Conserving America's Fisheries

An Assessment of Economic Contributions from Fisheries and Aquatic Resource Conservation

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This Assessment highlights the work of the Service's Fisheries Program and its accomplishments that generate economic benefits for the American people.

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Executive Summary

In 2004, working with its many partners in aquatic conservation through the Sport Fishing and Boating Partnership Council's Fisheries Steering Committee, the Fish and Wildlife Service (Service) completed its strategic vision document: "*Conserving America's Fisheries, U.S. Fish and Wildlife Service Fisheries Program Vision for the Future.*" The Vision includes goals, objectives, and action items on a national programmatic scale. The National Fisheries Program Strategic Plan was developed as a logical extension of the Vision, providing strategies to implement the Vision's focus areas and performance measures and targets designed to track progress. The purpose of this report is to estimate, to the extent possible, the annual economic contributions (in 2010 dollars) attributable to five focus areas detailed in the National Fisheries Program Strategic Plan for fiscal years 2004-2008.

No single economic measure is appropriate to value the economic contributions attributable to the Fisheries Program. The multi-faceted nature of the Program requires different economic approaches. Program activities that result in the public use of a resource are best measured in terms of economic impacts (direct, indirect and induced expenditures) or consumer's surplus (the public willingness to pay for an activity over and above the cost of the activity). When dealing with resources that are not used directly by the public but generate a benefit such as sediment control or clean water, then a cost avoidance approach is the appropriate measure. The same is true for invasive wildlife when programs limit damages to valuable resources. When dealing with endangered species the only measure available is consumer surplus for the preservation of the species.

Program activities that result in the public use of a resource are measured in terms of economic impacts or consumer's surplus. Natural resources that provide indirect benefits to the public require more economic assumptions and a more indirect approach such as benefit transfer. Where outcome quantification is not possible, a short description of the expected benefits is provided. The focus areas in the Strategic Plan where quantification was possible are shown in table 1.

Table 1. Summary of Economic Findings in 2010 Dollars

Focus Area	**Consumer Surplus** ($ million)	**Contributions**		**Value of Substitutes** ($ million)
		Output ($ million)	**Employment** (jobs)	
Aquatic Habitat Conservation	---	$1,986	45,000	---
Aquatic Species Conservation				
Refugia	$456	---	---	---
Invasive Species Management	---	$556	13,200	---
Subsistence fisheries	---	$121	1,854	$301
Public Use	---	$903	8,003	---
Total	$456	$3,566	68,057	$301

While each focus area produces both consumer surplus and impacts, only the effects that can be quantified are shown in this table. "Consumer surplus", "economic contributions", and the "value of substitutes" represent different economic concepts so it is not appropriate to add them together even though they are all measured in dollars.

In summary, the total economic contribution (direct, indirect and induced) attributable to the accomplishments of the Fisheries Program and its many partners amounted to $3.6 billion dollars per year with an additional $456 million dollars in consumer surplus for species held in refugia and $301million dollars in equivalent value for subsistence activities. The total number of jobs associated with this economic output is over 68 thousand jobs. Each of the focus areas is described in greater detail below.

Aquatic Habitat Conservation and Management

Working with Tribal, State and private sector partners, the Fish and Wildlife Service accomplished substantial resource restoration/enhancements under the strategic plan.

Aquatic habitat conservation will have an estimated economic contribution of $1.99 billion dollars and is associated with 45,000 jobs when projects achieve their full potential.

- An average of 14,197 acres of wetland habitat restored/enhanced with an estimated economic value of $109 million dollars annually when in full productivity.
- An average of 5,162 acres of upland habitat restored/enhanced with an estimated economic value of nearly $1.8 million dollars annually when in full productivity.
- An average of 1,433 in-stream miles restored/enhanced with an estimated economic value of $778 million dollars annually when in full productivity.
- An average of 961 riparian miles of habitat was restored/enhanced with an estimated economic value of $522 million dollars annually when in full productivity.
- An average of 10,394 acres of habitat opened to fish passage with an estimated economic value of $93 million dollars annually when in full productivity.
- An average of 890 miles of river habitat re-opened to fish passage with an economic value of $483 million dollars when in full productivity.

Aquatic Species Conservation and Management

The economic contribution of aquatic species work are a mixture of economic impact, net economic value, and equivalent value for fish conservation work supporting recreational fisheries.

- An average of 32 species is held in refugia with an estimated consumer surplus to the public in States where the species originated of $456 million dollars.
- The value of managing invasive species is exemplified by sea lamprey control which is valued at $556 million per year and is associated with an estimated 13,200 jobs.
- There is an average of 94 fish populations managed for subsistence with a minimum replacement value of $301 million dollar value, excluding cultural and social values.

Public Use/Cooperation with Native Americans

Stocking of Tribal lands in cooperation with Native Americans, fishery mitigation of Federal water development projects, and providing recreational fishing opportunities on Service lands, military lands, and other lands where the Service has a role.

- Alaska's subsistence fisheries have a minimum replacement value of $301 million, excluding cultural and social values. According to an Alaska Fish and Game study on subsistence activity, there is an economic impact from equipment expenditures for those engaged in subsistence activity totaling $121 million in direct expenditures and creating 1,854 jobs.
- In the year 2006, the estimate of the stocking of 123.1 million fish generated over 13 million angling days, $554 million dollars in retail sales, $903 million dollars of industrial output, $256 million dollars of job income and 8,000 jobs. In addition, over $37 million dollars of Federal tax income and $34 million dollars of state and local tax revenue were generated.

Leadership in Science and Technology

- The Fisheries 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 and other aquatic species and their habitats. Inadequate or missing data are bottlenecks and lack of cutting edge/modern tools restricts the ability to gather the data to manage effectively. Strategic Habitat Conservation has provided the Fisheries Program with a new approach to aquatic conservation and the challenge to address climate change while maintaining excellence in management and science. Service needs require a concerted and standardized approach to ensue the implementation of biological planning and conservation designs based on sound science. Excellence in science and technology are critical to earning and maintaining the trust and support of our partners, stakeholders, other Service programs, and the public. Increased science capacity in areas such as risk and vulnerability assessments, inventory and monitoring, population and habitat assessment, biological planning and conservation design, management evaluation and research, and conservation genetics contribute to landscape conservation strategies for fish and aquatic resources.

An Assessment of Economic Contributions from Fisheries and Aquatic Resource Conservation

Fisheries Program
U.S. Fish and Wildlife Service
September 2010

"Working with others, to conserve, protect, and enhance the fish, wildlife and plants and their habitats for the continuing benefit of the American people." (Mission of the U. S. Fish and Wildlife Service)

Introduction

The Fisheries Program of the U.S. Fish and Wildlife Service (Service) has played a vital role in conserving and managing fish and other aquatic resources since 1871. The vision of the Service and its Fisheries Program is working with partners to restore and maintain fish and other aquatic resources at self-sustaining levels and support Federal mitigation programs for the benefit of the American public. Today, the Fisheries Program is a critical partner with States, Tribes, other Federal agencies, other Service programs, private organizations, public institutions, and interested citizens in a larger effort to conserve these important resources.

The Fisheries Program is multi-faceted. It has numerous components all working together to preserve America's aquatic resources. The Program components include the National Fish Hatchery System, Fish and Wildlife Conservation Program, Aquatic Invasive Species Program, and the Marine Mammals Program. The Fisheries Program has a network of 64 Fish and Wildlife Conservation Offices (including a Conservation Genetics Laboratory), 70 National Fish Hatcheries, 9 Fish Health Centers, 7 Fish Technology Centers, one Historic National Fish Hatchery, and offices to support the Aquatic Invasive Species Program and Marine Mammals Program. A cadre of over 800 dedicated biologists, technicians, managers, maintenance workers and administrative staff work together to address restoration, recovery, mitigation, fish passage, fish habitat, and assessment and monitoring of fish and other aquatic organisms. These facilities and employees provide a network that is unique in its broad on-the-ground geographic coverage, its array of technical and managerial capabilities, and its ability to work across political boundaries and embrace a national perspective.

In 2004, working with its many partners in aquatic conservation through the Sport Fishing and Boating Partnership Council's Fisheries Steering Committee, the Service completed its strategic vision document: "*Conserving America's Fisheries, U.S. Fish and Wildlife Service Fisheries Program Vision for the Future*" (Fish and Wildlife Service, 2004). The Vision includes goals, objectives, and action items on a national programmatic scale. The National Fisheries Program Strategic Plan was developed as a logical extension of the Vision, providing strategies to implement the Vision's focus areas and performance measures and targets designed to track progress. All Fisheries Program goals are linked to outcome goals in the Department of the Interior's Strategic Plan.

The purpose of this report is to estimate, to the extent possible, the economic contributions attributable to five focus areas detailed in the National Fisheries Program Strategic Plan for fiscal years 2004-2008. Where outcome quantification is not possible, a short description of the expected benefits will be provided. The focus areas in the Strategic Plan to be evaluated in this report include:

- Aquatic Habitat Conservation and Management
- Aquatic Species Conservation and Management
- Public Use

- Cooperation with Native Americans
- Leadership in Science and Technology

The biological health and "ecosystem goods and services" of the Nation's aquatic resources are inextricably linked with the economic health of the Nation's human communities. The freshwater and marine environments have provided tremendous economic and aesthetic contributions to the entire Nation. The Fisheries Program and its partners and stakeholders recognize that many responsibilities for managing and conserving fish and other aquatic resources are shared, and overall success is contingent upon the combined knowledge, resources and commitment of each party.

Value of Fish and Aquatic Resource Restoration and Enhancement Projects

The Nation's fish and aquatic resources are among the richest and most diverse in the world. The aquatic resources, and the recreational, commercial, and subsistence opportunities they provide, have helped support the Nation's growth by providing enormous ecological, social, and economic contributions. An example of the magnitude of the economic value associated with fishery restoration was provided by Gates (2009). Gates estimated that the restoration of depleted stocks of four Mid-Atlantic fish species (summer flounder, black sea bass, bluefish and butterfish) would produce an annual economic value of $536 million (2007 dollars)

Despite the efforts by the Service and others to conserve fish and aquatic species, a growing number keep declining. The number of fish and aquatic species listed in the United States under the Endangered Species Act as either endangered or threatened as of 2009 include 25 amphibian species, 139 fish species, 70 mussel species, and 22 crustacean species. The primary reasons for these declines are linked to habitat loss or alteration in habitat (i.e., habitat destruction/fragmentation, sedimentation and pollution) and impacts from aquatic invasive species.

No single economic measure is appropriate to value the economic contributions of the Fisheries Program. Program activities that result in the public use of a resource are best measured in terms of economic impacts (direct, indirect and induced expenditures) or consumer's surplus (the public willingness to pay for an activity over and above the cost of the activity). When dealing with resources that are not used directly by the public but generate a benefit such as sediment control or clean water, then a cost avoidance approach is the appropriate measure. The same is true for injurious wildlife when programs limit damages to valuable resources. When dealing with endangered species the only measure available is consumer surplus for the preservation of the species.

