Conserving, Restoring and Enhancing America's Fisheries and Aquatic Resources

The Economic Contributions of the U.S. Fish and Wildlife Service Fish and Aquatic Conservation Program

Atlantic Salmon. Photo credit: Ryan Hagerty/USFWS

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This report summarizes the contributions and achievements of the U.S. Fish and Wildlife Service's Fish and Aquatic Conservation Program, emphasizing the economic benefits delivered to the American public.

[1] The Division of Economics is now called the Economics Branch and is administratively located within the Joint Administrative Operations branch of the U.S. Fish and Wildlife Service.

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Preface

The Economic Contributions of the U.S. Fish and Wildlife Service Fish and Aquatic Conservation Program
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This report was originally drafted in 2018 using economic data from fiscal year 2017. It was not published at the time due to resource constraints but is now being released to document the economic contributions of the Fish and Aquatic Conservation (FAC) program and to provide a useful reference for ongoing work in fisheries conservation.

Intended Use and Limitations

The findings in this report reflect the best available data at the time of drafting and remain relevant as an indicator of the economic contributions of the FAC program's work today. The core activities described –including fish passage improvements, aquatic invasive species management, hatchery operations, habitat restoration, and tribal partnerships—continue to be fundamental to the program's mission. While the general scope and economic role of the FAC program remain consistent, this report is not a real-time assessment of current economic conditions.

The economic estimates in this report are based on FY 2017 data and provide a reasonable proxy for ongoing contributions but do not capture year-over-year changes in funding, inflation, or program evolution. Program descriptions, policies, and funding allocations reflect the conditions as of 2018 and may not align with specific current agency priorities or structures. Any references to laws, strategic plans, or initiatives were accurate at the time but may have been updated or replaced. Readers seeking the most up-to-date policy information should refer to www.fws.gov/fisheries.

Approach to Data and Terminology

To preserve the integrity of the original analysis, economic contribution estimates, case studies, and methodology have not been altered. However, minor editorial updates (e.g., program names and URLs) have been made where necessary to ensure clarity. Where applicable, footnotes provide additional context on significant programmatic changes that have occurred since 2018.

Executive Summary

The Fish and Aquatic Conservation (FAC) program of the U.S. Fish and Wildlife Service (FWS) works in partnership with states, tribes, nonprofits, and other stakeholders to conserve and restore the health of the nation's freshwater aquatic ecosystems.

Mission of the Fish and Aquatic Conservation Program:
To work with partners and engage the public using a science-based approach to conserve, restore, and enhance fish and other aquatic resources for the continuing benefit of the American people.

FAC engages in numerous activities related to the conservation of aquatic species, the conservation and enhancement of aquatic habitats, aquatic invasive species management, aquatic animal drug research and development, the fulfillment of tribal trust and subsistence responsibilities, the enhancement of recreational fishing, and public engagement and education. To the extent possible, this report estimates the economic contributions associated with the program's activities in Fiscal Year 2017, drawing on spending data, project accomplishments, and related economic activity.

Interpreting the Contributions

This analysis uses the IMPLAN model, a widely used economic input-output tool, to estimate the ripple effects of FAC-related spending throughout the broader economy. Project-level expenditure data were primarily drawn from the Fisheries Information System (FIS). In addition, many benefits of aquatic conservation—clean water, healthy fish populations, and resilient ecosystems—are not traded in markets and can be difficult to quantify. To capture some of these values, the report draws on published case studies of similar work as well as existing research about the public's willingness-to-pay for ecosystem services such as water quality, biodiversity, and habitat restoration. These studies suggest that the public can value aquatic resource protection beyond what is captured in direct economic contribution estimates.

Table 1 provides a summary of the economic contributions of the FAC program's expenditures and economic activity supported from accomplishments reported for FY 2017. These estimates likely underestimate the full scale of the economic contributions associated with the FAC program because the economic contributions of all of the FAC program's accomplishments could not be quantified. While not every ecological outcome can be monetized, the data show that the FAC program not only provides conservation value—it also delivers meaningful economic returns to communities across the country.

Key Findings: FAC Program Overall

- In FY 2017, the total economic contributions (direct, indirect, and induced) associated with FAC program expenditures and expenditures by economic activity supported from FAC program accomplishments amounted to $2.1 billion in output and nearly 18,700 jobs.

- In FY 2017, FAC program project expenditures (i.e., funding from the FAC program budget, reimbursable accounts of other FWS programs, and contributions from project partners) supported $915.6 million in output and 6,253 jobs.
    - This translates to over $2.5 million in output and slightly more than 17 jobs supported per $1 million in FAC program expenditures.
- The FAC program was able to leverage $125.1 million from partners to implement projects and conduct activities towards meeting its goals.[2]
- Visits to FAC program facilities and sponsored activities supported roughly $51.0 million in output and 363 jobs.
- 99,504 adult volunteer hours and 13,604 children volunteer hours supported the FAC program. The adult volunteer hours are equivalent to 48 FTEs, with an estimated value of $2.5 million.[3]

Key Findings: Conservation of Aquatic Species and Habitat

- In FY 2017, the FAC program's Fish and Wildlife Conservation Offices (FWCO) accomplished:
    - The removal/bypass of 148 barriers reopening 3,213 miles (4,914 acres) of rivers and streams to fish passage;
    - The restoration of 178 miles of in-stream/shoreline habitat;
    - The enhancement of 2,433 acres of upland habitat, 243 acres of wetland acres, and of 57 miles of riparian habitat; and
    - The completion of 2,778 habitat assessments and 1,753 population assessments.
- Economic contributions associated with activities and projects of FWCOs amounted to $499.1 million in output and 3,277 jobs supported or nearly 17 jobs supported per $1 million in expenditures.
    - Expenditures on activities and projects benefiting fish passage supported $207.3 million in output and supported roughly 1,245 jobs.
    - Expenditures on activities and projects conserving and restoring aquatic habitat supported $34.1 million in output and 249 jobs.
    - Expenditures on activities and projects managing, monitoring, and assessing aquatic species and habitat supported $111.7 million in output and 668 jobs.

Key Findings: Aquatic Invasive Species (AIS)

- In FY 2017, the FAC program conducted 956 activities to support the management and control of AIS and completed 643 surveys for AIS baseline and trend information.
    - Expenditures on activities and projects for AIS management, control, prevention, coordination, and outreach supported $103.0 million in output and approximately 924 jobs.

[2] Source: U.S. Fish and Wildlife Service's Fisheries Information System.

[3] Based on 2,080-hour workweek and value per hour of volunteer time of $24.69 (Source: https://independentsector.org/news-post/value-of-volunteer-time-release/).

Key Findings: National Fish Hatcheries, Research, Science, and Technology

- Economic contributions associated with national fish hatcheries (NFHs), fish technology centers (FTCs), and fish health centers (FHCs) amounted to support of $233.4 million in output and 1,623 jobs.
    - This represents almost $2.7 million in output and just over 18 jobs supported per $1 million in expenditures.
- Recreational angling from the stocking and release of 95.2 million hatchery fish supported $1,207.7 million in output, 12,100 jobs, $88.3 million in federal tax revenue, and $77 million in state and local tax revenue.
- In FY 2017, National Fish Hatcheries stocked over 13 million fish that directly or indirectly benefited federally recognized tribes.[4]
    - More than 7 million fish were stocked directly into tribal waters.[5]
- Over 38 million fish were treated with Investigational New Animal Drugs (INAD) as part of the National INAD Program which works to obtain Food and Drug Administration approval of new medications for use in fish culture and fisheries management.
    - INADs under study included those to control mortality caused by disease/parasites, induce spawning, marking, and anesthetics with 16 INADs contributing data towards future drug approvals in FY 2017.
    - Slightly over 19 million fish were treated with INADs to limit mortality caused by infectious fish pathogens with roughly 20 percent, or 3.8 million fish, saved that would otherwise have died without treatment.
    - FY 2017 cost-reimbursable dollars generated by the INAD Program amounted to $177,100.

[4] Sources: U.S. Fish and Wildlife Service's Fisheries Information System database and personal communication with FAC program staff on August 17, 2018.

[5] Sources: U.S. Fish and Wildlife Service's Fisheries Information System database and personal communication with FAC program staff on August 17, 2018.

Table 1 Economic Contributions of the USFWS Fish and Aquatic Conservation Program for Fiscal Year 2017

FAC Program Area	Direct Expenditures ($ millions)	Labor Income ($ millions)	Output ($ millions)	Employment (jobs)
A. FAC Program Expenditures				
FWCOs[1]	$195.0	$211.5	$499.1	3,277
NFHs, FTCs, and FHCs	$87.8	$91.7	$233.4	1,623
Administration Offices[1]	$77.7	$81.2	$183.1	1,354
Total – FAC Program[1]	$360.5	$384.4	$915.6	6,253
B. Economic Activity Supported from FAC Program Accomplishments				
Recreational Angling from Fish Stocking and Release	$754.8	$483.0	$1,207.7	12,076
FAC Facility Visits and Activities	$28.1	$19.4	$51.0	363
AIS Prevention and Control	--	--	--	--
Species and Habitat Conservation and Restoration	--	--	--	--
Tribal Subsistence	--	--	--	--
Total	$782.9	$502.4	$1,258.7	12,439
Combined Total (A + B)	$1,143.4	$886.8	$2,174.3	18,692

[1] The direct expenditure values reported under A. FAC program Expenditures represent expenditures from the FAC program annual appropriations, reimbursable funding from other FWS programs and government agencies, and from project partners to implement projects and conduct activities in FY 2017.

Note: Numbers may not sum due to rounding. See glossary for definition of labor income, output, and employment.

