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Stocking Trends: A Quantitative Review of Governmental Fish Stocking in the United States, 1931 to 2004

ABSTRACT: This article provides a quantitative review of the type, number, and estimated weight of the fish stocked by the 50 state agencies and the U.S. Fish and Wildlife Service in the United States in 2004. I examined trends in the light of data from earlier reports dating back to 1931. Among other things, this analysis shows that 1.7 billion fish were stocked by these agencies in 2004, representing 104 types of fish weighing an estimated 19.8 million kg. This was the largest number of types of fish (species, subspecies, and hybrids) and the largest total weight of fish ever stocked for those years for which information was available. Because many fish are being stocked at larger sizes, the total number of fish stocked in 2004 was in fact lower than in the first half of the twentieth century. Reflecting a long-term trend, most of the stocking was done by state agencies. The majority of the fish stocked (by estimated weight) were in western states and the most commonly stocked fish by this measure were coldwater sportfish, especially rainbow trout (*Oncorhynchus mykiss*).

Revisión cuantitativa de los peces almacenados por el gobierno de los Estados Unidos, de 1931 a 2004

RESUMEN: En este artículo se presenta una revisión de los tipos, número y peso estimado de las especies de peces almacenados por las 50 agencias estatales y por el servicio de Pesca y Vida Silvestre de los EU en 2004. Se examinan las tendencias de los datos a la luz de reportes previos que datan de 1931. Entre otras cosas, el presente análisis muestra que 1.7 mil millones de peces fueron almacenados por estas agencias en el 2004, lo que representa 104 tipos de peces con un peso estimado de 19.8 millones de kilogramos. Este fue el número más alto de tipos de peces (especies, subespecies e híbridos) y el mayor peso total de peces almacenados jamás registrado. Ya que muchos peces que están siendo almacenados son de tallas grandes, el número total de peces almacenados en el 2004 fue de hecho menor que el de la primera mitad del siglo XX. Reflejando una tendencia de largo plazo, mucho del trabajo de almacenamiento fue realizado por las agencias estatales. La mayor parte de los peces fueron almacenados (por peso estimado) por las agencias del oeste del país y, en este sentido, los tipos más comunes fueron peces de agua fría destinado a la pesca deportiva, especialmente la trucha arcoíris (*Oncorhynchus mykiss*).

INTRODUCTION

Fish stocking in the United States by the state and federal governments has been a frequent topic of debate in recent decades. Fisheries managers have often led the discussion and have been rigorously examining the efficacy and effects of their stocking programs. The American Fisheries Society has published at least three different volumes on the topic since 1986 (Stroud 1986; Schramm and Piper 1995; Nickum et al. 2004).

However, other groups have also weighed in on various aspects of the governmental stocking programs. In 1994, at the request of U.S. Fish and Wildlife Service (USFWS) Director Mollie Beattie, an outside panel reviewed the National Fish Hatchery system and concluded that, with certain caveats, "the provision of hatchery fish for recreational fishing is not a federal responsibility" (The Conservation Fund 1994). In 1999, at the request of Representative George Miller, the General Accounting Office (GAO) investigated the USFWS fish hatchery program (GAO 1999). In its report, the GAO again criticized the agency for dedicating too many of its resources to commercial and recreational fisheries and not enough to "recovering threatened or endangered species and restoring other native fish stocks to self-sustaining levels."

More recently, scientists have contended that fish stocking may be at least partially responsible for the decline and disappearance of amphibian species and other aquatic biodiversity around the globe (e.g., Knapp 2005). This story has received widespread coverage in the popular press and thus become a topic of concern for at least some portion of the American public (e.g., Krist 2001). On the flip side, other segments of the general public continue to push for an increase in the level of stocking. Jackson et al. (2004) concluded from a survey of fisheries managers that, "pub-

lic pressure to stock cultured fishes is an important influence on agency decisions to use cultured fishes."