Accomplishment database: The Service's Fisheries Information System – Report Module was used to generate the annual accomplishments for each of the focus areas identified. In order to get a representative value, a three year average for each accomplishment was used. Most of the fisheries projects do not conform to an annual cycle. Many projects start in one year and conclude in another. For that reason using any one year as the sole data point to identify an accomplishment was not representative. Therefore, a three-year average was determined to be more representative and was used to assess program accomplishments. A three year average allowed for accomplishments from the first two years under the plan to be documented and start producing benefits.

Aquatic Habitat Conservation and Management – Working with Partners

Aquatic habitat conservation and management covers a wide range of activities. Some of these activities are intermediate steps that lead to improvements in fishery resources such as population surveys.

Population surveys provide the information that is used to improve habitat and the species that rely on that habitat. As such, the surveys provide economic contributions indirectly through their identification of management actions necessary to restore and enhance habitat. Activities with direct contributions to aquatic habitats include the restoration and enhancement of wetlands and upland habitats, the restoration of in-stream habitat and riparian areas, and the opening of waterways to fish passage.

The Service's Fish Passage Program and National Fish Habitat Action Plan are key components in improving fish habitat and passage. Funding is provided through these programs to focus on the restoration, enhancement, and protection of habitats for Federal trust fish species by designing and evaluating conservation at the landscape level. The National Fish Habitat Action Plan supports geographically-focused, locally-driven, and scientifically-based management efforts "to protect, restore, and enhance the nation's fish and aquatic communities through partnerships that foster fish habitat conservation and improve the quality of life for the American people." The National Fish Passage Program works with local communities and partner agencies on cost-share projects that restore instream flows and fish migration.

Types of Activities:

- Restoration, enhancement and protection of aquatic habitats.
- Restore instream flows and fish migration.
- Population surveys.

Methodology: A review of the literature to determine estimated economic contributions for aquatic habitat restoration and enhancement projects, and projects for fish passage, revealed an adequate number of studies for a benefits transfer methodology. However, transferring values from one study to a whole category of projects can be misleading. To provide some indication of the uncertainty surrounding the estimates, a range was used and the mid-point provided as a better measure of actual values. A list of the available research findings is given in Appendix A and summarized below in table 2.

Table 2. Sources of economic contribution values for benefit transfer

Study	Year of Study	Services	Comments	Value in ($2010)
NorthStar Economics	2008	Stream Restoration	Total Economic Impact Per river mile restored Per acre restored Original values generalized to represent four State area	$258,401,739 $570,423 $9,482
Richardson and Loomis	2008	Meta analysis of species existence values	Used four species in database that resembled fish in refugia	$23 per household per year
Robbins and Lewis	2008	River barrier removal	Total economic impact Impact per river mile Impact per acre	$9,782,447 $514,866 $8,559
Ingraham and Foster	2008	Value of ecosystem services per acre	Open water per acre Forest per acre Shrubland Grassland	$331 $976 $634 $59

			Wetlands	$10,204
Whitehead et al.	2006	Per acre values of freshwater wetlands	The following four values were taken from the Whitehead et al. paper	
Woodward and Wui			Habitat per acre	$516
Kazmierczak			Species protection	$319
Kazmierczak			Freshwater marsh	$75
Schuyt and Brander			Refugia	$264
Boulanger and Charbonneau	1989	Injurious wildlife control benefits	Total economic impact	$556 million
Prato and Hey	2006	Economic value of wetlands restoration	Economic benefit per acre	$5,096
Fall et al.	2007	Subsistence harvest	Replacement value	$301 million
Colt	2001	Economic impact	Direct economic impact of expenditures for subsistence harvest	$121 million

The estimates of economic contributions used to quantify aquatic habitat projects in this report were taken from the works of Prato and Hey (2006), Ingraham and Foster (2008), Robbins and Lewis (2008), and Hart at NorthStar Economics, Inc. (2008). All values were converted to 2010 dollars using the consumer price index. The economic approach used to measure the economic contribution appropriate to this type of work is the economic impact of expenditures attributable to restoration projects after completion. This includes the indirect, induced effects and employment generated. A three year average (2006-2008) of the accomplishments reported in the Accomplishments Module of the Fishery Information System database provided a fair representation of the expected annual accomplishments. Since many projects go beyond one year there is no representative year so the average was used to balance out variances in the data. Many of the projects have multiple partners. Therefore, the economic contributions generated (Table 3) are a summary of many local projects attributable to the Service working with State, Tribal and private groups to benefit the aquatic environment. Partners are recognized as contributors to the benefits generated by joint ventures.

Table 3. Aquatic Habitat Conservation Values Attributable to the Service Working with Partners

Habitat	Restored/Enhanced	Value Range (in millions)	Mid-Point Value (in millions)	Jobs
Wetland	14,197 acres	$72.3-$144.9	$109	2,465
Upland	5,162 acres	$.3-$3.3	$1.8	41
In-stream	1,433 miles	$738.2-$817.6	$778	17,657
Riparian	961 miles	$495.2-$548.6	$522	11,847
Opened to fish passage	10,394 acres	$88.9-$97.4	$93	2,115
Re-opened river habitat	890 miles	$458-$507.4	$483	10,958
Total		$1,852.7-$2,119.3	$1,986	45,083

The total economic contribution associated with aquatic habitat restoration/enhancement projects ranges from $1.9 to $2.1 billion annually with a representative average of $2 billion. The level of economic activity is associated with between 37 thousand and 53 thousand jobs with an average of 45,000 thousand jobs.

Examples of Aquatic Habitat and Conservation Projects that Contributed Directly and Indirectly to Measurable Accomplishments

Chipola River Basin, Florida aquatic habitat threats assessment. The need for aquatic habitat restoration/enhancement is identified by site surveys such as the 1,810 miles of riparian habitat along the Chipola River which was assessed using aerial photography and GIS by the Service's Panama City Fishery Resource Office. The Chipola River supports 6 of 7 listed mussels in the Apalachicola-Chattahoochee-Flint (ACF) River Basin. Reducing impacts to riverine environments is essential to recovery of the species. Non-point source pollution threats can limit habitat for aquatic species. Not knowing where these sites are located can hinder restoration efforts. A threat assessment was conducted using GIS stream data, land cover data, and aerial imagery. The analysis consisted of identifying stream segments that intersected areas with agricultural land cover. A 100-foot buffer zone was applied to estimate encroachment on the riparian buffer. These data were recorded as potential threats to aquatic resources. The analysis identified 140 out of 1,810 stream miles as having potential threats. These included a lack of riparian buffer, potential livestock access, row crop areas and potential bank erosion.

Southcental Alaska salmon priority habitats. Additional management is required to safeguard existing healthy fish populations such as those in Southcentral Alaska, home to wild runs of five species of salmon. These salmon runs support thriving commercial, recreational, and subsistence economies. Southcentral Alaska is also the most populous and most highly developed area in the state, with more than 1,000 known fish passage barriers in need of immediate restoration. Such aquatic habitat fragmentation compromises population viability and lead to reductions in sustainable harvests, adversely effecting ecosystem health and local and regional economies. The Service's National Fish Passage Program and National Fish Habitat Action Plan partnerships play a major role in the identification and removal of fish passage barriers (while improving transportation infrastructure) in high priority habitats of Southcentral Alaska. Anglers in Southcentral Alaska spent $989 millon in 2007, supporting 11,535 area jobs, and creating $91 million in state and local taxes (Alaska Department of Fish and Game, 2009). Ex-vessel (commercial catch) values for salmon in Upper Cook Inlet averaged $13.6 million annually from 1999 to 2004 (Kenai River Sportfishing Association, 2006). Sport fishing accounted for $35.5 million (65%) of the $54.6 million spent by visitors to the Kenai National Wildlife refuge during 2006 (Carver and Caudill, 2007).

Merritt Island National Wildlife Refuge, Florida; Restoring fish passage to wetlands. Restoring passage to artificially impounded wetlands opened up approximately 444 acres of wetlands to the estuary on Merritt Island National Wildlife Refuge. The project enhanced the restoration of aquatic habitat and the restoration/recovery of imperiled and depleted estuarine species. The estuaries are used by a multitude of species, including fish, birds, and amphibians. The inability of these species to utilize historical estuary sites contributes to the overall decline of these species and hinders their ability to maintain adequate population size and structure. This project breached the man-made dikes that closed off the impoundment to the estuary. Ten culverts were placed through breaches in the impoundment levees, allowing this water body to become part of the tidal estuary system, thus creating additional habitat for important aquatic species. Access was restored to a large area of extremely high quality habitat that had been lost for over 50 years. There are a host of species that utilize this habitat, including many depleted fish species, crustaceans, amphibians, and wading and diving birds that depend on these species as a food source.

Lower Mississippi River Fisheries Coordination Office, Mississippi; Restoring fish passage in the Lower Mississippi River. During the period 2006-2008 a Partnership was formed between the Service, U. S. Army Corps of Engineers (Mississippi Valley Division, Memphis District, & Engineer Research and Development Center), and Wildlife Mississippi to begin implementation of the Lower Mississippi River Conservation Committee's "Restoring America's Greatest River" plan. Using a Decision Support Model developed by the Corps of Engineers, four fish passage projects were selected from a suite of 239 aquatic habitat restoration projects previously identified during a series of state-level planning meetings conducted in Arkansas, Mississippi, and Tennessee. Sedimentation caused rock dikes used to divert flow into the Mississippi River navigation channel had closed access to secondary channels, except during periods of very high flow. The Partners shared fish passage funding, engineering technical expertise, and land management capabilities to construct 16 notches in 14 existing dikes. These notches restored flow through more than 22 miles of degraded secondary channels during all but the lowest flow conditions. Off-channel habitat was provided for the endangered pallid sturgeon and numerous species of recreational, commercial, and non-game fish species. In addition, severing the land bridge likely increased nesting success of the endangered interior least tern and provided extensive areas of shorebird foraging habitat during the critical fall migration period.

Upper Midwest habitat assessment and fish passage barrier removal. In the upper mid-west fish habitat projects and fish passage projects re-opened in-stream miles and restored/enhanced upland/wetland acres. Restoring or repairing wetland acres was accomplished by constructing earthen dikes, repairing eroded stream sites using “soft” bio-engineering techniques, replacing culverts at road crossings with bottomless culverts or bridges. Twenty five habitat assessments were conducted and one fish barrier was removed. In addition three miles of streams were re-opened and 23 in-stream miles were enhanced. There were 136 acres of upland habitat restored/enhanced and 73 acres of wetlands restored/enhanced.

Souhegan River, New Hampshire; Merrimack Village dam removal.The Merrimack Village Dam (MVD), Souhegan River, New Hampshire was removed in summer 2008. Removal of the MVD, the first dam on the Souhegan River, opened 14.1 miles of river habitat to the next upstream dam, McLane Dam in Milford, NH. Migratory fish within the Merrimack River watershed, such as blueback herring, alewife, American shad, Atlantic salmon, and American eel, can now access this restored habitat from the Atlantic Ocean through previously constructed fish passage facilities at two main stem dams located downstream on the Merrimack River. In addition, migratory and resident fish species have also gained access to approximately 5.0 more miles of tributary habitat. MVD removal also restored 1650 feet of free flowing river conditions to the previously impounded reach immediately upstream of the former dam. Importantly, the Souhegan River is a priority watershed for the Service and its partners to restore self-sustaining populations of Atlantic salmon, American shad, and river herring. The Souhegan River and its tributaries provide the necessary habitat (i.e. cobble/gravel substrate, appropriate water temperatures, oxygen levels and food sources) for excellent growth and survival of Atlantic salmon parr. On average, approximately 100,000 juvenile Atlantic salmon are stocked in the Souhegan River watershed annually and interagency efforts to restore populations of American shad have been supported through similar intermittent stockings of juvenile shad in the lower Souhegan River. The restoration of fish passage in the Souhegan River watershed will also help restore recreational angling areas and offer related economic benefits.