Overview of the Fish and Aquatic Conservation Program

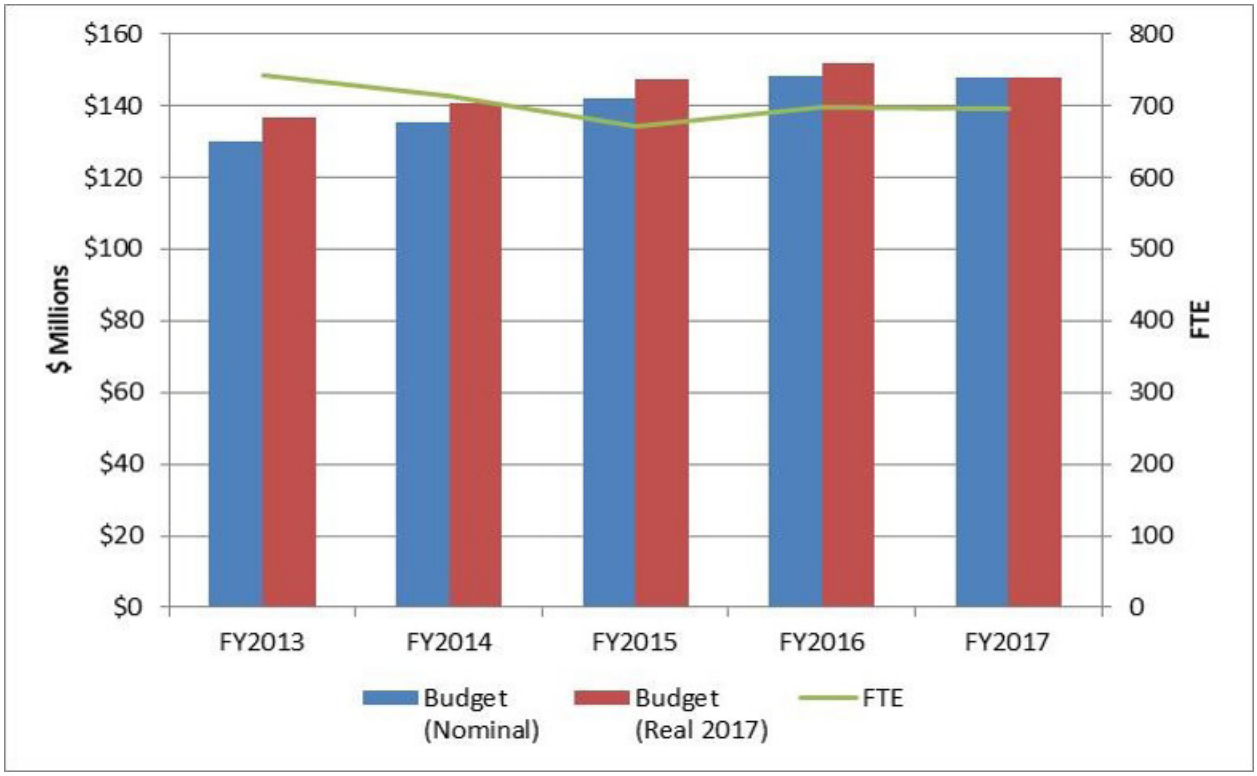
The Fish and Aquatic Conservation (FAC) program provides national leadership in conserving freshwater and anadromous fish and their habitats, supporting the biological health of America's aquatic resources. Its roots date back to 1871 with the establishment of the U.S. Commission on Fish and Fisheries, which later combined with the U.S. Biological Survey in 1934 to form what is now the U.S. Fish and Wildlife Service (FWS).

The United States hosts some of the world's most abundant and diverse freshwater and diadromous fisheries, which deliver recreational, commercial, cultural, subsistence, and economic value. Yet many aquatic species and habitats are in decline. More than 300 aquatic plant and animal species are now protected under the Endangered Species Act, largely due to habitat loss and the spread of invasive species. In response to these growing challenges, the FAC program's mission and activities have evolved to meet modern conservation needs.

The program works through national, regional, and local partnerships, guided by the mission of the FWS and the 2016–2020 Strategic Plan. Priorities are informed by federal laws and policies and focus on preventing species decline, supporting sustainable fisheries, and advancing conservation for recreational anglers, tribes, and other stakeholders. The program's strategic goals are to conserve aquatic species; conserve, restore, and enhance aquatic habitats; manage aquatic invasive species; fulfill tribal trust and subsistence responsibilities; enhance recreational fishing and other public uses of aquatic resources; increase staffing levels, technical capabilities, and natural and physical assets to fully meet its mission; and educate and engage the public and partners to advance its conservation mission.

The FAC program employs approximately 700 professional staff through direct appropriations and an additional 500 via reimbursable funding from other FWS programs and agencies, such as the U.S. Army Corps of Engineers. This work is carried out through a network of 72 National Fish Hatcheries, one historic hatchery, nine Fish Health Centers, seven Fish Technology Centers, one Aquatic Animal Drug Approval Partnership office, and 65 Fish and Wildlife Conservation Offices (FWCOs). Program leadership and policy coordination occur at FWS headquarters, with additional support provided by eight regional offices. Together, these efforts generate ecological, social, and economic value in communities across the country.

Figure 1 Annual Budget Appropriations of the FAC Program



Source: U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information
Note: Number of FTEs only represent staff supported by FAC program annual appropriations. Reimbursable funding sources from other FWS programs and other government agencies (e.g., U.S. Army Corps of Engineers) support approximately 500 additional staff.
Note: Nominal numbers converted to real using U.S. Consumer Price Index.

Analytical Approach for Estimating Economic Contributions

The estimates in this report represent the type of economic analysis known as "economic contributions" analysis. Watson et al. (2007) define an economic contributions analysis as capturing the "gross changes in a region's existing economy that can be attributed to a given industry, event, or policy." In general, an economic contributions analysis tracks how dollars cycle through the economy and its different economic sectors. For example, the dollars funding a dam removal and stream habitat restoration project will purchase construction materials and other services, which will, in turn, support jobs and generate income. Firms providing these services purchase materials to complete the work, and the suppliers of these materials will then purchase additional supplies, resulting in indirect economic effects. Finally, the employees of the affected firms use their income to purchase goods and services in the local economy, leading to additional induced economic effects (Thomas et al., 2016).

This analysis used the IMPLAN software to model how FAC program expenditures flow through the national economy.[6] IMPLAN is one of the most widely used software tools to estimate economic contributions, built upon a detailed collection of data from various sources, including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau. IMPLAN divides the economy into 536 different industry sectors and constructs regional economic models to analyze the interrelations among these industry sectors.. The primary input for the IMPLAN model is the expenditures associated with the particular program, policy, project, or event analyzed and the allocation of these expenditures across the 536 IMPLAN industry sectors. The Fisheries Information System (FIS) database served as the data source for FAC program and project expenditures used for the IMPLAN model. The expenditure data pulled from the FIS database was for fiscal year 2017.

This analysis adopted a "best-fit sector" approach to estimating the economic contributions of the FAC program. In a best-fit sector analysis, individual project expenditures are broken down and matched to one or more IMPLAN sectors.[7] Discussions with FAC program staff, along with project descriptions and other summary information recorded in the FIS database, helped guide the identification of best-fit sectors for the various projects and activities conducted by the FAC program for FY 2017. Existing economic contribution studies of projects similar to those of the FAC program also served as an input for identifying best-fit sectors for expenditures. After allocating FAC program project expenditures across their best-fit sectors, IMPLAN modeled how these expenditures cycle through the economy to estimate their economic contributions in terms of jobs, labor income, and total output supported.

Conservation of Aquatic Species and Habitat

Much of the FAC program's aquatic species and habitat conservation work centers around four key initiatives: the National Fish Passage Program, the National Fish Habitat Partnership, a national assessment and monitoring program, and the Sikes Act Program.[8] Overall coordination of these programs occurs at the FWS headquarters and regional offices, while the boots-on-the-ground biological and technical implementation happens through regional coordination and the 65 FWCOs strategically located across the country.

FWCOs play a critical, non-regulatory role in supporting the agency's aquatic resource conservation programs. They build partnerships, provide essential scientific support, and manage on-the-ground activities such as controlling invasive species and conserving habitat. FWCO

[6] IMPLAN was originally developed by the U.S. Forest Service to facilitate regional economic analysis of forest plans.

[7] "Analysis-by-parts" is another approach to estimating economic contributions. However, it relies on detailed project expenditure data and information to develop custom expenditure profiles to estimate economic multipliers associated with individual projects. For example, Thomas et al. (2016) relied on primary data collection efforts via surveys of businesses and contractors to develop IMPLAN models to estimate the economic impacts of different restoration projects.

[8] Through the Sikes Act Program, the Service works with the Department of Defense and the States to conserve habitat and restore imperiled species on military installations.

biologists assess fish populations, including hatchery-raised fish and imperiled species being considered for listing or recovery under the Endangered Species Act, to inform comprehensive conservation plans carried out by the FWS, states, and tribes.

The National Fish Passage Program (NFPP) works closely with partners at all levels to restore aquatic connectivity by removing or bypassing barriers. Projects range in size from large-scale dam removals to the repair or removal of culverts and agricultural water diversions. FWCO professional staff provide comprehensive fish passage engineering and technical assistance capacity, as well as biological science expertise. The fish passage engineers and technical specialists ensure that passage projects are strategically selected and structurally sound; meet restoration goals for large, connected natural areas; and provide the intended environmental and human community benefits.

