regulatory actions and reducing costs for reviewing, approving, monitoring, and enforcing regulatory requirements for aquaculture ventures.

Major interagency accomplishments include:

- Stronger interagency partnerships have improved information sharing, developing more efficient processes, reducing redundancies, enhancing collaboration in the permitting process, and implementing Executive Order 13921, *Promoting American Seafood Competitiveness and Economic Growth*.[60]
- NOAA worked with interagency partners in launching the Aquaculture Opportunity Areas[61] identification process in southern California, the Gulf of Mexico, and Alaska to facilitate science-based and publicly informed planning for sustainable U.S. aquaculture development. NOAA released two Aquaculture Opportunity Atlases for the Gulf of Mexico and southern California and is preparing Programmatic Environmental Impact Statements to analyze the adverse and beneficial impacts of commercial aquaculture

[60] Executive Order 13921 Promoting American Seafood Competitiveness and Economic Growth (7 May 2020). https://www.govinfo.gov/app/details/DCPD-202000342

[61] An AOA is a defined geographic area that NOAA has evaluated through both spatial analysis and the National Environmental Policy Act (NEPA) process and determined may be environmentally, socially, and economically appropriate for commercial aquaculture. *Aquaculture: Aquaculture Opportunity Areas*, NOAA Fisheries. https://www.fisheries.noaa.gov/topic/aquaculture/aquaculture-opportunity-areas

development. In Alaska, NOAA is working closely with state agencies to plan for shellfish and invertebrate aquaculture development in state waters; other work includes spatial modeling and extensive stakeholder outreach.

- Interagency partners distributed the *Guide to Permitting Marine Aquaculture in the United States* (2022),[62] which includes a collection of federal guidance for industry. They also distributed the *Guide to Federal Aquaculture Grant and Financial Assistance Services* (2022),[63] which provides information about grants and other financial tools available to aquaculture producers and associated stakeholders. NOAA published individual state permitting/leasing requirements for shellfish, seaweed, and finfish aquaculture.[64]
- The U.S. Army Corps of Engineers encouraged the development and use of aquaculture Nationwide Permits, Regional General Permits, and Programmatic General Permits that could further improve the efficiency of the aquaculture permitting process while meeting the needs of respective regions.
- The USDA Animal and Plant Health Inspection Service published the first *National Aquaculture Health Plan & Standards*.[65] This publication provides guidance for national disease reporting, laboratory and testing standardization, surveillance, response, biosecurity, data management, and education and training to support the overall health of the aquaculture industry and provide protection and assurance for producers of U.S. farm-raised aquatic animals.
- The U.S. Environmental Protection Agency (EPA) released a video that describes how National Pollutant Discharge Elimination System (NPDES) permits apply to discharges from aquaculture operations.[66]
- The EPA issued an NPDES permit for a marine aquaculture facility in federal waters of the Gulf of Mexico.[67] The permittee will operate a "net-pen" aquatic animal production facility and is anticipated to be the first time that cultured fish are grown for harvest in the Gulf's federal waters.
- The NOAA Seafood Inspection Program and U.S. Food and Drug Administration (FDA) worked with the Interstate Shellfish Sanitation Conference (ISSC) Federal Waters Committee to develop and draft new bivalve molluscan shellfish federal waters guidance and develop associated proposals to update the language for the National Shellfish Sanitation Program (NSSP) *Guide for the Control of Molluscan Shellfish*. The 2023 ISSC Biennial Conference voted on and adopted the Federal Waters Committee guidance recommendations and associated proposals for federal waters. These activities address

[62] *Guide to Permitting Marine Aquaculture in the United States (2022).* NOAA Fisheries. https://www.ars.usda.gov/sca/Documents/Guide-Permitting-Marine-Aquaculture-United-States-2022.pdf

[63] *Guide to Federal Aquaculture Grant and Financial Assistance Services (2022)*; https://media.fisheries.noaa.gov/2021-09/Guide-to-Federal-Aquaculture-Grant-and-Financial-Assistance-Services-August2021.pdf

[64] *State by State Summary of Finfish Aquaculture Leasing/Permitting Requirements.* NOAA Fisheries. https://media.fisheries.noaa.gov/2021-09/Report-State-by-State-Summary-of-Finfish-Aquaculture-Leasing-Permitting-Requirements-2021.pdf; *State by State Summary of Seaweed Aquaculture Leasing/Permitting Requirements.* NOAA Fisheries. https://media.fisheries.noaa.gov/2021-09/Report-State-by-State-Summary-of-Seaweed-Aquaculture-Leasing-Permitting-Requirements-2021.pdf; *State by State Summary of Shellfish Aquaculture Leasing/Permitting Requirements*. NOAA Fisheries. https://media.fisheries.noaa.gov/2021-09/Report-State-by-State-Summary-of-Shellfish-Aquaculture-Leasing-Permitting-Requirements-2021.pdf.