Humboldt Bay, California restoration project. Humboldt Bay is important habitat for a number of trust species, including several runs of listed salmon and steelhead, along with the tidewater goby, a listed species. This project replaced three old tide gates with state-of-the-art gates and installed a fourth gate to reduce velocities, increase tidal flow, restore scour, and reconnect the estuary with Humboldt Bay. The project improved habitat for gobies and salmonids by providing unimpeded passage for migrating fish all ebb tides, providing seasonal juvenile rearing habitat in the lower reach of Salmon Creek and increasing access to Salmon Creek Estuary.

Steven County, Washington; Enhancing fish passage by removing impassable culverts. Fish barrier corrections in Stevens County, Washington were carried out by the Mid-Columbia River Fish and Wildlife Conservation Office to remove impassable culverts. This enhanced salmonid recovery as access was restored to existing habitat and woody debris allowed moving through the system. Two fish species (bull trout and rainbow trout) identified as high priority for recovery by Washington's Department of Fish & Wildlife were blocked from high quality spawning and rearing habitat. Habitat forming large woody debris and stream substrate are blocked from moving downstream. These problems are caused by undersized culverts beneath forest access roads. The removal of existing undersized culverts and replacement with pre-fabricated steel bridges restored streambanks and stream channels within impact zone of culverts.

Wild Rice River, Wisconsin. Lake sturgeon restoration and recovery. Sportfish populations below the Heiberg Dam on the Wild Rice River had been disconnected from over 120 miles of prime riverine habitat. This project reconnected the prime habitats above the dam and allowed the lake sturgeon being stocked in White Earth Lake to migrate back to the Red River, thus increasing the chances of restoring this majestic fish to Reservation Waters. By constructing a rock-sloped stretch of rapids, fish can now migrate past the dam. This improved fish diversity above the dam and also increased the probability of success for the lake sturgeon restoration project which is a priority for the partnering agencies. This rock rapids and associated step pools created excellent sturgeon and walleye spawning habitat and allowed fish passage to over 120 miles of river.

Kelley Branch, Apalachicola Bluffs and Ravines Reserve, Florida; Dam and culvert removal to restore stream habitat. Dam and culvert removal on Kelley Branch, Apalachicola Bluffs and Ravines Reserve, Florida restored access to over 2 miles of high-quality spawning and rearing habitat for rare endemic aquatic species of Florida's Pandhandle. This was a joint project of the Service's Wadmalaw Island Fish and Wildlife Conservation Office and The Nature Conservancy. The dam removal facilitated the restoration of an additional 19 acres of previously inundated aquatic habitat. The project provided Alabama shad, skipjack, Apalachee shiner, and other rare endemic aquatic species with access to over 2 miles of steephead ravine spawning and rearing habitat blocked for over 40 years by a small dam and a perched culvert. Fish passage was accomplished by removing the 12-foot high dam, perched culvert, and the road fill associated with the culvert in the Apalachicola Bluffs and Ravines Preserve. Removal of these structures also restored 19 acres of aquatic habitat inundated by the lake associated with the dam.

Neuse Basin, North Carolina; Removal of Crantock Mill dam. The removal of the Crantock Mill Dam, Neuse Basin, North Carolina restored high-quality habitat for anadromous and riverine fishes. This was a joint project of the Service's Wadmalaw Island Fish and Wildlife Conservation Office and the Raleigh Ecological Service Office. State partners include the North Carolina Division of Marine Fisheries, the North Carolina Wildlife Resources Commission and the North Carolina Division of Water Resources. The project restored access to 29.9 miles of extremely high-quality spawning and nursery habitat for American shad, hickory shad, river herring, and American eel, and other riverine species in Middle Creek of the Neuse River Basin.

The project was accomplished by removal of the ten-foot-high Crantock Mill dam, a barrier that has blocked fish passage for approximately 40 years. The project also entailed removal of a semi-natural log jam that has developed immediately upstream of the mill dam. Economic benefits of the dam removal are increased commercial and recreational harvest of American shad, river herring, and striped bass.

Huron River watershed, Michigan; Removal and stream design of Dexter Dam. **.** The removal and stream design of Dexter Dam on Mill Creek in the Huron River Watershed at Dexter, MI re-connected 57 miles of natural stream flow through a 22 acre impoundment, provided improved fish habitat and enhanced recreational opportunities and economic benefits to local public. The work involved the removal of the dam and installation of restoration structures to provide for gradual gradient change. Rocks were placed to allow for fish passage and serve to raise the channel to provide grade control for impounded sediment. The expected outcome is for 38 species to re-occupy the watershed with increased recreational and economic benefits to the public.

Eglin Air Force Base, Florida; Okaloosa darter recovery efforts**.** The Okaloosa darter is a federally endangered species that occurs in only six small watersheds that drain into the north side of Choctawhatchee Bay in northwest Florida. Nearly the entire population of the endangered Okaloosa darter swims in water flowing through Florida's Eglin Air Force Base. One stream, Mill Creek, flows almost entirely on Elgin's manicured golf course. To restore habitat and remove barriers, the Service's Panama City Fishery Resources Office redesigned Mill Creek, taking out six barriers and two ponds that kept darter from moving upstream. The re-design included a 200 foot-long fish passage culvert underneath a fairway, replete with glass skylights to encourage fish to swim through. The National Fish Passage Program and Partners for Fish and Wildlife dollars were matched almost 5:1 with Elgin Air Force Base and the Florida Fish and Wildlife Conservation Commission.

Idaho Fish and Wildlife Conservation Office; Restoring habitat and passage for native trout species. The Idaho Fishery Resource Office has been working with Federal, State and Tribal agencies and non-governmental organizations to consolidate Idaho fish passage and barrier inventory data into a statewide database, identify additional barrier surveys, and develop a prioritization process for funding projects. Data from passage and barrier inventory will be added to the Service's Fish Passage Decision Support System, and will enable the Service and its partners to develop a project funding prioritization. Since 2006, the Service has also worked with partners in Idaho to identify and financially support via the Western Native Trout Initiative or National Fish Passage Program at least a dozen projects that restore habitat and/or passage for high-priority native trout species (e.g. Bull trout, Bonneville, Westslope cutthroat trout) and their habitats.

Walker Basin, Nevada; Lahontan cutthroat trout recover efforts. The Lahontan National Fish Hatchery funded and guided the completion of a watershed scale Biophysical Assessment in the Walker River, Nevada. This assessment provides the necessary baseline characterization of historic flow, sediment transport, riparian forest inventory, and historic and contemporary channel delineation that is guiding the programs restoration strategy for the Walker River. Through aerial photography and geomorphic measurements there is a comprehensive characterization of the basin. The assessment also provided a full inventory of diversion barriers in the watershed. Connection of the river to the terminal Walker Lake will set the stage for restoration of a self-sustaining Lahontan cutthroat trout population in Walker Lake.

Aquatic Species Conservation and Management

The Fisheries Program has a comprehensive set of tools and activities to conserve and manage self-sustaining populations of native fish and other aquatic species. These tools and activities are linked to management and recovery plans that help achieve restoration and recovery goals, provide recreational fishing benefits, and address Federal trust responsibilities. Reversing the decline of fish and other aquatic species populations requires approved management plans and assessment information to identify, prioritize, and evaluate management actions. In dealing with trust species, the Fisheries Program conducts planning and assessment in cooperation with State, Tribal, and Federal agencies with jurisdiction over these fish stocks. The key areas of focus for the Fisheries Program are native species, aquatic nuisance species, and interjurisdictional fisheries.

Types of Activities:

- Recovery of threatened and endangered fishes and aquatic resources.
- Restoration efforts for specific species (i.e. Apache trout, Atlantic salmon, striped bass, etc.)
- Development and implementation of fishery management plans.
- Aquatic nuisances control and prevention.
- Monitoring and assessment of fish and aquatic species populations.

Methodology

A review of the literature that deals with fishery values identified a number of studies that were summarized into a meta-analysis for endangered species by Richardson and Loomis (2008). The authors recommended a reduced form equation for estimating the consumer surplus value for endangered and threatened fish. However, the meta-analysis is heavily weighted toward high value species like salmon and steelhead. For the purposes of this analysis, the species held in refugia by the Service are better represented by species like Rio Grande silvery minnows, striped shiners, Colorado pikeminows, and Riverside fairy shrimp. The range of values for these species from the Richardson and Loomis review of the literature are used in this analysis to illustrate the economic importance the public places on species preservation.

The only study found that estimated the economic benefits of controlling an aquatic nuisance species was done by Boulanger and Charbonneau (1989). The annual economic benefits achieved by controlling the sea lamprey in the Great Lakes was estimated along with the jobs associated with the sustained harvest and angling.

Subsistence fishing in Alaska generates substantial benefits that were estimated by Fall et al (2007) and Colt (2001). The cost of the store bought nutritional equivalent of subsistence catch was estimated by Fall et al and the associated equipment requirements for engaging in subsistence activities was estimated by Colt. Subsistence activities have a greater value to participants than the nutrition received. Cultural and participation benefits are not captured by these economic values. The estimated economic contributions are therefore very conservative and form the minimum value attributable to subsistence activities.

The economic contributions attributable to aquatic species work, shown in table 4, are a mixture of economic contributions, consumer surplus value, and equivalent value for subsistence work. According to the Alaska Fish and Game study on subsistence activity there is an economic contribution from equipment expenditures for those engaged in subsistence activity. The Federal Subsistence Program in Alaska is mandated in Title VIII of ANILCA and provides a subsistence priority for rural Alaska residents which in many areas are predominantly Alaska Natives.

Table 4. Economic Contributions of Aquatic Species Accomplishments

Activity	Average Number	Annual Economic Contributions
Endangered species in refugia	32	$456 million for households in States where species originated
Sea lamprey control benefits	N/A	$556 million in economic contributions and an associated 13,200 jobs
Fish populations managed for subsistence in Alaska	94	$301 million replacement value, $121 million in direct expenditures and an associated 1,854 jobs

Examples of Species Conservation and Management Accomplishments

White Mountains, Arizona; Apache trout recovery efforts. Apache trout was one of the first species listed in 1967 under predecessor to the Endangered Species Act. Due to several decades of recovery efforts, the Apache trout may be the first fish removed from the list of threatened or endangered species due to recovery. The recovery efforts have involved a variety of partners: including Federal, State, and Tribal agencies; fly-fishing groups, private citizens, and other non-governmental organizations. The Apache trout was restricted to about 30 miles of stream habitat in 1967; but now anglers can fish for Apache trout in over 18 lakes and 10 streams in the White Mountains of Arizona. Additionally, Apache trout are found in 28 recovery populations (Fish and Wildlife Service, 2009). In the last three years, the Service and its partners completed: three reintroductions, seven renovations, restored 57.5 miles of habitat, mechanical removal of non-native trout in six streams, post-renovation surveys in five streams, swim performance experiments, artificial barrier repair on one stream, genetic sample collection on five streams, attended two recovery team meetings, a long-term grant from the National Fish and Wildlife Foundation, a draft revised recovery plan, and numerous outreach activities with focus on youth.