In response to such criticism and debate, managers have made substantial changes in their approach to fish stocking in recent years. The federal government has increasingly sought to focus its efforts on the restoration of and recovery of native fishes and has transferred many of its hatcheries to the states (GAO 1999). State agencies have also made changes. In the last few decades, state agencies have become much more likely to emphasize habitat management programs over fish culture, reduce or eliminate stocking in certain waters due to concerns about its potential impacts on biodiversity and native species, use native fishes and sterile fishes in their stocking programs, analyze the justifications for stocking individual waters and monitor the results, and increase the size of the stocked fish to improve survival (Jackson et al. 2004).

However, all of the criticism and all of the management changes that have been made in recent decades have taken place despite the lack of what would seem to be a crucial piece of data. Although Stroud (1986) and Heidinger (1993) provide valuable reviews, no single document since 1973 has compiled and comprehensively quantified the number, weight, and type of fish stocked by the state and federal governments in the United States. This article attempts to at least partially fill that gap by (1) documenting recent fish stocking statistics by all government agencies involved in the enterprise in the United States and (2) reviewing some of the historical trends that have led to current fish stocking programs. I have intentionally avoided any attempt to resolve any of the debates or make management recommendations here—such steps would require value judgments as well as science and data. Rather, I have tried to provide an unbiased quantitative review of governmental fish stocking programs in the United States so that it will be available to ground the debates when they occur in other venues.

METHODS

I sought fish stocking data from all 50 state fish and game agencies for the year 2004 from agency websites or by contacting agency officials. I also obtained stocking data from officials with the USFWS, the primary federal agency that currently stocks fish. Though I was able to get data from all 50 states and the federal government, in some cases the data represented fiscal year 2004 or fiscal year 2005 instead of calendar year 2004 and in one case (Arkansas) I was only able to obtain data for 2002. I refer to these data as data for the year 2004 in the rest of this document. To avoid double counting, I removed all records where data showed that fishes were not stocked but were instead transferred to another hatchery, aquarium, etc.

The datasets from the USFWS and 22 states included data on number and weight for every type of fish stocked. Four state datasets included information on weight for some of the fishes stocked. Datasets from 9 states included information about size class for the types of fish stocked. When the data included size class instead of total weight, weight was estimated based on standard conversion factors (egg, fry = 0.02 g/fish; fingerling, yearling = 3 g/fish; subcatchable, subadult, intermediate = 40 g/fish; catchable, adult = 100 g/fish; broodstock = 450 g/fish; parr = 2 g/fish; smolt = 50 g/fish; forage species = 1 g/fish; Everest et al. 1986; Fish 2004). Data from 13 states included information on the length of the fish stocked. In such cases, I estimated weight based on the commonly-used allometric function $W = CL^n$ where W is the weight, C is a specific constant, L is the averge length, and n is the exponential rate of change of weight as a function of length (Carlander 1969). I used the median values for C and n from Fishbase (Froese and Pauly 2006). Six state datasets lacked information on the size or weight of at least some of the fish stocked. In such cases, I estimated weight based on the average weight per fish by species from those data that included weight.

It should be emphasized that all three of the weight estimation techniques have the potential to introduce substantial amounts of error. Under any given set of definitions, size classes may include fish that are one half to twice the size of the average, and there may be different definitions in use. As Carlander (1969) points out, length-weight equations may not be exactly the same at early stages of growth because fry and young fingerlings are often more slender. In addition, the exponential nature of the length-weight equation has the potential to introduce a large degree of error into any weight estimate based on average length. (However, because it is likely that the data on average length was actually back-calculated by the agencies with a similar equation, this may not be as much of a source of error as it might at first appear.) And because different agencies use different stocking techniques for different purposes, the average size of the fishes in a given state may be very different from the average size of those fishes in the nation as a whole. Thus, using the average weight of fishes stocked in the country as a whole to estimate the weight of fishes stocked by those states for which no weight data was available may also introduce error.

For the analyses, I divided the fishes into typical management categories, though in many cases I lumped strains together. Thus, for example, I categorized all *Oncorhynchus mykiss* as rainbow trout except for those described as steelhead. I also placed each type of fish in one of the following categories: coldwater sport, coolwater sport, warmwater sport, salmon and steelhead, forage, rare or declining, marine and anadromous, and other. These categories are often polyphyletic from a taxonomic point of view and even from a management point of view are sometimes problematic. In many cases, a fish could have been placed in one of several categories. The data for each type for the year 2004 are presented in Table 1 should a different classification system be needed.