Through the NFPP, communities and aquatic species have received substantial benefits, including the restoration of natural stream flows, reduced sediment inputs, public safety benefits for communities and recreationalists, and increased resilience to flooding. The restored flow of streams and rivers allows fish to move freely and safely to habitats upstream and downstream, improving species survival and self-sustainability. Since the NFPP's inception in 1999, it has removed or bypassed over 2,933 barriers that pose risks to communities, aquatic life, and users of waterways for commercial and recreational transportation. This work has reconnected 52,600 miles of river and 192,361 wetland acres, benefiting more than 90 species of fish and freshwater mussels. NFPP projects have been effective at leveraging nonfederal funding to federal funding at a 3:1 ratio.[9]

The National Fish Habitat Partnership (NFHP)[10] leverages twenty Fish Habitat Partnerships to implement consensus-based, science-driven aquatic habitat restoration projects. Since 2006, 749 fish habitat conservation projects have been completed across all 50 states, leveraging $4 in partner contributions (a total of $123.6 million) for every $1 investment of federal funds (a total of $30.9 million). These projects restore aquatic habitats by reducing erosion by stabilizing stream banks, improving water flow, restoring living shorelines and aquatic vegetation, and adding other habitat improvements to provide structural elements needed for breeding, feeding, and shelter for fish and shellfish.

FWCO offices and other technical experts across the agency also work closely with the

[9] Sources: Personal communication with FAC program on May 1, 2018 and verified in 2025 using data reported in FIS at the time of the report.

[10] In 2020, the administration of the National Fish Habitat Partnership (NFHP) underwent significant changes following the passage of the America's Conservation Enhancement (ACE) Act. The information presented in this report reflects the structure and administration of the NFHP as it existed in 2018 and remains accurate for that time period.

[11] The Sikes Act, enacted in 1960, requires that all military installations create and maintain Integrated Natural Resources Management Plans (INRMPs) to provide for the management of natural resources, including fish, wildlife, and plants while also allowing for multipurpose uses of resources. Through INRMPs, military installations can provide public access and use of on-site natural resources, as necessary and appropriate, without a net loss in the capability of an installation to support its military mission.

Department of Defense (DoD) to develop and implement cooperative conservation programs conducted under the Sikes Act and other authorities.[11] This integrated approach has enabled military installations to protect 400 federally listed aquatic and terrestrial species and more than 550 at-risk species. It has also improved access to recreational hunting and fishing for military communities while enhancing training conditions that support military readiness. Additionally, the partnership with the DoD has increased flexibility by reducing regulatory burdens while enhancing fish and wildlife conservation. FWCO biologists, along with other FWS programs, cooperate with military installation natural resource managers and state fish and wildlife agencies on decisions affecting listed species; wildland fire support; conservation law enforcement activities; and recreational hunting and fishing programs.

The diverse aquatic species and habitat work carried out by FAC and the FWCO offices results in meaningful, on-the-ground benefits for aquatic species and habitats across the United States. Table 1 lists the accomplishments achieved from the expansive aquatic habitat and species conservation work of the FAC program for fiscal year 2017.

Table 2 Summary of Aquatic Species and Habitat Conservation Accomplishments through FWCOs for Fiscal Year 2017

Fish passage - # of barriers removed/bypassed	148
Fish passage – reopened (miles)	3,213
Fish passage – reopened (acres)	4,914
In-stream/shoreline habitat assessed (miles)	8,983
In-stream/shoreline habitat restored (miles)	178
In-stream habitat enhanced (miles)	135
Riparian habitat enhanced (miles)	57
Upland habitat assessed (acres)	54,253
Upland habitat restored/enhanced (acres)	2,433
Wetland habitat assessed (acres)	1,843
Wetland habitat restored/enhanced (acres)	243
Habitat assessments completed (number)	2,778
Population assessments completed	1,753

Source: FWS Fisheries Information System

Economic Effects of Aquatic Species and Habitat Conservation Activities

The restoration and conservation of aquatic species and habitat provides a variety of environmental and economic benefits to the American people. River and stream restoration projects improve conditions for wildlife, projects that remove dams or replace culverts improve water quality and flood resilience, and habitat restoration along rivers and streams can improve fishing, hunting, and recreational opportunities, as well as enhance property values nearby (Lewis, Bohlen and Wilson, 2008; Provencher, Sarakinos and Meyer, 2008).

The FAC program's activities related to aquatic species and habitat conservation can affect local and regional economies in multiple ways (see Figure 4). As restoration activities

move a degraded ecosystem toward a healthier restored state, immediate economic contributions arise from spending through by appropriations for the FAC program, other FWS partners, and outside contributors (e.g., NGOs) that directly support jobs and local businesses. Over time, a restored ecosystem can generate long-term economic contributions, such as sustained recreational and tourism opportunities, alongside broader public benefits like improved water quality, lower flood risk, and healthier wildlife habitat.

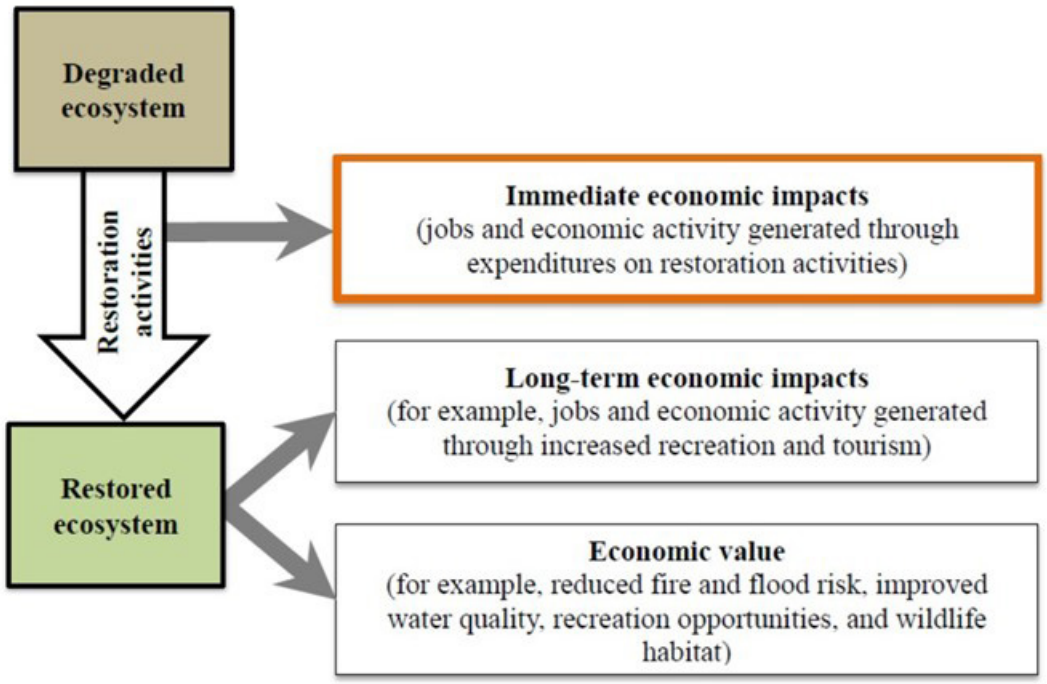
The estimates provided in this report capture the "immediate economic contributions" from expenditures on various aquatic species and habitat conservation and restoration activities by the FAC program in fiscal year 2017, summarized as follows:

- Overall, the economic contributions associated with the activity and project expenditures of FWCOs on aquatic species and habitat conservation activities ($195.0 million) amounted to $499.1 million in output and supported 3,277 jobs.
    - This represents roughly $2.6 million in output and nearly 17 jobs supported per $1 million in expenditures.
- Expenditures on FWCO activities and projects benefiting fish passage ($80.6 million) supported $207.3 million in output and supported roughly 1,245 jobs.
    - This represents nearly $2.6 million in output and over 15 jobs supported per $1 million in expenditures.
- Expenditures on FWCO activities and projects conserving and restoring aquatic habitat ($14.2 million) supported $34.1 million in output and 249 jobs.
    - This represents $2.4 million in output and 20 jobs supported per $1 million in expenditures.
- Expenditures on FWCO activities and projects managing, monitoring, and assessing aquatic species and habitat ($53.1 million) supported $111.7 million in output and 668 jobs.
    - This represents $2.1 million in output and nearly 13 jobs supported per $1 million in expenditures.

To place the FAC program's aquatic conservation contributions in context, several studies using similar methods are worth noting. For instance, Thomas et al. (2016) found that $1 million in DOI restoration spending supported 13 to 32 job-years and generated $2.4 to $3.4 million in total economic output. Samonte et al. (2017) examined 125 American Recovery and Reinvestment Act-funded habitat projects and reported roughly 15 jobs and $1.7 million in output per $1 million invested. Nielsen-Pincus and Moseley (2010) showed 14.7 to 23.1 jobs per $1 million spent on forest and watershed restoration, while a Massachusetts Department of Fish and Game analysis of four restoration projects indicated 9.9 to 13.2 jobs and $1.4 to $1.8 million in output per $1 million.

Although these examples vary widely, each uses detailed project-level data to assess how restoration spending cycles through local economies. The FAC program's overall economic estimates, developed at a programmatic level, fall within the same general range but do not have the same site-specific detail.

Figure 2 Economic Effects of Ecosystem Restoration



Source citation:
Cullinane Thomas, Catherine; Huber, Christopher; Skrabis, Kristin; and Sidon, Joshua, 2016, Estimating the economic impacts of ecosystem restoration—Methods and case studies: U.S. Geological Survey Open-File Report 2016–1016, 98 p., http://dx.doi.org/10.3133/ofr20161016.

In addition to the immediate and potential longer-term economic contributions, the FAC program's aquatic conservation and restoration work also improves numerous ecosystem goods and services that enhance economic well-being (e.g., new or improved fishing and hunting opportunities, enhanced aesthetics, improved water quality, reduced flood risk, increased resilience of riparian and shoreline areas to storm damage, and protection of threatened and endangered species and their habitat).