South Atlantic and Gulf Coast; Striped bass restoration. Atlantic and Gulf Coast striped bass have historically been an important commercial and recreational fish along the Atlantic seaboard and in the Gulf Coast region. Angling for striped bass generates billions of dollars in revenue for the American economy. Dam construction and habitat modification/degradation, as well as overfishing, have resulted in poor recruitment of wild populations and augmentation has become necessary. Monitoring efforts have identified survival/recruitment ratios of 55 to 1 in favor of phase II (2 inch to 9 inch fish) stockings. A self-sustaining wild population of Atlantic coast and Gulf striped bass is being developed by augmentation of the population by stocking fish from the Welaka National Fish Hatchery.

Tchefuncte and Tangipahoa Rivers, Louisiana; Striped bass restoration. In 2006 and 2007, the Service's Inks Dam National Fish Hatchery produced over 4,000 - 9" Gulf Coast striped bass for the Tchefuncte and Tangipahoa Rivers in Louisiana to aid in restoration and recovery purposes for this important commercial and recreational fishery. These fish provided 3,000 angler days and $425,000 in revenue to local economies.

Atlantic Coast Watersheds; Striped bass restoration. Striped bass have formed the basis of one of the most important fisheries on the Atlantic coast. Striped bass populations have been threatened by habitat loss, blocked access to spawning grounds, and overfishing. Both commercial and recreational fishermen alike have endured severe harvest restriction and closures. Annual production and stocking of 200,000 striped bass by the Edenton National Fish Hatchery in the Roanoke, Tar/Pamlico, Neuse, and Cape Fear watersheds have helped increase population levels. Spawning biomass of female Atlantic striped bass has been steadily rising, and a significant recreational fishery has grown over the last few years. Commercial lands have also increased from near-zero in the early 1990s.

Atlantic Coast Cooperative Striped Bass Tagging Program. Information was collected from over 1400 striped bass recaptured along the Atlantic Coast and tributaries. Information was imported into the striped bass database about 8022 fish tagged and released in 2007 and 2148 fish tagged and released in 2008. This program continues to assist in the restoration of striped bass fisheries along the Atlantic coast, providing increased opportunities for commercial fishermen and recreational anglers.

Great Lakes lake trout restoration to support Tribal harvest. A multi-faceted Region-wide program in the Great Lakes region involving Federal, State, Tribal, and international partners in a multi-agency approach, including an international invasive species control program (sea lamprey), assessment of fish stocks and fishery independent surveys, cooperatively establishing and monitoring commercial, tribal, and recreational harvest, analyzing data and recommending appropriate actions to allocate fishery resources among multiple user groups. In turn, substantial economic impacts are derived through commercial, recreational, and tribal harvest of lake trout and at the same time, a native fish is maintained or rehabilitated to self-sustaining levels.

Tennessee Tombigbee Waterway (Columbus Lake), Mississippi; Paddlefish restoration effort. Paddlefish serve both an ecological and economic role throughout the historic ranges of the Southeastern United States. Paddlefish are regarded as a key indicator species due to its low tolerance of sub optimal water conditions and its specific requirements for successful annual reproduction. The species shares an equally important role in supporting recreational and commercial fisheries in areas where population levels support a harvest. Columbus Lake is an area of the Tennessee Tombigbee Waterway that still contains adequate spawning habitat, key nursery areas, and a forage base suitable for maintaining a self-sustaining population. Working with the Mississippi Department of Wildlife, Fisheries and Parks, the Service's Private John Allen National Fish Hatchery provides paddlefish fingerlings for this restoration effort. All fish are tagged with binary coded wire tags prior to stocking. Populations are assessed annually. The outcome of this project will be an established, self-sustaining population of paddlefish in the Columbus lake portion of the Tennessee Tombigbee Waterway. Once established, the paddlefish in this lake will be able to support a limited recreational and commercial fishery if managed appropriately. Revenue generated through license, equipment sales and other associated expenditures by anglers will provide an economic boost to many of the small communities located adjacent to the river.

Yukon River, Alaska; Salmon stock sustainability for subsistence. The Yukon River stretches more than 2,300 miles across Alaska and deep into Canada. The Alaskan portion of the Yukon River is more than 1,200 miles long, has 42 rural villages and more than 1,500 fishing households. Yukon River salmon are interjurisdictional fisheries subject to international treaty provisions contained within the 2002 U.S./Canada Yukon River Salmon Agreement. Yukon River salmon stocks represent a unique and valuable resource to the many people that depend on them. Chinook, chum and coho salmon provide for important subsistence and commercial fisheries along the entire length of river. The Yukon River retains the largest remaining wild run of Chinook salmon in North America. The sustainability of these salmon resources is predicated on a management system that insures that salmon spawning escapement objectives are the first management priority. Many of the Yukon River's unique qualities: geographic distances between villages, limited road access, asynchronous run timing for multispecies, fluctuating stock abundances, broad spawning distributions, and the overall lack of information for many stocks, make management of its salmon resources complex. The Yukon River federal subsistence in-season fisheries management responsibilities were delegated to the Service by the Federal Subsistence Board to manage fisheries for healthy populations and sustained yield, while providing rural residents continued subsistence opportunities using 17 Federal Conservation System Units.

Commercially harvest salmon on the Yukon River provides substantial economic benefits. For example, in 2007 a total of 33,634 Chinook salmon and 198,201 summer chum salmon were commercially harvested for an ex-vessel value of $2.2 million; approximately 13 percent below the 1997-2006 average of $2.6 million (Alaska Department of Fish and Game, 2008). The 2007 commercial fall chum and coho salmon was 90,677 fall chum and 44,575 coho salmon with an ex-vessel value of $290,400 (Alaska Department of Fish and Game, 2008). In 2006 the estimated subsistence salmon harvest in the Alaskan portion of the drainage totaled 47,710 Chinook salmon, 90,922 summer chum, 83,800 fall chum, and 19,371 coho salmon. The annual economic value of the Yukon River subsistence salmon fishery has not been determined since it fails to capture the social, cultural and psychological value of subsistence harvest 400 (Alaska Department of Fish and Game, 2008).

Alaska recreational fishing economic impact. According to a 2007 survey by the Alaska Department of Fish and Game, the economic contribution of recreational fishing in Alaska generated $1.4 billion on licenses and stamps, trip related expenditures, pre-purchase packages, and equipment and real estate used for fishing. An estimated 475,534 resident and nonresident licensed anglers fished 2.5 million days, supported 15,879 Alaskan jobs, provided $545 million of income, and resulted in $123 million in state/local tax revenues in 2007. Nonresident anglers spent $653 million, supporting 9,437 jobs and $67 million in state/local taxes (Alaska Department of Fish and Game, 2009).

Kenai Peninsula, Alaska; Sport fishing economic impact. Sport and personal use fishing in Southcentral Alaska generate direct spending of $415 million (2003 dollars) and total sales of $532 million that support some 6,100 "full time equivalent" jobs that produce $171 million in income (Kenai River Sportfishing Association 2006). Sport fishing accounted for $35.5 million (65%) of the $54.6 million spent by visitors to the Kenai National Wildlife refuge during 2006 (Carver and Caudill 2007). The Kenai Peninsula supported 789,609 angler days or 32 percent of the state's total sport fishing effort during 2004 (Jennings et al. 2007). The Kenai River is the most intensively fished river in Alaska and supported 375,370 angler-days or 15 percent of the state's total sport fishing effort in 2004. Kenai Peninsula fish populations also support important commercial, personal use, and federal subsistence fisheries.

Colorado River System, Colorado, New Mexico, Arizona, Utah; Propagation of the endangered razorback sucker. Propagation of the endangered razorback sucker supports the goals of the Upper Colorado River and San Juan River Basin endangered fish recovery programs and the Lower Colorado River Multi-Species Conservation Program. This is accomplished by continually upgrading captive brood stock with offspring from paired matings and stocking hatchery reared fish into the Colorado River system to augment wild populations. The original broodstocks have also been supplemental with fresh genetics material from wild stocks in the system. Since 1996, the Service and its partners has stocked over 200,000 razorback suckers (age ~ 1.5 years) into the Colorado River system.

Wind River Indian Reservation, Wyoming; Propagation of burbot to augment populations. Burbot populations on the Wind River Indian Reservation are thought to be depleted. Habitat fragmentation or competition with introduced species may have contributed to the population decline. Burbot were traditionally an important fishery on the reservation in Wyoming. This project develops culture techniques to successfully spawn and propagate burbot for population augmentation. It will also provide the resources to evaluate the genetics of the populations in the region. Fin clips from burbot captured in the Missouri River, ND will be compared to those captured on the Wind River Indian Reservation to determine if the two are distinct populations. If they are the same, local stocks will be used to develop spawning and propagation techniques utilizing both extensive and intensive culture methods.

Aquatic Invasive Species Program; Hazard Analysis and Critical Point (HACCP) planning. The aquatic invasive species (AIS) program believes prevention is the most efficient and cost-effective way to reduce the impacts of aquatic invasive species. Hazard Analysis and Critical Control Point (HACCP) planning provides a framework to reduce or eliminate the inadvertent movement or introduction of aquatic invasive species to new waters. Likewise it may help reduce or eliminate the movement away from infested waters. HACCP will help protect our waters from unnecessary introduction of non-target organisms, related control costs, and the loss of economic benefits and ecosystem services from native species. In FY2008, the Service conducted two training workshops (Grand Isle, VT - October 23-24; Rochester, NY - February 5-6). Training was provided to state, Federal, and other agencies and provided information to partners to encourage the adoption of HACCP principles and the use of the HACCP website, (www.HACCP-NRM.org). The economic benefits of invasive species management are the avoided costs of harmful introductions. While data are not available to analyze all the costs of aquatic invasive species, it is well established that certain species have caused significant economic impact when they became established in new waters. Proving that prevention actions, such as HACCP, stopped a specific species from becoming established is difficult to prove, however. There are many factors that can affect whether an introduced species becomes an established one. If it does become established, it may not automatically become a nuisance or be considered invasive. Thus, it is difficult to calculate a direct economic savings from HACCP implementation alone.

Aquatic Invasive Species Program;100th Meridian Initiative. The goal of the 100th Meridian Initiative is to prevent zebra mussels and other aquatic nuisance species (ANS) from the eastern U.S., becoming established in the West using education and outreach tools. In FY08, the program focused on the more immediate threat of quagga mussels recently discovered in the Colorado River system, including enhanced detection monitoring. Activities needed to enhance prevention of ANS spread include providing information to boaters, marinas, and similar audiences via written materials, displays, signs, and other media; evaluating boater movement in the region; early detection monitoring; developing rapid response plans and capacity; and training law enforcement officials.