To analyze geographical trends, I used the same four divisions used by the American Fisheries Society: Western (Alaska, Arizona, New Mexico, Utah, California, Nevada, Colorado, Wyoming, Hawaii, Idaho, Montana, Oregon, Washington), North Central (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin), Southern (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia), and Northeastern (New York, Pennsylvania, Massachusetts, Connecticut, Rhode Island, Delaware, New Jersey, Maine, New Hampshire, Vermont). Because the data from the U.S. Fish and Wildlife Service included information about which state the fish were stocked in, I also divided and included this data in each of the divisions as appropriate.

To analyze temporal trends for the federal government, I gathered data from reports issued by the U.S. Fish and Wildlife Service and its predecessors. At

the state level, I surveyed the literature for documents that reported data for multiple states. I identified six manuscripts between 1931 and 1973 that contained at least some of these data in a format that was suitable for this analysis (Bureau of Fisheries 1932; Earle 1937; Tunison et al. 1949a, b; Hagen and O'Connor 1959; Bureau of Sport Fisheries and Wildlife 1968; Calhoun 1974). Because not all of these documents included all 50 states, I identified the 33 states that were included in all 6 of these documents and used these states to analyze historical trends.

Different agencies and different eras used different systems for classifying the size classes of the fish stocked. To analyze trends in these data, I categorized all fish as eggs and fry (<2.5 cm), fingerlings (2.5 to 15.2 cm), and large fish (>15.2 cm).

RESULTS AND DISCUSSION

State and federal agencies reported stocking approximately 1.75 billion fish in the waters of the United States in 2004, weighing an estimated 20 million kg (Table 1). I emphasize again that the weight estimate should be used with some caution. However, it appears to be relatively robust. Most of the datasets from the bigger agencies included weight data, such that 69% of the total estimated weight of fish stocked in the United States by all agencies was from such sources. About 22% of the total estimated weight was based on datasets that included lengths, and 6% was from datasets that included size classes. Only 3% of the weight estimate was based on datasets that included no data on the size of fish stocked.

In terms of total weight, fish stocking in the public waters of the United States was a bigger enterprise in 2004 than in any other year for which the data are readily available. Although this claim is based on historical data from 33 states and the federal government, it would probably hold true if data were available for all the states in the years analyzed. However, without another complete dataset after 1973, it is difficult to know whether the total weight in 2004 represents a peak, a plateau, or a decline since that time. There is some evidence that it may be one of the latter. For example, in the decades between those years many states reduced the number of water bodies stocked and turned instead to wild fish management (e.g., Stone 1995; White et al. 1995); many states reduced their stocking programs out of concern for native fauna, or because studies showed them to be economically inefficient (Jackson et al. 2004); some states were forced to reduce stocking in response to whirling disease (e.g., Epifanio 2000); and some agencies even began removing fish from areas that had previously been stocked (e.g., USFWS 1998; Moore et al. 2005).

Based on the data from the federal government and the 33 states for which data was available in all years, it appears that the total number of fish stocked in the 1930s was about 7 times higher than in 2004. However, the total estimated weight of the fish stocked in 2004 was about 10 times greater than that stocked in the 1930s (Table 2, 1). The divergent trends of the total number and total weight of fish stocked suggest there has been a large shift in the size of fish stocked over the last 80 years, and it would probably be even more pronounced were the data available from the 1930s and earlier (Figure 1). The trend is especially strong among salmon, steelhead, and coldwater sport fishes.

The upward trend in the size of fish stocked is probably the result of numerous factors. Many of the fish stocked in the early years were marine species that were propagated from eggs and milt of fish caught for commercial purposes. Such programs were viewed as an easy means of mitigating the effects of capturing mature fish and little effort was put into them beyond fertilizing the eggs and releasing them back into the ocean (e.g., Bureau of Fisheries 1932; Tunison 1949a; Allard 1978). The efficacy of such efforts for maintaining commercial catch was increasingly questioned, however, and by the middle of the century they had largely ceased (e.g., Tunison 1949a). Stocking larger individuals also became more common as managers focused less on trying to establish populations and species in waters to which they were not native, and more on planting individual fish that could be caught by anglers (e.g., Shetter 1947; Towle 2000). And, in terms of the latter goal, there was a growing perception among fisheries managers during the recreation boom that followed World War II that the higher survival rate of larger fish might, in some cases, compensate for the higher cost of producing them (e.g., Leitritz 1970).