[65] *National Aquaculture Health Plan & Standards (NAHP&S): 2021-2023.* USDA Animal and Plant Health Inspection Service. https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/aquaculture/national-aquaculture-health-plan

[66] EPA NPDES permit short video found here: https://www.youtube.com/watch?v=ro6Viys1OuI&t=1s. It can also be accessed from EPA Aquaculture webpage: https://www.epa.gov/npdes/managing-aquaculture-protect-water-quality

[67] *Ocean Era, Inc. – Velella Epsilon Aquatic Animal Production Facility National Pollutant Discharge Elimination System (NPDES) Permit,* see https://www.epa.gov/npdes-permits/ocean-era-inc-velella-epsilon-aquatic-animal-production-facility-national-pollutant

commercial bivalve molluscan shellfish harvesting (including shellfish aquaculture) in federal waters.

- The FDA established a Federal Waters Shellfish Biotoxin Advisory Board (FWSBAB), comprised of representatives from FDA, NOAA, Center for Disease Control and Prevention (CDC), and EPA for collecting, reviewing, and defining marine biotoxin data related to NSSP marine biotoxin requirements for the commercial harvest of bivalve molluscan shellfish in federal waters.
- FDA's Center for Veterinary Medicine continues to advance initiatives under its Aquaculture Strategic Plan.[68] For example, the FDA published Guidance for Industry (GFI) #61 entitled "Special Considerations, Incentives, and Programs to Support the Approval of New Animal Drugs for Minor Uses and for Minor Species" that is intended to assist those interested in pursuing FDA approval of new animal drugs intended for minor species, including finfish and shellfish.
- The Interstate Shellfish Sanitation Conference Biennial Conference adopted guidance developed by NOAA Seafood Inspection Program and FDA for bivalve molluscan harvest and aquaculture in federal waters.
- The U.S. Fish and Wildlife Service published its Aquatic Animal Health Policy that defines how the agency conducts aquatic animal health work.[69] This policy includes criteria and methods for detecting aquatic animal pathogens.

National Strategic Plan for Aquaculture Research

The Science Planning Task Force is charged with communicating federal priorities for research and technology development. These priorities facilitate the responsible expansion of domestic aquaculture, support science-based regulatory frameworks, secure domestic seafood availability and safety, create jobs, and provide economic and recreational opportunities while providing for the protection and restoration of healthy aquatic ecosystems. Federal agencies routinely engage with industry representatives, farming communities, academia, and non-governmental organizations to better understand research needs and the best use of research capacity.

Major interagency accomplishments include:

- The Aquaculture Information Exchange (AIE) was established as an online communication, coordination, and collaboration platform for the U.S. aquaculture community.[70] The AIE is jointly funded by the DOC and USDA to connect individuals from the public and private sectors, such as researchers, extension personnel, industry members, and others with interests in U.S. aquaculture. The AIE facilitates topic-based discussions; forming project-based working groups; sharing aquaculture-related information; and hosting community forums, member blogs, an events calendar, and a job board, among other resources.

[68] The Food and Drug Administration Center for Veterinary Medicine Aquaculture Strategic Plan is found at https://www.fda.gov/animal-veterinary/aquaculture/center-veterinary-medicine-aquaculture-strategic-plan-fiscal-years-2022-2026
[69] *Aquatic Animal Health Policy Introduction.* U.S. Fish and Wildlife Service. https://www.fws.gov/policy-library/713fw1
[70] *Virginia Sea Grant Launches the USDA and NOAA-Supported Aquaculture Information Exchange Online Community Platform.* NOAA Sea Grant, 26 October 2023. https://seagrant.noaa.gov/virginia-sea-grant-launches-the-usda-and-noaa-supported-aquaculture-information-exchange-online-community-platform/