Unlike measures of economic contributions that track how dollars cycle through the economy, the economic value of conservation and restoration represents a monetary estimate of the benefits received by the public for the ecological changes. Calculating this monetary measure involves estimating the public's willingness-to-pay (WTP). WTP, an economic measure distinctly different from economic contributions, represents a monetary estimate of the increase in benefits enjoyed by the public from changes in the natural resource goods and services affected by conservation and restoration actions. Because ecological changes resulting from conservation and restoration actions are not bought and sold in markets, estimating WTP for these non-market goods and services typically relies on the use of revealed preference and/or stated preference

methods.[12] Furthermore, estimates of WTP can reflect preferences associated with changes in use and/or non-use values.[13]

Research by Brouwer and Sheremet (2017) and Bergstrom and Loomis (2017), for example, suggests that households may be willing to spend between a few dollars and several hundred dollars annually to support river or stream restoration, depending on the scope and benefits provided. This research helps put some perspective on the potentially significant economic benefits of the annual accomplishments of the FAC program's aquatic species and habitat conservation and restoration activities.

These non-market considerations underscore that many benefits of aquatic conservation, such as maintaining biodiversity or preventing future habitat degradation, do not appear in traditional market-based analyses. Measuring these effects at a national scale, however, requires substantial data on localized changes in recreation and ecosystem conditions. Consequently, this report focuses on immediate contributions tied to program expenditures while acknowledging that long-term benefits are often significant, yet less easily quantified.

Aquatic Invasive Species

Invasive species, such as bighead carp, quagga mussel, giant salvinia, lionfish, and brown tree snake, cost the nation billions of dollars in prevention and control costs, lost economic and industrial productivity, infrastructure damage, human health issues, lost or diminished recreation opportunities, and ecological damages each year. Invasive species significantly affect the health of native species and natural areas where they are second only to habitat destruction as the leading cause of declining fish and wildlife populations in the United States. Over forty percent of the imperiled species in the United States are threatened primarily by invasive species (Wilcove et al., 1998). Furthermore, natural areas stressed by pollution, development, and other factors are more susceptible than healthy ecosystems to harm from invasive species.

The Aquatic Invasive Species (AIS) program provides critical leadership and a vital regional and field presence on the ground in the fight against AIS across the United States. More broadly, AIS program efforts encompass national coordination, prevention, control, and management, focusing on aquatic species that will cause significant ecological and economic harm if they become established and/or continue to spread.

Central to this effort is the Aquatic Nuisance Species (ANS) Task Force, co-chaired by the FWS and the National Oceanic and Atmospheric Administration. Comprised of thirteen

[12] Revealed preference methods infer economic values for non-market goods and services from observed behavior that has a link to the good or service being valued (e.g., values for changes in water quality can be estimated from economic models of anglers' decisions to go fishing). Stated preference methods estimate economic values using surveys to elicit an individual's preferences for non-market goods and services.

[13] In general, non-use value captures an individual's preferences for the resource or resource changes not derived from its use. Other terms used synonymously with non-use value include "existence" and "passive use" value.

federal agencies and fifteen ex-officio entities, the Task Force is the only federally mandated intergovernmental body exclusively dedicated to preventing and controlling AIS. Working in tandem with six regional ANS panels, it has approved nine national control and management plans and an action plan for quagga and zebra mussels in western states—all developed through the coordinated efforts of numerous federal, state, and non-governmental organization representatives.

To support state and tribal priorities, the FWS also funds and implements forty-three State/Interstate Aquatic Nuisance Species Management Plans, fostering cost-sharing agreements and technical assistance aimed at preventing the introduction and spread of AIS. Proactive prevention strategies are coordinated at the national, regional, and local levels to minimize the risk of new invasions. A notable example is the "Stop Aquatic Hitchhikers!" campaign, which encourages recreational users to clean, drain, and dry watercraft and equipment after leaving the water. More than one thousand public and private organizations, ranging from fish and wildlife agencies to businesses, have joined this nationwide effort to combat hitchhiking organisms.

The AIS program coordinates resources among federal, tribal, state, local, and nongovernmental partners to target and contain high-priority AIS like quagga and zebra mussels in the Lower Colorado River Basin and invasive carp, which threaten the Great Lakes, a multibillion-dollar commercial and recreational fishery. In addition, the FWS supports species-specific control plans for other invasives, such as snakehead and the New Zealand mudsnail, ensuring a comprehensive and adaptive approach to AIS management.

Beyond these highlights, the AIS program engages the public, coordinates with federal, tribal, state and local partners, and provides technical expertise on an annual basis in numerous ways that is critical to the management and control of AIS. Table 3 provides a summary of the activity accomplishments reported by the AIS program for 2017.

Table 3 Aquatic Invasive Species Program Accomplishments for Fiscal Year 2017

Number of activities conducted to support the management and control of AIS	956
Number of technical assistance/coordination activities conducted for AIS	917
Number of invasive species partnerships established and maintained	520
Number of activities conducted to address priority pathways	73
Number of AIS related outreach/education activities conducted	278
Number of surveys conducted for aquatic invasive species baseline/trend information	643
Number of surveys conducted for early detection and rapid response for AIS	171
Number of surveys conducted for early detection	146
Number of activities conducted for rapid response	25

Source: FWS Fisheries Information System

Economic Effects of Aquatic Invasive Species Activities

AIS pose significant challenges because they are often difficult to detect, their pathways

may not be obvious, and their effects can be difficult to ascertain. AIS are also nearly impossible to eradicate once established. Furthermore, the nature of invasive species control requires coordinated efforts among the various local, state, federal, and private entities affected to limit their establishment, spread, and damage. Estimates of the combined economic damages and associated control costs for both terrestrial and aquatic invasive species are approximately $120 billion per year in the United States (Pimentel et al., 2005). While Pimentel et al. focus on the direct costs through production losses in agriculture, forestry and other segments of the U.S. economy and the costs to manage invasive species, the economic effects of invasive species may extend much further. If a more comprehensive monetary measure that directly accounted for both market and non-market economic effects of invasive species in the U.S. were available, the estimates by Pimentel et al. would likely be considerably larger (Zhang and Boyle, 2010).

AIS management, control, prevention, coordination, and outreach activities with federal, tribal, state and local partners affect local and regional economies in many different ways. The spread of AIS can negatively affect various industries via unplanned facility expenditures to address AIS invasions, changes in operations and behaviors to limit the introduction and spread of AIS, or changes in natural resource use and enjoyment by public and private entities due to the presence of AIS. Federal, state, and local agencies expend considerable resources due to the significant environmental and economic harms AIS cause. While not a measure of economic benefits, one way to communicate how local communities are affected is through measurement of the economic contributions associated with the expenditures on efforts to prevent, control, manage, and raise awareness about AIS. Such information can inform agency officials and stakeholders about the socioeconomic contributions of AIS activities undertaken to protect resources critical to our economic well-being.

From the FAC program's expenditures on AIS management, control, prevention, coordination, and outreach activities in FY 2017:

- Approximately $44.4 million in expenditures supported $103.0 million in output and 924 jobs.
    - This represents roughly $2.3 million in output and nearly 21 jobs supported per $1 million in program expenditures.

These estimates only focus on the immediate economic contributions from the expenditures related to the FAC program's AIS activities and projects. However, the overall economic effects of invasive species go well beyond management and control expenditures. Without AIS policies and management, severe ecological and economic harm can occur. Studies estimating economic contributions of AIS commonly report the total damages caused by AIS, but it is often unclear if these estimates represent damages in the absence of any AIS management and control efforts, damages with limited management and control efforts, or damages with extensive management and control efforts (Homans and Smith, 2013). When control measures are in place, they often reduce or contain an invasive population's spread and, in turn, lessen the potential damages.

Estimating the economic effects of AIS is challenged by the underlying complexities of ecological systems and uncertainties regarding how AIS affect them over time and space. The counterfactual, what would have happened without any management, is typically unknown or depends on complex biological and ecological modeling to predict possible outcomes. As a result, broad estimates of AIS damages (and benefits or damages avoided) on different industries (e.g., recreational and commercial fishing, public utilities) or natural resources (e.g., alteration of ecosystem processes, loss of biodiversity) are generally not available (Lovell et al., 2006). Furthermore, the FAC program's AIS work is typically just one component of a broader coordinated strategy requiring contributions from other federal, tribal, state, and local partners. This coordination makes identifying and estimating the portion of total economic benefits attributable solely to the FAC program a difficult task. In addition, estimates of economic damages and/or benefits on their own do not provide a complete picture of the issues associated with AIS. It is important to combine them with estimates of control and management costs when establishing AIS policy and management actions (Homans and Smith, 2013). While not exclusive to the FAC program, the information that follows highlights the importance of the FAC program's AIS efforts as a key input in the fight against AIS and the resulting ecological and economic benefits.

The Great Lakes are a major focal point for the FAC program's AIS efforts, given the threats posed by species such as sea lamprey, invasive carp, and quagga and zebra mussels. These waters support significant industrial and recreational activity (see Tables 5 and 6), including 19.6 million fishing days and billions of dollars in related expenditures. Sustained control measures have kept sea lamprey at low levels, yet they remain costly to manage—analyses estimate net benefits of at least $93 million to Michigan anglers alone if populations stay in check (Lupi, Hoehn, and Christie, 2003). Other studies in Lake Champlain (Gilbert, 1999) reveal similar benefit-cost ratios for lamprey reduction, underlining why the FAC program's investments in AIS containment here are so crucial.