Some species such as walleye (*Sander vitreus*) continue to be stocked at a small size because diet, disease, cannibalism, and other factors make it prohibitively difficult to raise them to large sizes (M. Mason, Iowa Department of Natural Resources, pers. comm.). But for other species such as rainbow trout, catchables are now the most commonly stocked size class (Figure 2).

Because of the small size at which they are typically stocked, close to 60% of the total number of fish stocked were walleye, however, they accounted for less than 1% of the fish stocked by weight in the year 2004. Conversely, although they accounted for only about 5% of the total number of fish stocked, rainbow trout (not including steelhead) made up an estimated 50% of the fish stocked by weight (Table 1, Figure 3). More broadly, coldwater sport fishes made up the majority of stocked fish by weight (65%), while coolwater sport fishes made up the majority of fishes stocked by number (64%) (Table 1). Sportfishes and the forage fishes planted for their benefit made up a vast majority of the fish stocked in 2004 by both number and weight (82% and 72%, respectively). Though this may seem unremarkable today, it is interesting to note that this was not always the case. Many governmental fish stocking programs were begun as a means to support commercial fisheries—an enterprise that waned in the first half of the twentieth century when managers concluded most of these programs were having little effect (e.g., U.S. Commission of Fish and Fisheries 1874; Tunison 1949a)

Agencies reported stocking 104 types of fish (species, subspecies, and hybrids) in 2004. Although most of these fish were stocked for sport and commercial fishing, at least 37 of these fishes were considered threatened, endangered, or of special concern by state or federal governments, and an additional 16 were rare or had undergone a severe population decline. Mostly because of the propagation of such rare species, the total number of species propagated in 2004 is larger than at any other time for which data were available.

Based on the data from the federal government and the 33 states for which data was available in all years, the federal government produced a smaller percentage of the total number of fish stocked in 2004 than in any other year. The total weight of fish stocked by the federal government in 2004 was smaller than in any other year except 1947 and 1958 (Table 2). The types of fish stocked by the federal government reflected the patterns described above and

Table 1. Types of fish stocked by the U.S. Fish and Wildlife Service and the state governments in 2004. The first number represents the estimated number in thousands. The number in parentheses represents weight in thousands of kilograms. The states are grouped into four regions (see text). Asterisks indicate hybrids. Those types with a (3) after the name are triploids. In some cases the data reported were for the 2004 or 2005 fiscal, not calendar year. The data for Arkansas is for the year 2002. All records where the data showed the fish were not stocked but were instead transferred to another hatchery, aquarium, etc. were removed from the data. The final column represents the total number of states in which the fish were reported stocked by the state or federal government.