- Agencies across USDA, DOC, and DOI conducted and supported research to define the nutrient requirements of many fish species throughout their lifespans and to develop feeds and diets for meeting these requirements. This included research on alternative feed ingredients and supplements and optimizing feeding strategies. Alternative ingredients include plant-based proteins, insect meal, and macroalgae products that were assessed as replacements for fishmeal and fish oil in carnivorous fish diets.[71,72] Early life-stage research includes transitioning from live feeds to commercial diets.
- The Interagency Working Group for Farming Seaweeds and Seagrasses was established and includes 46 members representing various agencies and offices in USDA, HHS, DOI, EPA, U.S. Department of Energy, Department of Defense, and National Science Foundation.[73] This group is charged by Congress with (1) studying how mangroves, kelp forests, tidal marshes, and seagrass meadows could help de-acidify the oceans; (2) studying emerging ocean farming practices that use kelp and seagrass to de-acidify the oceans while providing feedstock for agriculture and other commercial and industrial inputs; and (3) coordinating and conducting research to develop and enhance pilot-scale research that advances these objectives.
- USDA, DOC, and DOI supported projects directed at aquaculture workforce training and development for Tribal entities, minorities, and small businesses. These projects include education and training programs on sustainable farming practices and using novel and innovative learning tools and virtual experiences. Outputs from these projects include aquaculture-focused curriculum development at community colleges, like USDA-NIFA's NexTGen Sustainable farming program at Bergen Community College in New Jersey,[74] NOAA Sea Grant's investment in developing a commercial seafood workforce training program in South Carolina, and NOAA Fisheries Minorities in Aquaculture Internship Program[75].
- Researchers and colleagues used the "One Health" lens to make advances in understanding natural and anthropological impacts on shellfish and finfish species. Supported projects investigated how farming practices such as breeding, feeding, and gear affect the surrounding environment, and their downstream impacts on the quality, nutritional value, and content of animal products.

Strategic Plan for Aquaculture Economic Development (in draft)

The third and final thematic area of the National Aquaculture Development Plan is economic development. Beyond drafting the new Strategic Plan for Aquaculture Economic Development (SPAED) itself, a significant accomplishment of this task force was to establish and cultivate

[71] Romano, N., Webster, C.D., Sinha, A., Beck, B.H., Yamamoto, F. 2023. Dietary inclusions of black soldier fly (*Hermetia illucens*) larvae frass enhanced production of channel catfish (*Ictalurus punctatus*) juveniles, stevia (*Stevia rebaudiana*, and lavender (*Lavaridula angustifolia*) in an aquaponic system. Aquaculture. 575:739742.
[72] Aksoy, M., Eljack, R.M., Beck, B.H., Peatman, E. 2022. Nutritional evaluation of frass from black soldier fly larvae as potential feed ingredient for Pacific white shrimp, *Litopenaeus vannamei*. Aquaculture. 27:101353. https://doi.org/10.1016/j.aqrep.2022.101353.
[73] *Interagency Working Group for Farming Seaweeds and Seagrasses.* U.S. Agricultural Research Service. https://www.ars.usda.gov/animal-production-and-protection/aquaculture/docs/iwg-farming-seaweeds-and-seagrasses/#:~:text=The%20Interagency%20Working%20Group%20for,agricultural%20products%2C%20such%20as%20livestock
[74] *From Learning to Leading: Cultivating the Next Generation of Diverse Food and Agriculture Professionals (NextGen).* U.S. National Institute of Food and Agriculture. https://www.nifa.usda.gov/grants/programs/learning-leading-cultivating-next-generation-diverse-food-agriculture-professionals
[75] *Partnership Supports Minorities in Aquaculture Internship* Opportunity. NOAA Fisheries (9 March 2022). https://www.fisheries.noaa.gov/feature-story/partnership-supports-minorities-aquaculture-internship-opportunity

new interagency partnerships to support a globally competitive aquaculture industry. In the process of drafting the SPAED, the task force co-chairs recognized the need to partner with agencies beyond those that traditionally were engaged in aquaculture matters, especially those focused broadly on national economic development activities. As a result, the SCA now has access to a broad network of highly engaged federal agency leaders and technical experts with expertise in economic development, many of whom had previously not focused specifically on this industry. Effective implementation of this Strategic Plan will rely on expanding and leveraging these new partnerships.