Table 4 Great Lakes Recreational Fishing Activity and Economic Contributions in 2011

State	Anglers	Fishing Days	Retail Sales	Salaries	Jobs	Total Output
Illinois	69,300	147,545	$58,496,056	$34,388,935	786	$105,389,187
Indiana	26,691	113,863	$18,918,669	$7,114,508	213	$27,872,459
Michigan	649,639	10,987,320	$1,272,352,928	$774,938,502	19,805	$2,231,549,094
Minnesota	45,578	206,745	$85,158,787	$51,378,186	1,494	$154,284,123
New York	331,774	4,484,574	$612,789,066	$340,811,049	6,787	$1,029,998,139
Ohio	343,626	2,160,773	$486,482,882	$207,718,420	7,048	$759,942,999
Pennsylvania	119,742	387,356	$55,208,013	$31,861,877	891	$95,433,266
Wisconsin	178,268	1,246,411	$114,344,635	$56,867,409	1,833	$185,460,010
Total for U.S.[1]	1,664,824	19,660,829	$2,971,195,133	$2,205,174,067	49,298	$7,227,424,732

[1] Includes contributions from purchases made in inland states for Great Lakes fishing.

Source: U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, Census Bureau, 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Washington, DC, revised 2014. Southwick Associates, *Sportfishing in America: An Economic Force for Conservation*, Produced for the American Sportfishing Association (ASA) under a U.S. Fish and Wildlife Service Sport Fish Restoration grant (F12AP00137, VA M-26-R) awarded by the Association of Fish and Wildlife Agencies (AFWA), 2012.

Table 5 Great Lakes Commercial Fishing Landings and Revenue in 2016

State	Landings (pounds)	Revenue
Michigan	6,698,000	$9,837,000
Minnesota	286,000	$238,000
New York	62,000	$137,000
Ohio	4,585,000	$4,981,000
Pennsylvania	105,000	$125,000
Wisconsin	3,019,000	$3,844,000
Total	14,755,000	$19,162,000

Source: U.S. Department of Commerce, National Marine Fisheries Service, *Fisheries of the United States 2016*, Silver Spring, Maryland, August 2017

Beyond the Great Lakes, FAC helps combat quagga and zebra mussels that can obstruct water intakes and harm hydropower facilities, as well as invasive carp that displace native fish. Such threats drive high potential costs for states unprepared to contain new outbreaks (Connelly et al., 2007; Davis and Moeltner, 2010). Invasive aquatic plants—like elodea spp. in Alaska—disrupt ecosystems and industries from salmon fisheries to floatplane operations (Schwoerer and Baek, 2017). Meanwhile, species such as Eurasian watermilfoil can erode property values by up to 19 percent, affecting tax revenue and community services (Halstead et al., 2003; Horsch and Lewis, 2009; Zhang and Boyle, 2010; Olden and Tamayo, 2014; Liao, Wilhelm, and Solomon, 2016). These estimates rely on scenario-based modeling and do not account for all existing mitigation efforts; however they illustrate the stakes if invasive species go unchecked.

Investments in AIS management can occur across different stages of species invasion, from preventing the entry of new species to the control of widely spread species. The preference of policymakers are for investments in invasive species prevention measures as they are argued to be the most cost-effective management option and will likely lead to higher social returns compared to focusing on actions to reduce impacts only after ecosystems have been affected (Finnoff et al, 2007). Even when potential impacts of invasive species are inevitable, the public has expressed positive willingness-to-pay to delay the harmful ecosystem, health, and economic effects they cause (McIntosh, Shogren, and Finnoff, 2010).[14] However, once a species is introduced outside its native range, expenditures to reduce, eradicate, and prevent it from spreading further are often necessary. The AIS program provides critical leadership and assistance to state and local jurisdictions and other federal partners to help avoid the costly economic and ecological burdens of AIS and to prevent their introduction and expansion into areas across the United States.

[14] McIntosh, Shogren, and Finnoff (2010) found the average household is willing to make a one-time payment of $48 for a one-year delay of low to high impacts to inland water bodies from inevitable invasions of aquatic invasive species. To delay low to high impacts for a decade, the one-time willingness-to-pay for the average household was $218.

National Fish Hatcheries, Research, Science, and Technology

National Fish Hatcheries

For nearly 150 years, the National Fish Hatchery System (NFHS) has worked with state, tribal, federal, and private sector partners to maintain healthy, self-sustaining fish populations that are critical to recreation, food security, and business development. This challenging task is accomplished with an interwoven network of 70 production facilities along with nine fish health centers, seven fish technology centers, and the Aquatic Animal Drug Approval Partnership Program. National fish hatcheries (NFH) work in concert with habitat and harvest management actions to conserve aquatic populations at levels supporting human demand. NFH propagation addresses top priorities such as the enhancement of recreational fishing and public use of aquatic resources, mitigation for impacts of energy harvest, recovery of federally-listed threatened or endangered species, restoration of imperiled species, and fulfillment of tribal partnerships and trust responsibilities. NFHs work closely with federal agency partners, like the U.S. Army Corps of Engineers, to mitigate impacts of energy harvest through federal water projects via reimbursable service agreements. In order to maintain excellence in aquatic conservation and ensure healthy fisheries, FWS professionals closely monitor the health, status, and trends of aquatic populations; measure the quantity and quality of important aquatic habitat to support strong fisheries; and limit the outbreak and spread of invasive species and disease-causing pathogens.

The FWS helps fulfill federal mandates for the recovery, restoration, and inter-jurisdictional management of depleted fish stocks. NFHs, FWCOs, Fish Technology Centers, and Fish Health Centers have focused their efforts to recover aquatic species listed as threatened, endangered, or candidates under the Endangered Species Act; restore and maintain depleted anadromous or highly migratory fish stocks and aquatic habitats at productive or self-sustaining levels; and establish, protect, or restore resources for which Congress has assigned responsibilities to the agency through legislation (i.e., mitigation of federal water development projects).[15] In addition, FWCOs may carry out population assessments of fish hatchery products.

NFH Fish Production and Stocking

In 2017, the NFHS produced and stocked over 134 million juvenile and adult fish, along with over 70 million eggs. Table 6 shows juvenile production by species common name and percent of total production. Chinook and king salmon account for 35 percent of total production, while other salmon species including coho, silver, chum, and Atlantic account for 12.5 percent. Walleye account for 31 percent of 2017 production, while rainbow, steelhead, redband, and lake trout account for 10.9 percent. Forty-one other species account for 4.4 percent of total juvenile production.

[15] The Service implements several forms of mitigation associated with existing federal water development projects: 1) those that minimize adverse project impacts (i.e. constructing fish-passage facilities); 2) those that rectify project impacts (i.e., restoring habitat); and 3) those that compensate affected parties for project impacts (i.e., enhancing fishery resources in reservoirs and tail waters created by federal water development projects).

Table 6 National Fish Hatchery Juvenile Production, by Major Species 2017

Species Common Name	Quantity	Percent of Total Production
Chinook Salmon or King Salmon	44,586,519	35.0%
Walleye	39,412,406	31.0%
American Shad	9,116,163	7.2%
Rainbow, Steelhead, Redband Trout	8,593,737	6.8%
Lake Trout	5,224,260	4.1%
Northern Pike	3,118,939	2.5%
Coho Salmon or Silver Salmon	3,112,672	2.4%
Fathead Minnow	2,590,155	2.0%
Chum Salmon	2,166,500	1.7%
Atlantic Salmon	1,983,918	1.6%
Striped Bass	1,763,468	1.4%
Other (41 Species)	5,559,549	4.4%
Total	127,228,286	100.0%

Table 7 shows the distribution of adult fish in 2017. Various species of trout accounted for over 98 percent of adult fish distribution, with rainbow, steelhead, and redband accounting for 75.2 percent of total adult stocking. The two species of cutthroat trout, Lahontan and westslope, account for a total of 11.9 percent. Brown, brook, and lake trout account for 11.1 percent.

Table 7 National Fish Hatchery Adult Distribution by Species, 2017

Species Common Name	Quantity	Percent of Total
Rainbow, Steelhead, Redband Trout	5,446,843	75.2%
Lahontan Cutthroat Trout	572,383	7.9%
Brown Trout	417,584	5.8%
Westslope Cutthroat Trout	291,280	4.0%
Brook Trout	273,691	3.8%
Lake Trout	111,713	1.5%
Other (22 species)	127,326	1.8%
Total	**7,240,820**	**100.0%**

Table 8 shows egg production in 2017. Rainbow, steelhead, and redband trout accounted for 51.4 percent of total egg distribution, with walleye and lake trout accounting for 15.4 and 9.4 percent, respectively. The total egg distribution was 70.1 million.

Table 8 National Fish Hatchery Egg Production by Species, 2017

Species Common Name	Quantity	Percent of Total
Rainbow, Steelhead, Redband Trout	36,034,908	51.4%
Walleye	10,792,531	15.4%
Lake Trout	6,596,057	9.4%
Chinook Salmon Or King Salmon	6,094,315	8.7%
Atlantic Salmon,	2,686,958	3.8%
Brown Trout	2,216,498	3.2%
Northern Pike	1,512,000	2.2%
Bloater	1,377,097	2.0%
Brook Trout	689,939	1.0%
Other (10 Species)	2,104,689	3.0%
Total	**70,104,992**	**100.0%**

Table 9 shows recreational stocking in 2017. Walleye accounted for 32.5 percent of recreational fish stocking, chinook salmon for 31.5 percent, rainbow, steelhead, and redband for 10.2 percent, and American shad, lake trout and northern pike accounted for 9.6, 4.7 and 3.3 percent, respectively. Walleye, salmon, and trout species accounted for 86.2 percent of recreational fish stocked. Total recreational stocking amounted to 95.2 million in 2017.