Type	Common name	USFWS		Western		North Central		Northeastern		Southern		Total		# States
COLDWATER SPORT														
Coregonus clupeaformis	Lake whitefish	0	(0)	0	(0)	610.2	(0.3)	0.2	(<0.05)	0	(0)	610.4	(0.3)	2
Oncorhynchus clarki	Cutthroat trout	1,324.0	(40.6)	4,936.1	(128.2)	0	(0)	0	(0)	211.1	(17.6)	6,471.2	(186.3)	7
Oncorhynchus clarki bouvieri	Yellowstone cutthroat	0	(0)	1,475.0	(23.0)	0	(0)	0	(0)	0	(0)	1,475.0	(23.0)	3
Oncorhynchus mykiss	Rainbow trout	8,300.4	(856.9)	51,037.0	(4,524.7)	6,146.7	(843.3)	4,074.4	(755.5)	9,633.2	(1,716.4)	79,191.7	(8,696.8)	45
Oncorhynchus mykiss (3)	Rainbow trout (3)	0	(0)	6,232.2	(1,266.9)	0	(0)	0	(0)	0	(0)	6,232.2	(1,266.9)	1
Oncorhynchus mykiss aguabonita	Golden trout	0	(0)	113.8	(0.1)	0	(0)	8.8	(7.2)	39.7	(13.8)	162.3	(21.2)	5
*Oncorhynchus mykiss***clarki*	Rainbow*cutthroat	0	(0)	549.7	(41.3)	0	(0)	0	(0)	0	(0)	549.7	(41.3)	2
*Oncorhynchus mykiss***clarki* (3)	Rainbow*cutthroat (3)	0	(0)	38.3	(0.2)	0	(0)	0	(0)	0	(0)	38.3	(0.2)	1
Oncorhynchus nerka	Kokanee	0	(0)	39,168.6	(106.0)	0	(0)	84.0	(<0.05)	0	(0)	39,252.6	(106.0)	10
Salmo salar (landlocked)	Landlocked Atlantic salmon	162.1	(12.9)	12.6	(1.6)	0	(0)	1,414.0	(39.8)	0	(0)	1,588.7	(54.3)	6
Salmo trutta	Brown trout	698.4	(36.6)	2,323.9	(92.4)	5,490.6	(237.4)	6,607.6	(797.1)	1,572.2	(142.6)	16,692.7	(1,306.1)	39
Salmo trutta (sea run)	Sea run brown trout	0	(0)	0	(0)	0	(0)	29.0	(2.6)	0	(0)	29.0	(2.6)	1
Salmo trutta x Salvelinus fontinalis	Tiger trout	0	(0)	458.4	(6.3)	0	(0)	8.3	(6.8)	0	(0)	466.7	(13.1)	6
Salvelinus alpinus	Arctic char	0	(0)	300.8	(5.6)	0	(0)	0	(0)	0	(0)	300.8	(5.6)	1
Salvelinus fontinalis	Brook trout	345.0	(6.2)	1,383.3	(75.3)	974.2	(35.6)	4,525.8	(528.9)	827.2	(120.4)	8,055.5	(766.5)	27
*Salvelinus fontinalis***namaycush*	Splake	0	(0)	382.8	(4.4)	539.9	(19.0)	66.2	(10.4)	0	(0)	988.9	(33.9)	8
Salvelinus namaycush	Lake trout	4,434.4	(161.3)	2,325.3	(163.7)	1,466.9	(39.3)	1,056.8	(39.7)	168.4	(3.0)	9,451.8	(406.9)	14
Total coldwater sport fish		**15,264.4**	**(1,114.5)**	**110,737.6**	**(6,439.6)**	**15,228.4**	**(1,175.0)**	**17,875.2**	**(2,188.1)**	**12,451.7**	**(2013.9)**	**171,557.4**	**(12,931.1)**	
COOLWATER SPORT														
Esox lucius	Northern pike	3,520.5	(0.8)	679.0	(0.2)	5,618.7	(9.2)	107.9	(1.2)	18.5	(<0.05)	9,944.6	(11.4)	16
*Esox lucius***masquinongy*	Tiger muskie	0	(0)	42.3	(2.5)	64.7	(0.4)	250.5	(7.5)	13.5	(0.1)	371.0	(10.6)	15
Esox masquinongy	Muskellunge	0	(0)	0	(0)	1,712.9	(19.1)	738.0	(2.6)	110.8	(1.6)	2,561.7	(23.2)	16
Esox niger	Chain pickerel	0	(0)	0	(0)	0	(0)	1.5	(<0.05)	0	(0)	1.5	(<0.05)	1
Perca flavescens	Yellow perch	720.4	(0.4)	122.2	(6.8)	3,708.6	(78.6)	1,000.0	(<0.05)	0	(0)	5,551.3	(85.9)	12
Sander canadensis	Sauger	0	(0)	349.4	(<0.05)	28,723.0	(2.5)	18.6	(<0.05)	382.9	(0.2)	29,474.0	(2.8)	9
*Sander canadensis***vitreus*	Saugeye	0	(0)	11,739.5	(0.2)	15,325.6	(4.3)	4.0	(<0.05)	699.6	(0.7)	27,768.8	(5.1)	9
Sander vitreus	Walleye	15,677.9	(3.8)	78,836.7	(2.2)	630,595.6	(133.9)	303,392.2	(9.7)	17,637.6	(4.9)	1,046,140.1	(154.4)	34
Total coolwater sport fish		**19,918.8**	**(5.0)**	**91,769.1**	**(12.0)**	**685,749.3**	**(248.0)**	**305,512.7**	**(21.0)**	**18,863.0**	**(7.5)**	**1,121,812.9**	**(293.5)**	