Lahontan National Fish Hatchery, Nevada; Lahontan cutthroat trout restoration. Lahontan National Fish Hatchery Complex houses a broodstock of a unique strain of the threatened Lahontan cutthroat trout for use in the programs recovery and recreational fishing programs. Genetic analysis has demonstrated that this particular strain is directly related to the original populations of Lahontan cutthroat trout found in Pyramid Lake and Lake Tahoe before they were extirpated in the 1930's. The Hatchery manages the broodstock under rigorous genetic management practices, regularly infusing the broodstock with gametes from the wild population. Lahontan cutthroat trout produced from this broodstock are now stocked into Pyramid Lake, the Truckee River and Fallen Leaf Lake, and will soon be utilized in a reintroduction program in Lake Tahoe.

Public Use

Successful fishery conservation in the United States has always depended upon the contributions of recreational anglers and commercial fisherman. Recreational fishing and its benefits has always been the cornerstone of the Service's history and its mission. Aquatic conservation would not have succeeded without the support of the fishing public. Fishery conservation is a 3-way partnership between the Service, the States and the fishing public. For example, sportfishing has a significant impact on the U.S. economy. Anglers support slightly over one million jobs with $45 billion in retail sales injecting over $125 billion annually into the Nation's economy, with $7.4 billion generated for state and local taxes. (American Sportfishing Association, 2008). The Service enhances recreational fishing opportunities that in turn provide an enormous economic boost to the economy and creates a positive ripple effect for all Americans. Caudill (2005) reported that for each taxpayer dollar budgeted for rainbow trout production, $32.20 in retail sales and $36.88 in consumer surplus are generated. This represents a total annual economic output of over $325 million from the stocking of 9 million rainbow trout by the Service. In addition, the Service cooperates closely with Native American Tribes and provides hundreds of pounds of salmon to Tribes for ceremonial purposes each year.

Opportunities exist for the Fisheries Program to support quality recreational fishing enjoyment and outreach on Service lands, tribal lands, military lands, and other lands where the Service has a role. Providing recreational fish to support quality fishing in impoundments can serve as a supplement to the primary mission of the National Wildlife Refuge, the tribal government, or the military purpose of the Federal land. Fishery mitigation is a joint Federal/State partnership involving the Service and State resource agencies. Although clearly a Federal responsibility, the combined efforts of the Service and the States have been successful in addressing fishery mitigation responsibilities resulting from construction of Federal water development projects throughout the United States. The Fish and Wildlife Coordination Act of 1934 requires that fish and wildlife be given equal consideration with other project purposes in making decisions about Federal water projects.

Types of Activities:

- Development of recreational fishing opportunities on and off Service lands.
- Fishery mitigation of Federal water development projects.
- Cooperative restoration stocking efforts with State and Tribal partners.

This report provides an estimate of the economic effects of the recreational use of fish produced and stocked by the National Fish Hatchery (NFH) System in 2006. This report shows a summary of the number of fish stocked by major species and summarizes the economic impacts associated with NFH production and stocking.

National Fish Hatcheries

Over the past 120 years, Federal stewardship of the nation's fishery and aquatic resources has been a prime responsibility of the U.S. Fish and Wildlife Service. The Service works with a variety of stakeholders, including Federal agencies, State resource agencies, Tribal governments and private organizations, to improve fishery conservation efforts. The Service focuses its efforts on fulfilling Federal mandates for recovery, restoration, and inter-jurisdictional management of depleted fish stocks. National Fish Hatcheries, Fish and Wildlife Resource Management Offices, Fish Technology Centers and Fish Health Centers focus 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 Service through legislation (i.e., mitigation of Federal water development projects).

In addition to all the biological, ecological and educational benefits from the Service's Fisheries Program, the production, stocking and recreational angling of a wide variety of fish species results in a significant amount of economic activity across the U.S. The next two sections summarize the number and type of species produced and stocked and estimate the economic impacts associated with the recreational angling of these species.

2006 NFH Recreational Stocking

Table 5 shows 2006 stocking of major species. Recreational stocking includes both species stocked specifically for recreational purposes and those species stocked for other purposes but which are subject to recreational angling.

Table 5: 2006 National Fish Hatchery recreational stocking by major species.

Species	Number Stocked (in millions)	Percent of Total
Chinook	43.1	35.0
Walleye	20.9	17.0
Rainbow Trout	11.6	9.4
American Shad	9.9	8.1
Lake Trout	5.6	4.5
Steelhead	4.9	4.0
Bluegill	4.1	3.3
Coho	4.0	3.3
Northern Pike	3.1	2.5
Yellow Perch	2.8	2.3
Striped Bass	2.5	2.0
Sauger	2.1	1.7
Cutthroat Trout	1.6	1.3
Largemouth Bass	1.0	0.8
Other Species	5.8	4.8
Total Stocked	123.1	100

Source: Fishery Information System Database (2006)

Economic Impacts of Recreational Stocking

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

Recreation:

- Replacing lost fishing opportunities
- Creating additional fishing opportunities
- Visitor center and facility tours
- Enhancing visitor experiences
- Expenditures by anglers and their effect on local and regional economies

Information:
- Environmental and fisheries educational programs
- Fisheries research
- Fish health diagnostics

Ecological use:
- Mitigation of environmental damages

Federal spending:
- Fisheries budget expenditures and their effect on local and regional economies

While acknowledging the contribution of hatcheries to a wide variety of ecological and biological goods and services, this report focuses on the recreational impacts of fish stocking, more specifically the economic impacts of recreational angling for federally produced and stocked fish. Economic impacts refer to economic output, jobs, job income, and federal and state tax revenue that occur as the result of consumer expenditures (retail sales) on angling - related goods and services.

Spending associated with angling can generate a substantial amount of economic activity in local and regional economies. For example, anglers spend money on a wide variety of goods and services. Trip-related expenditures may include expenses for food, lodging and transportation. Most anglers also buy equipment and angling–related goods and services such as rods, reels, lures, hooks, lines, bait, boats, boat fuel, guide and outfitter services, camping equipment, and memberships in fishing clubs and organizations. Because this spending directly affects towns and communities where these purchases are made, angling can have a significant impact on local economies, especially in small towns and rural areas. 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. For example, a family may decide to purchase a set of fishing rods for an upcoming vacation. Part of the total purchase price will go to the local retailer, say a sporting goods store. The sporting goods store in turn pays a wholesaler who in turn pays the manufacturer of the rods. The manufacturer then spends a portion of this income to cover manufacturing expenses. In this way, each dollar of local retail expenditures can affect a variety of businesses at the local, regional and national level. Consequently, consumer spending associated with angling can have a significant impact on economic activity, employment, household income and local, county, State and Federal tax revenue.

General Approach

The general approach to estimating economic impacts associated with hatchery stocking is to link stocking information to angler days. Once angler days are determined, total retail sales can be calculated and economic impacts estimated.

Estimating Recreational Angling Days Associated with NFH Stocking

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 associated with annual NFH stocking: (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 comprised of NFH produced fish (accounting for the possibility of wild fish and fish produced by state hatcheries); and (4) the total number of fish stocked at the site by NFH hatcheries. Unfortunately, information on items (1), (2) and (3) are not available for the vast majority of stocking sites. For example, in a recent year, NFH rainbow trout hatcheries stocked 603 different sites across 16 states for a total of

1,963 separate stockings (many sites were stocked multiple times). Survey information on the number of anglers and angler days is available for very few sites. Consequently, alternative approaches must be identified which make use of the information which is available (NFH stocking totals) 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.

Previous reports: *The Economic Effects of National Fish Hatchery Production and Distribution in the Southeastern U.S.(Caudill, 2001); The Economic Effects of the Recreational Use of Alchesay-Williams Creek National Fish Hatchery 2004 Stocking (Caudill, 2006); The Economic Impact of Trout Stocking on Tailwaters in the Southeast Aquatic Resource Partnership (Caudill, 2007),* and *The Economic Effects of the Recreational Use of National Fish Hatchery 2004 Stocking in Region 6 (Mountain-Prairie Region)(Caudill, 2005)* provide detailed explanations of how the estimates of angler days were derived. Depending on a variety of factors, most significantly the species and geographical area being considered, information from creel surveys, angler use surveys, coded wire tag data, best professional judgment on mortality rates and seasonal carry-over, and other pertinent information, are all used to derive the estimates of the number of angler days associated with NFH stocking.

Total Economic Contributions of Retail Expenditures

Recreational angling for fish produced and stocked by the various hatcheries result in considerable expenditures for recreation-related goods and services. Table 6 shows total angler expenditures associated with recreational angling for fish produced and stocked by Federal hatcheries along with estimates of total industrial output, job income, jobs, Federal tax revenue and State tax revenue. These estimates were obtained using multipliers from the report, *Sportfishing in America* published by the American Sportfishing Association (2008).

Retail sales shows the total 2006 angling expenditures associated with the recreational catch of the specified Regions stocking. The expenditures are based on per day per angler travel-related expenditures (gas, lodging, groceries, etc.) averaged over each Service Region. (Expenditures were obtained from *the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*, (Fish and Wildlife Service, 2007).

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 impacts of spending money; for example, spending money in a grocery store for a fishing trip or purchasing fishing line, lures or bait are examples of direct effects. The purchase of the fishing line by a sporting goods retailer from the line manufacturer or the purchase of canned goods by a grocery 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, 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.

Job income and jobs includes both full and part-time jobs with associated wages and salaries, with a job defined as one person working for at least part of the calendar year, whether one day or the entire year.

Taxes include revenues from sales and motor fuel taxes, state income taxes (where applicable) and federal income tax and other taxes generated by angler expenditures on NFH stocked fish.

Retail sales associated with recreational angling for NFH stocking is estimated to be about $554 million. These expenditures generated $903 million in industrial output. Over 8,000 jobs are associated with this economic activity with wage and salary income of over $256 million. Federal tax revenue is estimated at $37 million, and state and local tax revenue is estimated at $35 million (Table 6).

Table 6. Estimate of 2006 NFH Recreational Stocking Economic Impacts

Item	Value	Units
Fish stocked	123.1	million fish
Angling days	13.5	million days
Angling retail sales	$553.9	million 2010 dollars
Industrial output	$902.9	million 2010 dollars
Job income	$256.2	million 2010 dollars
Employment	8,003	jobs
Federal income tax	$37.1	million 2010 dollars
State & local income tax	$34.7	million 2010 dollars

Examples of Public Use Accomplishments

Desoto Lake, Iowa; Recreational fishery. Desoto Lake, a 768 acre oxbow lake on Desoto NWR, is an important Regional fishery in western Iowa and eastern Nebraska due to a lack of public waters in the area. The results from the Service's sampling events and creel survey in 2006 indicate that the DeSoto Lake fishery is robust. Assuming that the 2006 creel survey is representative of each fishing season, DeSoto Lake fish populations receive over 26,000 angling visits and an estimated harvest of more then 75,000 fish during the summer months. Additionally, DeSoto Lake is an important fishery for the region, inputting $1,337,797 to the local economy each season. Many anglers, 35.24%, were fishing for crappie species and caught more then 111,000 individuals, affirming that crappie are the most highly caught species at DeSoto Lake. It was also found that most of the anglers travel less than 30 miles to reach DeSoto Lake.