Table 9 National Fish Hatchery Recreational Stocking, Juveniles and Adults 2017

Species common name	Quantity	Percent of Total
Walleye	30,947,404	32.5 %
Chinook	29,963,113	31.5 %
Rainbow, Steelhead, Redband	9,663,057	10.2 %
American Shad	9,116,103	9.6 %
Lake trout	4,490,093	4.7 %
Northern Pike	3,103,939	3.3 %
Coho	2,363,028	2.5 %
Chum	2,166,500	2.3 %
Brown Trout	730,154	0.8 %
Lahontan Trout	462,807	0.5 %
Bonneville Cutthroat	422,810	0.4 %
Brook Trout	396,050	0.4 %
Large Mouth Bass	378,148	0.4 %
Sockeye	341,664	0.4 %
Catfish	187,031	0.2 %
Yellow Perch	146,889	0.2 %
Yellowstone cutthroat	106,215	0.11 %
Blue Gill	94,670	0.10 %
Black Crappie	57,992	0.06 %
Small mouth bass	11,860	0.01 %
Apache Trout	1,961	0.00 %
Tiger Trout	961	0.00 %
Total	**95,152,449**	**100.0 %**

Economic Contributions of Hatchery Stocking and Recreational Angling Expenditures

Federal hatcheries provide a variety of environmental and natural resource goods and services. These services can be grouped into four broad categories:

1. Recreational and commercial harvest
    a. Maintaining recreational and commercial fishing opportunities
    b. Creating additional fishing opportunities
    c. Replacing lost fishing opportunities
2. Information and community connections
    a. Fisheries research and development to promote healthy and productive fisheries
    b. Fish health diagnostics, inspection, and surveillance
    c. Environmental and fisheries educational programs
    d. Visitor center and facility tours
3. Ecological use
    a. Mitigation of environmental damages
    b. Restoration and recovery of declining fish populations
4. Federal investment and economic contributions
    a. Hatchery budget expenditures and their economic contributions on local and regional economies

While all these services make important contributions, this section focuses only on the economic contributions associated with recreational angling for NFH-produced and stocked fish. Economic contributions refer to employment, employment income, industrial output, and federal and state tax revenue that occur as the result of consumer expenditures (retail sales) on trip- and angling-related goods and services. Spending associated with angling can generate a substantial amount of economic activity in local, regional, and national economies. For example, anglers spend money on a wide variety of goods and services, such as expenses for food, lodging, and transportation, as well as consumer goods like bait, tackle, and services like licensing and charters. Oftentimes, these expenditures occur in remote locations, acting not only as a critical component of diversifying economies but also fortifying livelihoods. These direct expenditures are only part of the total picture, however. Businesses and industries that supply the local retailers where the purchases are made also benefit from angler expenditures. In this way, each dollar of local retail expenditures can affect a variety of businesses at the local, regional, and national levels.

Estimating Recreational Angling Days Based on NFH Stocking and Release

The basis for estimating the economic effects of NFH stocking is to determine the number of angling days associated with the number of stocked fish. Once angling days are estimated, determining economic effects is a relatively straightforward process, at least conceptually.

General Approach

The general approach to estimating economic contributions associated with NFH stocking is to link stocking information to angler days. Once angler days are determined, total retail sales can be calculated, and economic contributions estimated. So, in a general sense:

Fish Stocking ⟶ Angler Days ⟶ Retail Sales ⟶ Economic Contributions

The basic approach is to link the quantity of fish stocked by the hatcheries with an estimate of the number of anglers who fished for these stocked fish. Ideally, the following information would be available to estimate angler days: (1) the number of anglers at each stocking site; (2) the total number of angling days at the stocking site; (3) the percent of total stocking at each site that is comprised of NFH stocked fish; and (4) the total number of fish stocked at the site by NFH. Unfortunately, comprehensive information on these items is not available for the vast majority of hatchery stocking sites. For example, in 2017, there were over a thousand juvenile and adult stocking sites across the U.S. Survey information on the number of anglers and angler days is available for only a few sites. Consequently, alternative approaches must be identified that make use of the information that is available and use this information in conjunction with assumptions about the applicability of information that does exist on anglers and angling days to all the remaining sites where such information is not available.

Angler Effort Approach

In addition to stocking information, this approach relies on information about the number of fish caught over a given period of time and how many hours an angler fishes on an average day or over a given trip length. For example, a creel survey may indicate that at a particular location, anglers average 0.5 bluegill caught per hour and that they average about four hours of fishing per day. Consequently, about two fish per day per angler are caught, on average. This information is used in conjunction with modified or adjusted stocking data to estimate the number of angling days associated with the level of stocking for site under consideration. Stocking data is adjusted to reflect that not all stocked fish are caught by anglers. For a given stocking year, a number of the fish die or carry over into the next year before being caught. As a hypothetical example, consider an area is stocked with 10,000 smallmouth bass annually. It is estimated that mortality and carry over account for 40 percent of all fish stocked in a given year; consequently about 60 percent of total annual stocking is caught. If creel surveys indicate that two bass per day are caught per angler, then total angler days equal (10,000 x 0.60) divided by 2 or 3,000 angler days. For an example of this particular approach, see *The Economic Effects of the Recreational Use of National Fish Hatchery 2004 Stocking in Region 6 (Mountain-Prairie Region)* (Caudill, 2005).

Angler Days Associated with National Fish Hatchery Stocking

Given the large number of stocking sites for which angler use information is not available, a number of assumptions were made in order to estimate the number of angler days associated with NFH stocking. These assumptions are based primarily on extrapolating angler

use information from sites where such information does exist and reliance on best professional judgment of fisheries biologists and managers when site-specific information from reports or studies are not available.

Major Assumptions:

- Only recreational stockings are included (classified as such by stocking data in FIS).
- If specific stocking events were not classified by purpose(recreation, research, inter-jurisdictional, etc.), it is assumed that game species would be subject to recreational angling consistent with state fishing regulations.
- All fish caught are for recreation (information is not available for identifying commercial catch, if any, from total harvest).

Retail expenditures show the total annual travel-related expenditures associated with the recreational catch of NFH stocking.

Industrial output shows the total industrial output generated by the angler expenditures. Total output is the production value (alternatively, the value of all sales plus or minus inventory) of all output generated by angling expenditures. Total output includes the direct, indirect, and induced effects of angling expenditures. Direct effects are simply the initial effects or contributions of spending money; for example, spending money in a grocery store for a fishing trip or purchasing fishing line or bait are examples of direct effects. The purchase of fishing line by a sporting goods retailer from the line manufacturer or the purchase of canned goods by a grocery store from a food wholesaler would be examples of indirect effects. Finally, induced effects refer to the changes in production associated with changes in household income (and spending) caused by changes in employment related to both direct and indirect effects. More simply, people who are employed by the grocery store, by the food wholesaler, and by the line manufacturer spend their income on various goods and services, which in turn generate a given level of output. The dollar value of this output is the induced effect of the initial angling expenditures.

Jobs and **job** include direct, indirect, and induced effects in a manner similar to total industrial output. Employment includes both full- and part-time jobs, as well as associated wages and salaries. A job is defined as one person working for at least part of the calendar year, whether one day or the entire year.

Tax revenues are shown for state income tax (where applicable) and federal income tax generated by angler expenditures on NFH-stocked fish. Like output, employment, and income, tax contributions include direct, indirect, and induced tax effects of angling expenditures.

National Economic Contributions Results of Recreational Angling for NFH Stocked Fish

Table 10 shows the estimated economic contributions of recreational angling for NFH-produced and stocked fish. Stocked fish used recreationally totaled 95.2 million, accounting for 13.2 million angling days. Retail expenditures associated with these angling days ($57.18 per angling day) totaled $754.8 million, with an industrial output of $1,207.7 million. These expenditures accounted for 12,076 full- and part-time jobs, with a job income of $483.0 million. Federal tax revenue and state and local tax revenue totaled $88.3 million and $77.0 million, respectively.

Table 10 National Economic Contributions of Recreational Angling for NFH Stocked Fish in FY 2017 (2017 $)

Economic Contribution	Low	High	Mid
Stocked Recreation Fish	--	--	95.2
Angler Days	11.2	15.2	13.2
Retail Expenditures	$641.6	$868.0	$754.8
Output	$1,026.6	$1,388.9	$1,207.7
Jobs	10,264	13,887	12,076
Job Income	$410.6	$555.5	$483.0
Federal Tax Revenue	$75.1	$101.5	$88.3
State and Local Tax Revenue	$65.5	$88.6	$77.0

Note: All values in millions except jobs.

Research, Science, and Technology

The FAC program has a responsibility to provide leadership in the development and application of state-of-the-art science and technology for the conservation and management of fish, other aquatic species, and their habitats. Fish Technology Centers (FTCs) provide applied science support for recovery and restoration programs. The seven FTCs conduct practical research in animal culture biology, genetics, ecological physiology, nutrition, biometrics, modeling, and cryopreservation for application in aquatic resource management. The knowledge gained from FTC studies informs conservation efforts, supports the aquaculture industry, and enhances fish propagation practices. Over the past 30 years, FTCs have published nearly 1,000 peer-reviewed papers, including 50 publications in 2017 alone. Recent FTC publications cover diverse topics, such as developing and evaluating new sportfish diets, testing fish passage engineering designs, assessing the safety of aquaculture drugs, and comparing environmental DNA sampling with traditional sampling methods. These peer-reviewed articles effectively transfer applied scientific knowledge and technological tools to partners, demonstrating the broader contributions of FTC research beyond the agency.