WARMWATER SPORT														
Ambloplites rupestris	Rock bass	0	(0)	0	(0)	0	(0)	3.5	(<0.05)	0	(0)	3.5	(<0.05)	1
Ameiurus melas	Black bullhead	0	(0)	0	(0)	3.6	(1.0)	0	(0)	0	(0)	3.6	(1.0)	1
Ameiurus natalis	Yellow bullhead	0	(0)	0	(0)	<0.05	(<0.05)	0	(0)	0	(0)	<0.05	(<0.05)	1
Ictalurus furcatus	Blue catfish	0	(0)	169.8	(0.3)	45.5	(1.8)	0	(0)	1,235.5	(49.6)	1,450.7	(51.7)	9
Ictalurus punctatus	Channel catfish	418.7	(22.5)	1,830.5	(102.0)	6,402.5	(191.9)	422.1	(8.0)	5,065.2	(385.6)	14,138.9	(710.1)	38
Lepisosteus platystomus	Shortnose gar	<0.05	(<0.05)	0	(0)	0	(0)	0	(0)	0	(0)	<0.05	(<0.05)	
Lepomis auritus	Redbreast sunfish	0	(0)	0	(0)	0	(0)	0	(0)	1,190.4	(3.6)	1,190.4	(3.6)	1
Lepomis gibbosus	Pumpkinseed	0	(0)	0	(0)	0.7	(0.1)	0	(0)	0	(0)	0.7	(0.1)	1
Lepomis macrochirus	Bluegill	1,292.8	(1.2)	75.2	(1.3)	5,347.1	(14.8)	42.3	(1.0)	10,737.7	(23.6)	17,495.1	(41.8)	31
*Lepomis macrochirus***cyanellus*	Bluegill*Green Sunfish	0	(0)	0.7	(<0.05)	0	(0)	0	(0)	0	(0)	0.7	(<0.05)	1
Lepomis microlophus	Redear sunfish	98.7	(<0.05)	0	(0)	927.4	(1.1)	34.7	(<0.05)	1,751.0	(3.5)	2,811.8	(4.7)	16
Lepomis spp.	Sunfish	0	(0)	0	(0)	139.1	(2.6)	3.0	(0.4)	2,130.8	(4.4)	2,272.9	(7.4)	9
Micropterus cataractae	Shoal bass	0	(0)	0	(0)	0	(0)	0	(0)	212.8	(0.6)	212.8	(0.6)	1
Micropterus dolomieu	Smallmouth bass	17.1	(0.1)	93.3	(1.4)	249.7	(1.0)	48.2	(0.4)	63.6	(0.3)	472.0	(3.1)	22
Micropterus punctulatus	Spotted bass	0	(0)	0	(0)	0	(0)	0	(0)	2.7	(<0.05)	2.7	(<0.05)	1
Micropterus salmoides	Largemouth bass	1,798.2	(2.2)	529.4	(5.9)	2,414.0	(9.8)	30.0	(0.2)	17,584.4	(62.2)	22,356.0	(80.2)	35
Morone chrysops	White bass	0.4	(0.1)	0	(0)	820.3	(0.7)	0	(0)	2,331.3	(1.2)	3,152.0	(2.1)	4
Morone saxatilis	Striped bass	1,656.9	(14.7)	100.0	(<0.05)	236.5	(0.7)	13,734.4	(<0.05)	18,625.8	(38.3)	34,353.7	(53.7)	20
*Morone saxatilis***chrysops*	Hybrid striped bass	0	(0)	3,672.3	(0.7)	13,835.4	(6.6)	137.4	(0.8)	14,364.8	(17.2)	32,009.9	(25.3)	27
Pomoxis annularis	White crappie	0	(0)	0	(0)	127.3	(3.0)	1.1	(<0.05)	616.8	(11.6)	745.1	(14.6)	7
Pomoxis nigromaculatus	Black crappie	47.5	(0.1)	215.7	(2.0)	529.1	(5.5)	1.2	(0.1)	1,588.6	(4.3)	2,382.0	(11.9)	18
Pomoxis spp.	Crappie	0	(0)	0	(0)	0.2	(<0.05)	0	(0)	0	(0)	0.2	(<0.05)	1
Pylodictis olivaris	Flathead catfish	0	(0)	4.3	(<0.05)	0.4	(<0.05)	0	(0)	44.9	(0.3)	49.6	(0.3)	5
Total warmwater sport fish		**5,330.4**	**(41.0)**	**6,691.2**	**(113.6)**	**31,078.7**	**(240.5)**	**14,457.8**	**(10.9)**	**77,546.1**	**(606.4)**	**135,104.2**	**(1,012.5)**	
SALMON AND STEELHEAD														
Oncorhynchus gorbuscha	Pink salmon	0	(0)	1,820.3	(2.2)	0	(0)	0	(0)	0	(0)	1,820.3	(2.2)	1
Oncorhynchus keta	Chum salmon	966.2	(0.9)	36,741.4	(35.9)	0	(0)	0	(0)	0	(0)	37,707.5	(36.8)	1
Oncorhynchus kisutch	Coho salmon	3,528.2	(90.0)	33,597.8	(838.1)	1,794.0	(55.8)	250.0	(6.7)	0	(0)	39,170.1	(990.6)	9
Oncorhynchus mykiss (shd)	Steelhead	4,392.6	(369.7)	20,110.9	(1,666.1)	2,289.1	(122.9)	1,975.8	(73.9)	0	(0)	28,768.3	(2,232.7)	11
Oncorhynchus nerka(sockeye)	Sockeye salmon	0	(0)	12,862.8	(12.1)	0	(0)	0	(0)	0	(0)	12,862.8	(12.1)	2