Chinook salmon production, Coleman National Fish Hatchery, Anderson, California. The Fall Chinook Salmon Production Program supports valuable commercial and recreational fisheries in northern California as mitigation for 187 miles spawning habitat lost due to the construction of Shasta Dam in 1942. Each year, the Service rears and releases over 12 million fall and late-fall Chinook salmon juveniles. It is estimated that these fish result in 60,000 adults that contribute to highly valuable commercial and recreational fisheries off the coast of California and Oregon, within the San Francisco Bay-Delta, and in the rivers and streams of California's Central Valley. These fish also result in approximately 10,000 adults that are part of a freshwater recreational fishery. Spending associated with angling can generate a substantial amount of economic activity in local and regional economies. Expenditures include trip-related expenditures (food, lodging, and transportation) and equipment and angling-related goods and services. The Pacific Fisheries Management Council has valued the commercial and recreational ocean fisheries for Sacramento River salmon at over $100 million annually.

Recreational use of hatchery-stocked fish generates significant economic effect in the Southeastern United States. National Fish Hatcheries in Arkansas, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Louisiana annually stock a total of 22.3 million fish of 15 game species in 12 States. In 2005, this generated over 3.2 million angler-days of fishing, $239 million in total economic output, and 3,100 jobs with incomes totaling $63 million, and $14 million in state and federal taxes. This economic fuel was generated by spending less than $5 million in budget allocations to produce and stock these fish. This translates to an economic benefit of $48 for every $1 of taxpayer money spent on NFH recreational fish production in the Southeast.

Cooperation with Native Americans

Assistance that is provided to the Tribes by the Service results in the management, protection, and conservation of their statutorily defined trust natural resources which helps Tribes develop their own capabilities. The Fisheries Program plays an important role in providing support to the Tribes as they exercise their sovereignty in the management of fish and wildlife resources on more than 55 million acres of Federal Indian trust land and in treaty reserve areas. The Fisheries Program provides technical assistance and fish for stocking on Tribal lands. With the assistance of the Service, 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 the Tribes to manage their fishery resources. Additionally, retail sales related to recreational fishing on tribal lands provides significant revenues to tribes and local economies. For example, every dollar spent raising trout at Alchesay-Williams Creek NFH Complex, Arizona, that are stocked on Tribal lands in the Southwest, generates $19 dollars in retail sales (Caudill, 2006).

Types of Activities

- Providing technical assistance to tribes
- Providing fish for stocking on Tribal lands
- Providing technical training and job opportunities to Tribal members.

Methodology

The National Fish Hatchery System has a unique responsibility in helping to recover species listed under the http://www.fws.gov/endangered/index.htmlEndangered Species Act, restoring native aquatic populations, mitigating for fisheries lost as a result of federal water projects, and providing fish to benefit Tribes and National Wildlife Refuges. This section of the report summarizes NFH stocking which is allocated to Indian tribes (note: this section focuses on stocking only and does not estimate the economic value or impact associated with the distribution and stocking of fish to tribes. The Public Use section of the report does include tribal stocking and an estimate of economic value and impact).

Table 7 shows the number of species stocked by NFH which were allocated to Tribes in 2006. Chinook salmon accounted for over 1.95 million fish, which represented 25.1 percent of total stocked fish allocated to tribes. Coho salmon accounted for 1.77 million fish and 22.8 percent of the total, and rainbow trout and walleye accounted for 1.6 million and 955 thousand stocked fish and 20.6 and 12.3 percent of total tribal stocking respectively. All species of salmon accounted for 3.7 million stocked fish and 47.9 percent of all stocked fish with all species of trout accounting for 2.7 million stocked fish and 34.5 percent of total tribal stockings.

Table 7. 2006 National Fish Hatchery Stocking Allocated to Indian Tribes: By Species

Species	Number Stocked	Percent of Total Tribal Stocking
Chinook Salmon	1,951,309	25.1%
Coho Salmon	1,769,742	22.8%
Rainbow Trout	1,603,765	20.6%
Walleye	955,021	12.3%
Cutthroat Trout	540,889	7.0%
Brook Trout	274,011	3.5%
Channel Catfish	180,831	2.3%
Apache Trout	174,536	2.2%
Bluegill	98,190	1.3%
Largemouth Bass	85,550	1.1%
Brown Trout	71,421	0.9%
Lake Sturgeon	22,200	0.3%
Lake Trout	20,643	0.3%
Northern Pike	19,000	0.2%
Black Crappie	7,812	0.1%
Total	7,774,922	100.0%

Table 8 shows 2006 NFH stocking in pounds by species for tribal stocking. Rainbow trout accounted for 197,859 pounds of stocked fish representing 45.2 percent of total pounds allocated to tribes. All trout species accounted for 268,795 pounds and 61.3 percent of total tribal pounds stocked. Both salmon species accounted for 122,221 pounds and 27.9 percent of total tribal pounds stocked.

Table 8: 2006 National Fish Hatchery Pounds Stocked Allocated to Indian Tribes: By Species		
Species	Pounds Stocked	Percent of Total Tribal Pounds Stocked
Rainbow Trout	197,859	45.2%
Coho Salmon	90,709	20.7%
Apache Trout	47,061	10.7%
Channel Catfish	41,633	9.5%
Chinook Salmon	31,512	7.2%
Brook Trout	13,679	3.1%

Cutthroat Trout	4,381	1.0%
Brown Trout	4,153	0.9%
Walleye	2,742	0.6%
Lake Trout	1,662	0.4%
Largemouth Bass	1,188	0.3%
Lake Sturgeon	1,100	0.3%
Bluegill	153	0.03%
Black Crappie	125	0.03%
Northern Pike	16	0.004%
Grand Total	437,973	100.0%

Table 9 summarizes selected characteristics of NFH tribal stocking in 2006. There were 15 different species stocked distributed by 25 hatcheries. Stocking events totaled 561 at 232 different sites across 19 states.

Table 9. Selected Characteristics of 2006 NFH Stocking Allocated to Indian Tribes				
Species	Hatcheries	Stockings	Sites Stocked	States Stocked
15	25	561	232	19

Examples of Cooperation with Native Americans Accomplishments

Tribal assistance in conducting fish health inspections. Fish health inspections are conducted each year at Tribal fish hatcheries by fish health biologists from the LaCrosse Fish Health Center through reimbursable agreements. Fish health biologists collected 915 fish tissue and fluid samples from brook trout, rainbow trout, lake trout, and walleye reared at the tribal hatcheries. The fish were inspected for eight fish pathogens as listed in the Great Lakes Fish Health Policy Guidelines. The Center provided confirmatory or other specialized tests needed to substantiate or refute test results of health inspections. The Center provides fish health laboratory reports, guidance and recommendations to the tribal hatchery manager based on the laboratory findings. The Fish Health Center also inspected wild populations of northern pike and yellow perch in ceded tribal waters in Wisconsin for detection of Viral Hemorrhagic Septicemia virus, in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

Tribal assistance in fishery management. Fishery assessment field work was conducted on Menominee and White Earth Reservations. Data from these surveys will be used to develop management plans, make immediate fishery recommendations, and develop action plans. Topical areas include: Federal Energy Regulatory Commission (FERC) re-licensing, fish passage, sturgeon restoration, and trout management. La Crosse FWCO assisted GLIFWC with spring walleye assessments on Mille Lacs Lake in Central Minnesota. We also obtained and transported lake sturgeon eggs from Rainy River First Nations (Canada) to Genoa NFH for the Red Lake

Band, and provided technical assistance on fish passage issues and fishery surveys to the White Earth and Menominee tribes.

Returning Coho Salmon to the Wa'atch River. Returning adult coho salmon to the Wa'atch River contribute to international and domestic ocean commercial fisheries. In addition, adult returns support important tribal commercial and subsistence fisheries on the Makah Reservation and offer quality sport fishing opportunities to the general public. The coho salmon program was initiated in response to the low returns of adult salmon to the region in the early 1970's, due primarily to overfishing, habitat degradation and poor ocean conditions. As part of an ongoing annual stocking effort, in FY2008, the hatchery transferred 39,871 yearling coho smolts to the Makah Tribal acclimation ponds for release into the Wa'atch after several weeks of imprinting.

New Mexico Fish and Wildlife Conservation Office, New Mexico; Providing assistance to the Tribes. There are 22 Native American Tribes and Pueblos within the state of New Mexico. The New Mexico Fish and Wildlife Conservation Office (NMFWCO) provide technical assistance in the management of fisheries on tribal lands for the benefit of recreation and/or native fish conservation. In the last three years, NMFWCO has provided technical assistance to 20 New Mexico Tribes with fishery management actions that adhere to management, recovery, and conservation plans. The office conducts spring lake surveys to evaluate population dynamics, focusing on subcatchable rainbow trout stocked in fall; conducts surveys to monitor post-fire effects to recreational lakes, including water quality and fish growth and survival, and help develop and implement fisheries management plans for five Native American Tribes. In cooperation with Inks Dam National Fish Hatchery, NMFWCO inspects hatchery shipments for non-target organisms prior to each warm water stockings to avoid the stocking of non-target organisms commonly associated with warm water hatcheries. This is standard operating procedures for all National Fish Hatcheries in the Southwest. Avoidance of negative interactions between recreational and native fisheries programs is very important to many tribes as well as to Service biologists. The office also assists with mechanical removal of nonnative species that threaten native fish populations or invaded sacred water bodies. In collaboration with tribal partners, NMFWCO conducts surveys to evaluate native trout streams to assess the impacts on nonnative salmonids on native Rio Grande cutthroat trout populations on tribal lands. The NMFWCO also oversees the Youth Conservation Corp at the Mescalero Tribal Fish Hatchery for 8-week duration which allows Native American high school students to engage in multiple projects ranging from hatchery operations, trail construction, stream & riparian restoration, and spring renovation. In addition, NMFWCO participates annually in Southwest Region-Native American Fish and Wildlife Society Youth Practicum and Tribal Youth Environmental Summer Camp which provides tribal youth hands on experience and education about environmental issues facing tribal communities.

Leadership in Science and Technology

The Fisheries 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 and other aquatic species and their habitats. Inadequate or missing data are bottlenecks and lack of cutting edge/modern tools restricts the ability to gather the data to manage effectively. Consequently, there is a need to expand technology and information necessary to promote restoration or recovery of these aquatic resources. Likewise, technology and information needs must be addressed for those populations currently not in serious declines or are stable. This will ensure sound scientific technologies and information is applied to the management of aquatic resources resulting in better management decisions and protection to aquatic resources from actions that would result in declining, threatened, or endangered population levels.

Strategic Habitat Conservation and the National fish Habitat Action Plan have provided the Fisheries Program with new strategic approaches to aquatic conservation and the challenge to address climate change while maintaining excellence in management and science. Climate change resiliency ranking of restoration efforts and the eastern Brook Trout Joint Venture is just one promising example. Service needs require a concerted and standardized approach to ensue the implementation of biological planning and conservation designs based on sound science. Excellence in science and technology are critical to earning and maintaining the trust and support of our partners, stakeholders, other Service programs, and the public. Increased science capacity in areas such as risk and vulnerability assessments, inventory and monitoring, population and habitat assessment, biological planning and conservation design, management evaluation and research, and conservation genetics contribute to landscape conservation strategies for fish and aquatic resources. Nationally unique efforts being developed to implement the Chesapeake Bay Executive Order offer another example where all of the aforementioned efforts to build new scientific and management capabilities are being integrated.