The Aquatic Animal Drug Approval Partnership (AADAP) Program, established in 1994, ensures FWS compliance with the Federal Food, Drug, and Cosmetic Act and the health and fitness of agency-released and wild fish. AADAP is the only program in the U.S. singularly focused on obtaining access to critically needed new drugs for use in aquatic species. The

AADAP Program works with the U.S. Food and Drug Administration (FDA) and other tribal, state, and federal agencies, academic institutions, and private partners to obtain FDA approval of safe and effective new drugs needed for aquaculture and fisheries management. In addition to federal appropriations, the program receives financial support from cost-reimbursable dollars generated by the National Investigational New Animal Drug (INAD) program and FDA research grants; in FY 2017, the INAD program brought in $177,100.

The INAD Program provides fishery managers and aquaculture facilities across the country with legal access to a variety of experimental drugs for which AADAP is pursuing FDA approval which would otherwise be unavailable. Over 250 non-FWS facilities in 45 states receive direct benefits through participation in this unique program and the use of drugs that are in the approval process. During FY 2017, over 38 million fish were treated with INADs, including those to control mortality, induce spawning, marking, and anesthetics. Slightly over 19 million fish were treated with INADs to limit mortality caused by infectious fish pathogens with an estimated 20 percent, or 3.8 million fish, that would otherwise have died without these treatments. The FWS uses the data generated from the coordinated use of INADs to contribute to drug approvals through the FDA; in FY 2017, 16 INADs contributed data for future drug approvals.

Aquatic animal health biologists operating at nine Fish Health Centers (FHCs) across the nation detect, monitor, and mitigate disease-causing pathogens. Their findings inform decisions that improve the health of captive fishes at hatcheries and of fish populations in the wild. Fish health professionals also investigate emerging health issues, such as invasive species that can be vectors for disease, to help prevent the introduction or spread of dangerous aquatic pathogens.

The FHCs guide the agency's implementation of the National Aquatic Animal Health Plan in partnership with the National Oceanic and Atmospheric Administration, the National Marine Fisheries Service, and the Department of Agriculture's Animal and Plant Health Inspection Service. The FHCs are also an integral part of the Nation's aquatic animal health testing system: the National Animal Health Laboratory Network. This network of standardized testing facilities serves as the preeminent source of information on the status of aquatic animal pathogens in the wild and facilitates interstate and international commerce of aquatic animals, while protecting the natural resources of the United States.

Cooperation with Native American Tribes and Alaska Native Peoples

The FWS has a unique set of responsibilities and opportunities to work with and serve federally recognized tribes and Alaska Native peoples. Under its Native American Policy (https://www.fws.gov/policy-library/510fw1), the FWS works to "further the trust responsibility of the Service and the Department of the Interior to federally recognized tribes to protect, conserve, and use tribal reserved, treaty guaranteed, or statutorily identified resources." In its 2016-2022 Strategic Plan, the FAC program committed to fulfill tribal trust and subsistence responsibilities for the agency and to develop and maintain effective relationships between the FWS and federally recognized tribes. This commitment builds upon decades of FWS assistance to tribes, including the stocking of fish on tribal lands, providing technical assistance to tribes

for fish and wildlife resource management needs within and outside of tribal lands and waters, and working closely with tribes to propagate fish in federal, state, or tribal hatcheries. While the economic value of the FAC program's work with tribal and Alaska Native communities is not always captured through traditional metrics, these activities reflect long-standing trust responsibilities, support culturally and economically important fisheries, and contribute to the stewardship of aquatic resources across vast and diverse landscapes.

The FAC program works with tribal resource agencies to manage fish and wildlife on 56 million acres of tribal trust lands and 44 million acres of Alaska Native peoples' lands. Fish and wildlife conservation on tribal lands is advanced through cooperative management with tribes, specifically by providing technical assistance, training, financial support, and equipment. Assistance provided to tribes results in the management, protection, and conservation of their statutorily defined trust natural resources, which helps tribes develop their own capabilities as they exercise their sovereignty in the management of fish and wildlife resources.
Across the nation, tribes manage and maintain their own hatcheries and work closely with hatcheries run by states, by the NFHS, or other federal agencies to propagate priority fish species. For example, hatcheries help to ensure the availability of fish species to traditional tribal uses where dams or other water infrastructure interfere with or compromise the natural reproduction or sustainability of species important to tribes. The NFHS propagates fish in "mitigation" hatcheries with the financial support of the U.S. Army Corps of Engineers, the Tennessee Valley Authority, or the Bonneville Power Administration to ensure that these important fish species are available to local tribal members.

With assistance from the FWS, tribes have developed and expanded their fish and wildlife management programs that oversee the conservation, protection, and preservation of their natural resources. This has increased the economic and social opportunities for many tribes. Revenues generated through recreational and commercial fishing on tribal lands have helped support tribal governments and furthered the development of capabilities for tribes to manage their fishery resources. Additionally, retail sales related to recreational fishing on tribal lands provides significant revenues to tribes and the surrounding local economies. In FY 2017, NFHs stocked over 13 million fish that directly or indirectly benefited federally recognized tribes with slightly more than 7 million fish stocked directly into tribal waters.[16,17]

FWCO biologists with the FAC program also provide on-the-ground technical assistance to tribes, oversee subsistence use by rural Alaskans on federal lands, evaluate fish stocks and aquatic habitat, and collaborate with partners, including tribes, to conserve fish species that move across multiple jurisdictions. For example, FWCOs in the Midwest and Northeast Regions work closely with tribal, state, provincial, and other valued partners to restore lake trout in the Great Lakes. The FWS monitors these populations by marking all hatchery-produced fish with

[16] Sources: U.S. Fish and Wildlife Service's Fisheries Information System database and personal communication with FAC program staff on August 17, 2018.
[17] Separate economic contribution estimates for the tribal allocation of NFH stocked fish are not available. However, the economic contribution estimates from recreational angling for all NFH stocked fish presented in the previous section does include the tribal allocation that supports recreational angling.

coded-wire tags. Tags are recovered through cooperation with partners and returned to FWCOs for extraction and analysis. These data help the FWS understand population trends, assess program success, and inform management decisions in the cooperative effort to restore this highly valuable native species in support of sustainable commercial and recreational fisheries. The Great Plains FWCO provides technical assistance for fisheries management to tribes in South Dakota, Nebraska, and Kansas, where reservoirs on tribal lands provide angling opportunities. There, FWCO biologists conduct fisheries surveys, help prioritize areas for fish management, provide management recommendations, and coordinate fish stocking requests through the federal hatchery system. The Montana Tribal FWCO works closely with the Montana/Wyoming Tribal Fish and Wildlife Commission to address regional issues that affect fish and wildlife on reservation lands. The Lander FWCO, in Wyoming, has been working with the Eastern Shoshone and Northern Arapaho Tribes of the Wind River Reservation on fisheries conservation since 1941. This reservation provides an abundance of habitat for native cutthroat trout, burbot, and sauger, as well as a variety of non-native fish, including lake, brown, rainbow, and brook trout.

The NFPP employs a voluntary, non-regulatory approach to restoring native fish and other aquatic species to self-sustaining levels by reconnecting habitat fragmented by barriers. Each year, the FWS partners with tribes, as well as other federal agencies, states, private landowners, local governments, and non-governmental organizations in the effort by providing technical assistance and funding support for a variety of projects that remove barriers to the movement of aquatic species. A number of federally recognized tribes have treaties with the United States to ensure that anadromous fish species important to them are able to swim upstream to their breeding grounds, and these obligations are supported by the NFPP.

Tribes also play a key role in projects funded through the National Fish Habitat Partnership. There are 20 Fish Habitat Partnerships, including four in Alaska, one in Hawaii, and 14 on the mainland. In Alaska, the Central Council Tlingit Haida Indian Tribes participated in the early formation of the Southeast Alaska Fish Habitat Partnership. Several FHPs are carried out in cooperation with tribes and some, like the Pacific Lamprey Conservation Agreement Initiative, are primarily aimed at restoring an important food source for several tribes. For example, the Southwest Alaska Salmon Habitat Partnership, which formed in 2000, includes both tribal and corporate Native Alaska organizations and subsistence users of this fish resource. Through the Mid-West Glacial Lakes FHP, conservation efforts help support tribal resources for the Ojibwe, for which hunting, fishing, and gathering rights have been protected under treaties signed in 1836, 1837, 1842, and 1854. The Pacific Lamprey Conservation Agreement Initiative was established in 2007 to promote and coordinate the implementation of conservation measures for Pacific Lamprey in Alaska, Washington, Oregon, Idaho, and California in order to achieve the long-term persistence of this species to support traditional tribal cultural use throughout its historic range.

The FAC program also administers grant programs that support tribal fisheries in the contiguous United States. For example, in the Great Lakes Basin, the FWS administers grant funding and collaborates with states and tribes to identify, develop, and implement regional fish and wildlife conservation projects. Under the Great Lakes Fish and Wildlife Conservation Act,

Congress created a grant authorization to "develop and implement proposals for the restoration of fish and wildlife resources in the Great Lakes Basin and to provide assistance to the Great Lakes Fisheries Commission, states, tribes, and other interested entities to encourage cooperative conservation, restoration, and management of the fish and wildlife resources and their habitats in the Great Lakes Basin." The Great Lakes Fish and Wildlife Restoration Proposal Review Committee includes tribal representation. Projects awarded grant funds under this authority in 2017 included "Aquatic Connectivity under the Tribal Stream and Michigan Fruit Belt Collaborative, which received $150,000 toward the long-term restoration and protection of tribal fisheries.

Although these partnerships may not always yield easily quantified economic contributions, they represent a sustained federal investment in ecological stewardship, food security, and cultural continuity—critical foundations of long-term community and environmental resilience.