Types of Activities

- Wild Fish Health Survey.
- Advancements in fish technology.
- Advancements in fish health diagnostics.
- Native mussel propagation
- Advancements in fish nutrition and diet development.
- Advancements in fish marking techniques.
- Advancements in conservation genetics.
- Grass Carp Inspection Program

Methodology

Leadership in science and technology encompasses numerous achievements in the production, survival, and health of the fishery resources.

- Advances in fish nutrition and diets, health diagnostics, and disease identification and control all lead to increased survival rates and a quality fish that not only survives in the environment but is capable of reproducing. Measures of the economic effects of science and technology are demonstrated in advances in fish diets and survival. Both diets and survival rates lead to a quality product and are seen in production efficiency. The trends in dietary cost per pound of fish produced and the survival rate increases demonstrate the economic efficiency brought about by science and technological innovations.

- Federal fish hatcheries have incorporated the best scientific practices into their operating protocols. Fish Technology Centers and Fish Health Centers provide science support to the national fish hatchery system. Through technical expertise and applied research both of which are focused on increasing the efficiency, effectiveness and overall success of captive propagation programs. Not all science and technology advances produce direct and easy to measure economic benefits. Many of the findings of research eventually find their way into higher quality products produced at the same or lower costs. Much of the science and technology work performed by the Service leads to quality improvements.

- Cryopreservation techniques developed at Fish Technology Centers are now employed to more efficiently manage broodstocks for restoration and recovery. This technology is especially useful with rare species, allowing genetic material to be frozen and stored until needed, thereby greatly increasing the ability to maximize genetic variation and implement genetic management plans.

Experimental natural rearing systems are being introduced to improve the survival of propagated fish through behavioral and physiological factors associated with reduced human contact, exposure to native fish assemblages, natural diets, and habitat simulation. A Fish Technology Center has implemented a fish feed quality control program to monitor the quality of commercial fish feeds. The industry that produces fish feeds use the analysis of results to improve the quality of feed produced which his crucial to efficient and effective hatchery operations.

- Fish Health Centers enhanced their ability to detect pathogens by implementing state-of-the-art molecular techniques which rapidly and effectively detect and quantify viruses, bacteria, and parasite that can infect fish at hatcheries and in the wild. Ultrasound technology is being developed to effectively and efficiently batch-vaccinate larval fish for several diseases that cause substantial fish health problems. This avoids expensive disease treatment. Studies indicate that ultrasound increases the absorption rate of the vaccine.

Examples of Leadership in Science and Technology Accomplishments

Lamar Fish Technology Center, Pennsylvania; Patented marking technique. A new mass marking technique and detection device uses calcein, a substance which binds with bony tissues in fish and is non-lethally detected under ultra violet light. The marking technique is continually being refined, and fishery managers now have an additional tool to help them evaluate both hatchery-reared and wild fish populations for restoration and enhancement programs. A total of 21 calcein experimental studies were conducted at 12 fish culture facilities during 2008 to test the usefulness of this marking technique; including trials at five U.S. Fish and Wildlife Service fish hatcheries, one National Oceanic and Atmospheric Administration facility, four state hatcheries, one private hatchery, and one tribal hatchery. There were 13 species involved in these studies. In 2009 there were an additional 10 trials performed, but results are not yet available. Since 2003, the Aquatic Animal Drug Approval Partnership (AADAP) office at the Fish Technology Center in Bozeman Montana has reported that 112 marking trials have been performed involving over 50 facilities. In addition, there have been numerous international calcein marking trials, including studies in Canada, England, and Australia, which are testimony to the value of this new technique but are not routinely reported via the AADAP program.

Scale and otolith samples from feed-induction marked fish were assessed by the Lamar Fish Technology Center and a technique for quantifying the mark intensity was developed. The Technology Center performed a calcein marking study to apply scale banding patterns to Atlantic salmon smolts which were released at various locations in the Connecticut River to be evaluated for mark longevity as returning adults in 2010. The Service has also provided numerous evaluations of calcein marks for state and federal partners concerning a wide variety of issues ranging from law enforcement to endangered species, including Endangered Rio Grande Silvery Minnows.

Germplasm Program; Storage of genetic resources fishes and other aquatic organisms. A Memorandum of Agreement (MOA) was initiated with the US Department of Agriculture's National Animal Germplasm Program (NAGP) for the archival storage of valuable cryopreserved sperm samples from fish species such as striped bass and sturgeon. The NAGP was designed to securely store genetic resources from agricultural species throughout the United States. The Agreement allows the Service to retain ownership of the samples, while providing a free and secure storage site. The Agreement eliminated the need for multi-million dollar facility and $60,000 per year operating costs to operate a similar facility by the Service.

Cryopreservation Laboratory, Georgia; Preservation of genetic diversity. The Warm Springs Fish Technology Center's Cryopreservation Laboratory assisted the Service in the development of cryopreservation techniques. These techniques allow the preservation of genetic diversity from these species. The conserved valuable genetic resources from candidate and endangered species reduced the need to create a cryopreservation laboratory in each Region – saving at least $200,000 annually in salary and operating expenses and at least $100,000 in facility expenses. The Laboratory has collaborated with other Regions of the Service on Atlantic sturgeon and Atlantic salmon sperm cryopreservation research, and on pallid sturgeon and Alabama sturgeon sperm cryopreservation research. This enabled the conservation of valuable genetic diversity from these species.

National Wild Fish Health Survey. The National Wild Fish Health Survey (NWFHS) is conducted by the Service's National Fish Health Centers, in cooperation with stakeholders such as Tribes, states, and the aquaculture industry. Pathogens present in wild populations of fish could have detrimental impacts to other listed species of reintroduced or stocked fish, resulting in loss of economic input from fish that are reared and stocked for sport fish. Knowledge gained in the National Wild Fish Health Survey and accessed through a National Wild Fish Health Database provides managers critical information in managing fish populations. Knowledge of distribution of parasites and disease allow managers to make sound decisions about control and containment strategies for areas or species that may already harbor a pathogen as well as identify areas or species where pathogens or parasites have not been detected and which may warrant special protection. Information provided through the National Wild Fish Health Survey will provide additional measures to safeguard these precious resources ensuring the continued economic benefits from angling. Information about the distribution of pathogens in wild stocks also helps the aquaculture industry by strengthening the biological basis for laws and regulations that govern the transport and sale of aquaculture products. Information from the National Wild Fish Health Survey shows that in some places, regulations limiting or prohibiting movement of hatchery fish for commercial purposes can be relaxed for certain pathogens without jeopardizing wild stocks.

Conservation Genetics; Fish Technology Centers. Geneticists at the Service's Fish Technology Centers address questions related to population delineation, landscape genetics, population connectivity, and management and conservation of genetic diversity. The Dexter National Hatchery and Technology Center, New Mexico, developed new genetic markers for gambusia and conducted the first genetic screening for several endemic gambusia species. Dexter also developed genetic management and captive propagation plans for the endangered humpback chub and Clear Creek gambusia. The Warm Springs Fish Technology Center, Georgia, determined that the alligator gar in the Mississippi River basin should be treated as several distinct populations. Because of this data, alligator gar management plans were adjusted accordingly. At Warm Springs, genetics work was directed at three imperiled freshwater mussels – the fat threeridge, purple bank climber, and oval pigtoe. Genetics work will help prioritize mussel populations for conservation and risks associated with hatchery restoration, augmentation, and captive refuge programs. The genetics lab in Alaska works on dozens of species – from salmon to sea otters. Genetics research allows managers to integrate genetics into restoration and recovery efforts.

San Marcos National Fish Hatchery and Technology Center, New Mexico; Refugia for threatened and endangered fish species. Maintaining refugia populations of threatened and endangered aquatic species (fish, salamanders, invertebrates, and plants) provides a population source if those in the wild are depleted, thus providing some protection for these listed species. Additionally, research with the captive organisms can provide biological information useful for management of these species. Droughts, which are a normal component of the regional weather pattern, will decrease the availability of water required by these species. The refugium work at San Marcos Fish National Fish Hatchery and Technology Center provides a backup source of these species and through research provides insight into their biology and environmental requirements. Organisms are monitored, studied, and collected from the wild and maintained and studied in captivity. These projects provide the building, equipment, and expertise needed to expand and establish refugia for listed species as called for in the recovery/contingency plans. Future droughts and human population growth will increase water demand and may trigger lawsuits and additional court involvement in the San Marcos National Fish Hatchery and Technology Center program. Droughts and the increasing demand for water also will accelerate the damage to critical habitats by aquatic nuisance species. The economic benefit from preventing possible extinction during periods of spring flow cessation, establishment of genetic reserves of listed organisms, and accumulation of life history information on listed and nuisance species is substantial. Estimated cost for providing supplemental regional water is over a billion dollars.

Summary and Conclusions

This report is a first attempt at measuring the economic contributions attributable to the five focus areas in the National Fisheries 2004-2008 strategic plan. The measurement of the economic contribution of four of the focus areas was possible with available data (Aquatic Habitat Conservation and Management, Aquatic Species Conservation and Management, Public Use, and Cooperation with Native Americans). The contributions of science and technology underlie the accomplishments of the other four focus areas and are difficult to isolate and measure. A text description of this focus area suffices to explain the role science and technology plays in support of the fisheries and aquatic resource program.

Working with Tribal, State and private sector partners, the Fish and Wildlife Service accomplished substantial resource restoration/enhancements under the strategic plan. Aquatic habitat conservation consisting primarily of wetland habitat, upland habitat, the restoration of in-steam habitat, riparian habitat, and opening rivers to fish passage will have an estimated economic contribution of $2 billion dollars and is associated with 45,000 jobs when projects achieve their full potential.

Aquatic species conservation and management work consisting of species held in refugia, managing invasive species, and managing for subsistence harvest produced a mixture of economic impact, consumer surplus, and equivalent value. In total, species in refugia were valued by the public at $456 million dollars. The value of managing invasive species is exemplified by sea lamprey control which is valued at $556 million per year and is associated with an estimated 13,200 jobs. The average of 94 fish populations managed for subsistence has a minimum replacement value of $301 million dollars, excluding cultural and social values.

The Service has a role in stocking fish on public lands, Tribal lands in cooperation with Native Americans, fishery mitigation of Federal water development projects, and providing recreational fishing opportunities on Service lands, military lands, and other lands. This activity generates a substantial economic contribution. According to an Alaska Fish and Game study on subsistence activity, there is an economic impact from equipment expenditures for those engaged in subsistence activity totaling $121 million in direct expenditures and creating 1,854 jobs. The estimate of the stocking of 123.1 million fish in 2006 generated over 13 million angling days, $554 million dollars in retail sales, $903 million dollars of industrial output, $256 million dollars of job income and 8,000 jobs. In addition, over $37 million dollars of Federal tax income and nearly $35 million dollars of state and local tax revenue were generated.

The economic contribution of leadership in science and technology underlies accomplishments in the other focus areas. The development and application of state-of-the-art science and technology for the conservation and management of fish and other aquatic species and their habitats is providing the Fisheries Program with a new approach to aquatic conservation and the challenge to address climate change while maintaining excellence in management and science.

Table 10 shows a partial list of the typical expenditures associated with angling as reported in the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation. This pattern of spending generates the economic contribution associated with the operations of the Fisheries Program.

Table 10. Angler Expenditures in 2006

Item	Expenditures (Thou. Dollars)	Percent of Total
Food and Lodging	$6,302,524	17.2%
Transportation	$4,961,830	13.5%
Other Trip Costs	$3,205,582	8.7%
Boating Costs	$3,408,623	9.3%
Equipment	$3,043,829	8.3%
Rods, Reels, Etc.	$2,288,572	6.2%
Auxiliary Equipment	$778,740	2.1%
Special Equipment	$12,646,229	34.5%
Total	$36,635,929	100.0%

Special equipment includes boats, campers, cabins etc.
Source: 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation.

Table 1 illustrates that the Fisheries Program is associated with as much as $3.6 billion in output and over 68,000 jobs. This is a remarkable impact for a program that spent only $126.5 million in 2008. In constant 2010 dollars, the annual appropriation for the Fisheries Program has changed little in the 2004-2008 budget years. Table 11 shows that budget increases have not kept pace with inflation. The nominally higher appropriation in 2008 is actually lower than the 2004 budget in constant dollar terms.

Table 11. Annual Appropriations for the Fisheries Program during the Strategic Plan years in unadjusted dollars and constant 2010 dollars.

Year	Annual Appropriation (unadjusted dollars, thousands)	Appropriation (constant 2010 dollars, thousands)
2004	$114,321	$131,872
2005	$114,569	$127,827
2006	$116,488	$125,906
2007	$117,778	$123,775
2008	$126,499	$128,025

Prior chapters demonstrated the contributions generated by Fisheries Program activities but they failed to show how spending by the program for wages and supplies is associated with additional impacts on local economies. The total economic impact of Fisheries Program budget expenditures for the year 2008 is approximately 253 million dollars and associated jobs range from 5,060 to 6,324 annually with a mid-point of 5,692. This is in addition to the impacts shown in Table 1.

This report provides a rough estimate of the level of efficiency and the services provided to the American public by the Fisheries and Aquatic Resources Program. Supported by its research and science capabilities, the Program has achieved substantial economic contributions that benefit all segments of American society.

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.

Employment Income (see Job Income)

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

Impacts: The new economic activity generated in a region as a result of new spending or other changes in the regional economy.

Indirect and induced: Secondary impacts of changes in a regional economy. 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 and additional people are employed in the region.

Job Income: Income to households from labor including wages and salaries. 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: 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.

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Appendix A
Literature Review

A short review of the literature used in this report to determine the economic contributions derived from the restoration/enhancement of fish habitat. The original estimates were converted to 2010 dollars using the consumer price index.

NorthStar Economics, Inc., Principal Investigator is Alan J. Hart, April 2008
The Economic Impact of Recreational Trout Angling in the Driftless Area

The NorthStar Economics, Inc. report was based on a survey of trout anglers in the driftless area of the States of Minnesota, Michigan, Iowa, and Wisconsin. A total of 39.1 percent of the anglers lived in the driftless area with the remaining 60.9 percent living outside the area. The total economic impact (direct, indirect, and induced) of $1.1 billion was attributed to the 155,070 holders of trout stamps. The original economic estimate of angler expenditures was based on an angler survey to determine where anglers lived and total annual spending. As shown below, to determine the direct economic impact of $647 million dollars the weighted average annual spending of $4,171.15 was multiplied by the trout stamp holders. The indirect and induced effects were estimated with an input-output model.

Total Angler spending/year	Percent resident/non resident In Driftless area		Total	Weighted Average	
$4,827.18	0.391		$1,887.43	$4,171.15	
$3,749.95	0.609		$2,283.72		
trout stamp sold	155,070				
Indirect/induced impact	$3,427.30	0.391	$1,340.07	$646,819,673	direct impact
per angler	$2,699.96	0.609	$1,644.28	$464,691,659	Indirect/induced
			(2006 $)	$1,111,511,332	Total Impact

In order to generalize the NorthStar Economics results this study used the number of trout anglers and their annual spending on travel and equipment reported in the 2006 National Survey of Fishing, Hunting, and Wildlife Associated Recreation. Using the trout stamps sold and the economic multipliers from the NorthStar report along with the State supplements to the National Survey produced an estimated $258 million (2010 dollars) in total economic impact for trout angling. This translated into an estimated $570 thousand dollars per river mile restored or $9.4 thousand dollars per acre.

Combining the NorthStar coefficients with the 2006 National Survey of Fishing, Hunting and Wildlife Associated Recreation state supplement results serves to generalize the Northstar findings for use in this report.

State	Trout Anglers	Annual Ave. Spending	Total Spending	
Minnesota	27,000	$1,142	$30,834,000	
Michigan	157,000	$843	$132,351,000	
Iowa	34,000	$673	$22,882,000	
Wisconsin	90,000	$1,018	$277,687,000	
Total	308,000		$901.58	Weighted Average

Adjusted 2010 Dollars

Direct Impact	$151,112,128
Indirect/Induced	$107,289,611
Total Impact	$258,401,739

Per restored/enhanced mile	$570,423	Assuming 60.2 acres/mile
Per restored/enhanced acre	$9,369	

The weighted average spending of State trout anglers amounted to $901.58. This was multiplied by the trout stamp holders to get a direct economic impact of $151,112,128. The indirect and induced effects used the NorthStar multipliers.

Leslie Richardson and John Loomis, Ecological Economics 2008
Total Economic Value of Threatened, Endangered and Rare Species: An updated meta-analysis.

The authors recommended benefit transfer model in $2006 dollars is a reduced form equation. This equation was initially used to develop the range of values of how much households would be willing to pay annually to preserve endangered species. However, the inclusion of high value game species like salmon skewed the results and was not representative of the species held in refugia. The per year household values are multiplied by number of households in the state where the species are found to calibrate annual net economic values. The database used in the Richardson and Loomis study contained four species with the following annual values that more closely resembled the species in refugia.

	(2006$)	(2010$)	
Silvery minnow	$37.77	$40.82	per year per household net
Striped Shiner	$8.32	$8.99	economic values
Squawfish	$11.65	$12.59	
Riverside fairy shrimp	$28.38	$30.67	
	Total	$93.08	
	Average	$23.27	

The average annual net economic value for saving endangered species amounted to $23 per household.

Jesse Lance Robbins and Lynn Y. Lewis, Journal of the American Water Resources Association, December 2008.

Demolish it and they will come: Estimating the economic impacts of restoring a recreational fishery.

The economic value of removing a barrier and letting fish migrate up river.

	(2005$)	(2010$)
Economic impact per freshwater angler	$55	$61.36
Annual direct economic impact per angler	$342	$381.58
Total economic impact per angler	$588	$656.31

18.54 percent were freshwater anglers

Total Impact was $8,767,838

	(2005$)	(2010$)
Per river mile	$461,465	$514,866
Per acre	$7,671	$8,559

A total of 19 river miles (1,143 acres) were opened to fish migration.

Molly W. Ingraham and Shonda Foster, Ecological Economics, 2008
The Value of Ecosystem Services Provided by the U.S. National Wildlife Refuge System in the Contiguous U.S.

Value of ecosystem services	(2004$)	(2010$)
	(Dollars per acre per year)	
Open water	$287	$331
Forest	$846	$976
Shrubland	$550	$634
Grassland	$51	$59
Wetlands	$8,846	$10,204

John C. Whitehead, Peter A. Groothuis, Rob Southwick and Pat Foster-Turley
March 20, 2006
Economic Values of Saginaw Bay Coastal Marches with a Focus on Recreational Values

Estimated values of freshwater wetlands per acre from the academic literature.

	(2005$)	(2010$)
1- Habitat	$462	$516
2- Species/habitat protection	$286	$319
3- Freshwater marsh	$67	$75
4- Habitat/refugia	$237	$264
5- Total ecosystem services	$10,573	$11,797

1 - Habitat values from Woodward,R.T. and Y.S. Wui, 2001. "The economic value of wetland services: A meta-analysis", Ecological Economics 37: 257-270

2 - Species/Habitat protection from Kazmierczak, R.F., 2001a. "Economic Linkages Between Coastal Wetlands and Habitat Species Protection: A Review of Value Estimates Reported in the Published Literature" Agricultural Economics and Agribusiness Staff Paper 2001-01

2 - Kazmierczak, R.F.,2001b "Economic Linkages Between Coastal Wetlands and Hunting and Fishing: A Review of Value Estimates Reported in the Published Literature," Agricultural Economics and Agribusiness Staff Paper 2001-03

3 - Freshwater marsh from Schuyt, K. and L.Brander, 2004"The Economic Value of the World's Wetlands", World Wildife Fund, Gland, Switzerland

4 - Habitat/refugia average values from Costanza et al.

5 - Total ecosystem services from average values from Costanza et al.

Francois Boulanger and John Charbonneau, November 28, 1989
An Analysis of the Economic Contribution of the Great Lakes Sea Lamprey Program, Volume 2 to the Report of the Evaluation of the Great Lakes Fishery Commission by the Bi-National Evaluation Team

	(1988$)	(2010$)
Total Economic Impact	$302,000,000	$556,262,046
Jobs supported	13,200	13,200

The economic value of salmonids saved with sea lamprey control after accounting for the substitution effect. Jobs are from a Canadian input/output model with 36 direct and indirect/induced jobs per million dollars. Impacts converted to Canadian dollars to determine jobs affected.

Tony Prato and Donald Hey: Journal of the American Water Resources Association, Feb. 2006
Economic Analysis of Wetland Restoration along the Illinois River

The Hennepin and Hooper Lakes restoration project is valued at an annual net benefit of $1,827 per ha of restored wetland.

	(2005$)	(2010$)
Wetlands per hectare	$1,827	
Wetlands per acre	$4,567	$5,096

James A. Fall, et al., Alaska Department of Fish and Game, Division of Subsistence Technical Paper no. 318, Juneau, Alaska. 2007.
Alaska Subsistence and Salmon Fisheries 2005 Annual Report.

More than 135,000 people in over 270 communities live in rural Alaska and are entitled to subsistence activities on Federal Land. Across Alaska the average subsistence harvest is 375 pounds of food per person. Replacing subsistence harvested food with store-bought foods would cost approximately $301 million (2010 $).

Steve Colt, Institute of Social and Economic Research, University of Alaska. January 2001.
The Economic Importance of Healthy Alaska Ecosystems.

Direct economic impact of expenditures and jobs from Steve Colt's report adjusted to 2010 dollars. Expenditures for subsistence harvest and jobs created were derived from Goldsmith 1998.

Total harvest	50,000,000 pounds
Expenditures to support harvest in 2010 dollars	$120,981,288
At $65,242.56 dollars per job	1,854 jobs

J.M. Gates. Published by the Pew Environment Group, Washington, D.C. 2009.
Investing in our Future: the Economic Case for Rebuilding Mid-Atlantic Fish Populations.

Gates provides a new analysis of the potential economic benefits of rebuilding stocks of four Mid-Atlantic species: summer flounder, black sea bass, bluefish, and butterfish. In the recreation sector, rebuilding these four fish population would increase landings with an annual economic value of approximately $536 million per year (in 2007 dollars). These are saltwater species and not directly comparable to freshwater species but it demonstrates the substantial economic values placed on healthy fish populations.

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