Conclusion

FAC program activities range from habitat restoration and hatchery operations to invasive species control and applied research and development. These annual activities deliver substantial economic contributions and ecological gains. Immediate expenditures contribute to jobs and local business activity, while non-market values, such as clean water and sustained fisheries promise lasting benefits well beyond market metrics. Looking ahead, dynamic challenges like invasive species spread and evolving habitat conditions will require strategic coordination with federal, state, tribal, and private partners. By refining data collection, prioritizing cost-effective prevention measures, and ensuring accountability in resource allocation, the FAC program can continue to safeguard America's aquatic resources for future generations. Its holistic approach underscores that effective conservation is not solely an environmental imperative but also an investment in the economic health and resilience of communities nationwide.

Glossary

Consumer Surplus: The difference between the total value people receive from the consumption of a particular good and the total amount they pay for the good.

Direct, Indirect and induced Effects: Direct effects refer to the immediate effects of new spending, e.g. income to direct suppliers. Indirect effects occur in the second and later rounds of spending such as when suppliers restock. Induced effects occur as employees spend their income supporting employment of additional people in the region.

Employment Income (see Labor or Job Income)

Final Demand: The total spending by final consumers on all goods.

Employment: Annual average number of full-time/part-time jobs supported.

Economic Contributions: The economic activity supported in a region resulting from spending or other changes in the economy.

Labor or Job Income: Income to households from labor including wages and salaries. Labor or job income excludes returns to property and proprietorship income.

Multiplier: Multipliers show the total regional economic effects resulting from changes in final demand for a commodity or group of commodities.

Output or Total Output: The production value of all goods generated by industry. Alternatively, output is also the value of all sales plus or minus the change in inventory.

Substitutes: Goods are substitutes if they can perform some or all of the same functions as each other.

Willingness-to-pay: The amount of money an individual is willing to pay rather than do without an increase in a good or service.

References

Bergstrom, John C. and John B. Loomis. 2017. "Economic Valuation of River Restoration: An Analysis of the Valuation Literature and its Uses in Decision-making", *Water Resources and Economics*, 17:9-19.

Brouwer, Roy and Oleg Sheremet. 2017. "The Economic Value of River Restoration", *Water Resources and Economics*", 17:1-8.

Caudill, James. 2005. "The Economic Effects of the Recreational Use of National Fish Hatchery 2004 Stocking in Region 6 (Mountain-Prairie Region). Division of Economics, USFWS.

Davis, Alison and Klaus Moeltner. 2010. "Valuing the Prevention of an Infestation: The Threat of the New Zealand Mud Snail in Northern Nevada", *Agricultural and Resource Economics Review*, 39(1): 56-74.

Fall, James A. 2016. "Subsistence in Alaska: A Year 2014 Update", Alaska Department of Fish and Game Division of Subsistence. http://www.adfg.alaska.gov/static/home/subsistence/pdfs/subsistence_update_2014.pdf

Finnoff, David, et al. 2007. "Take a Risk: Preferring Prevention over Control of Biological Invaders." *Ecological Economics*, 62(2): 216–22.

Gilbert, A.H. 1999. "Benefit Cost Analysis of the eight-year Experimental Sea Lamprey Control Program on Lake Champlain. VTDFW, Waterbury, VT.

Halstead, John M. et al. 2003. "Hedonic Analysis of Effects of a Nonnative Invader (*Myriophyllum heterophyllum*) on New Hampshire (USA) Lakefront Properties", *Environmental Management*, 32(3): 391-398.

Hatchery Scientific Review Group. 2015. Annual Report to Congress on the Science of Hatcheries, 2015. http://hatcheryreform.us/wp-content/uploads/2016/05/HSRG_Report-to-Congress_2015.pdf.

Homans, Frances R. and David J. Smith. 2013. "Evaluating Management Options for Aquatic Invasive Species: Concepts and Methods", *Biological Invasions*, 15(1): 7-16.

Horsch, Eric J. and David J. Lewis. 2009. "The Effects of Aquatic Invasive Species on Property Values: Evidence from a Quasi-Experiment", *Land Economics*, 85(3): 391-409.

Industrial Economics, Inc. 2011. "Economic Impacts of Massachusetts Ecological Restoration Projects", Final briefing presentation to the Massachusetts Department of Fish and Game, Division of Ecological Restoration.

Lewis, Lynne Y., Curtis Bohlen, and Sarah Wilson. 2008. "Dams, Dam Removal and River Restoration: A Hedonic Property Value Analysis", *Contemporary Economic Policy*, 26(2): 175–186.

Lewis, Lynne Y. and Craig E. Landry. 2017. "River Restoration and Hedonic Property Value Analyses: Guidance for Effective Benefit Transfer", *Water Resources and Economics*, 17:20-31.

Liao, Felix Hailfeng, Frank M. Wilhelm, and Mark Solomon. 2016. "The Effects of Ambient Water Quality and Eurasian Watermilfoil on Lakefront Property Values in the Coeur d'Alene Area of Northern Idaho, USA. *Sustainability*, 8(1): 1-12.

Lovell, Sabrina J., Susan F. Stone, and Linda Fernandez. 2006. "The Economic Impacts of Aquatic Invasive Species: A Review of the Literature", *Agricultural and Resource Economics Review*, 35(1): 195-208.

Lupi, Frank, John P. Hoehn, and Gavin C. Christie. 2003. "Using an Economic Model of Recreational Fishing to Evaluate the Benefits of Sea Lamprey (*Petromyzon marinus*) Control on the St. Mary's River", *Journal of Great Lakes Research*, 29(Supplement 1): 742-754.

McIntosh, Christopher R., Jason F. Shogren, and David C. Finnoff. 2010. "Invasive Species and Delaying the Inevitable: Valuation Evidence from a National Survey." *Ecological Economics*, 69(3): 632-640.

Nielsen-Pincus, Max, and Cassandra Moseley. 2010. "Economic and Employment Impacts of Forest and Watershed Restoration in Oregon", University of Oregon, Institute for a Sustainable Environment, Ecosystem Workforce Program, Working Paper Number 24, 28 p.

Olden, Julian D. and Mariana Tamayo. 2014. "Incentivizing the Public to Support Invasive Species Management: Eurasian Milfoil Reduces Lakefront Property Values", PLoS ONE, 9(10): 1-6.

Pimentel, David, Rodolfo Zuniga, and Doug Morrison. 2005. "Update on the Environmental and Economic Costs Associated with Alien-invasive Species in the United States", *Ecological Economics*, 52(3): 273-288.

Provencher, Bill, Helen Sarakinos, and Tanya Meyer. 2008. "Does Small Dam Removal Affect Local Property Values? An Empirical Analysis", *Contemporary Economic Policy*, 26(2): 187-197.

Samonte, Giselle, Peter Edwards, Julia Royster, Victoria Ramenzoni, and Summer Morlock. 2017. Socioeconomic Benefits of Habitat Restoration. NOAA Tech. Memo. NMFS-OHC-1, 66 p.

Schwoerer, Tobias and Jungho Baek. 2017. "The Economic Risk of Elodea spp. to Commercial Sockeye Salmon Fisheries and Recreational Floatplan Pilots in Alaska", Prepared for Alaska SeaGrant.

Southwick Associates. 2012. "Sportfishing in America: An Economic Force for Conservation", Produced for the American Sportfishing Association (ASA) under a U.S. Fish and Wildlife Service (USFWS) Sport Fish Restoration grant (F12AP00137, VA M-26-R) awarded by the Association of Fish and Wildlife Agencies (AFWA).

Speed, R., Li, Y., Tickner, D., Huang H., Naiman, R., Cao, J., Lei G., Yu, L., Sayers, P., Zhao, Z. & Yu, W., 2016. River Restoration: A Strategic Approach to Planning and Management. Paris, UNESCO.

Stern, Charles V., Harold F. Upton, and Cynthia Brougher. 2014. "Asian Carp and the Great Lakes Region", *Congressional Research Service Report R41082*.

Thomas, Cathy C., et al. 2016. Estimating the Economic Impacts of Ecosystem Restoration—Methods and Case Studies: U.S. Geological Survey Open-File Report 2016–1016, 98 p., http://dx.doi.org/10.3133/ofr20161016.

Trushenski, Jesse T., Gary E. Whelan, and James D. Bowker. 2018. "Why Keep Hatcheries? Weighing the Economist Cost and Value of Fish Production for Public Use and Public Trust Purposes", *Fisheries* 43(6): 284-293.

U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information Fiscal Year 2014.

U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information Fiscal Year 2015.

U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information Fiscal Year 2016.

U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information Fiscal Year 2017.

U.S. Department of the Interior – U.S. Fish and Wildlife Service, Budget Justifications and Performance Information Fiscal Year 2018.

Watson, Philip, Joshua Wilson, Dawn Thilmany, and Susan Winter. 2007. "Determining Economic Contributions and Impacts: What is the Difference and Why Do We Care?" *The Journal of Regional Analysis and Policy* 37(2): 140-146.

Wilcove, David S., David Rothstein, Jason Dubow, Ali Phillips, and Elizabeth Losos. 1998. "Quantifying Threats to Imperiled Species in the United States", *Bioscience*, 48(8): 607-615.

Zhang, Congwen and Kevin J. Boyle. 2010. "The Effect of an Aquatic Invasive Species (Eurasian Watermilfoil) on Lakefront Property Values", *Ecological Economics*, 70(2): 394-404.

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This report presents an estimate, to the extent possible, of the economic contributions associated with activities, projects, and accomplishments from FY 2017 conducted towards meeting the goals identified in the Strategic Plan for the U.S. Fish and Wildlife Service Fish and Aquatic Conservation Program: FY2016-2020. Dr. James Caudill and Dr. Peter Grigelis, U.S. Fish and Wildlife Service, Division of Economics, Falls Church, Virginia, were the senior authors.

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