Oncorhynchus tshawytscha	Chinook salmon	42,238.9	(388.8)	105,942.7	(1,606.7)	8,312.6	(61.3)	1,837.2	(8.1)	0	(0)	158,331.3	(2,064.9)	14
Salmo salar	Atlantic salmon	11,073.1	(75.1)	0	(0)	49.0	(4.9)	2,635.6	(5.2)	0	(0)	13,757.6	(85.2)	5
Total	**salmon and steelhead**	**62,198.9**	**(924.4)**	**211,075.8**	**(4,161.2)**	**12,444.6**	**(245.0)**	**6,698.6**	**(93.9)**	**0**	**(0)**	**292,417.9**	**(5,424.5)**	
RARE OR DECLINING														
Acipenser fulvescens	Lake sturgeon	52.9	(1.0)	0	(0)	65.6	(0.6)	4.6	(0.1)	19.4	(0.1)	142.4	(1.8)	5
Acipenser transmontanus	White sturgeon	0	(0)	1.9	(0.2)	0	(0)	0	(0)	0	(0)	1.9	(0.2)	1
Alosa mediocris	Hickory shad	0	(0)	0	(0)	0	(0)	6,115.7	(0.1)	0	(0)	6,115.7	(0.1)	1
Alosa aestivalis	Blueback herring	218.0	(<0.05)	0	(0)	0	(0)	0	(0)	0	(0)	218.0	(<0.05)	
Alosa pseudoharengus	Alewife	3.2	(<0.05)	0	(0)	0	(0)	4.3	(<0.05)	0	(0)	7.5	(<0.05)	1
Alosa sapidissima	American shad	4,792.2	(<0.05)	0	(0)	0	(0)	4,710.4	(<0.05)	2,329.8	(<0.05)	11,832.4	(<0.05)	3
Atractosteus spatula	Alligator gar	<0.05	(<0.05)	0	(0)	0	(0)	0	(0)	0	(0)	<0.05	(<0.05)	
Catostomus discobolus	Bluehead sucker	0	(0)	0.5	(0.1)	0	(0)	0	(0)	0	(0)	0.5	(0.1)	1
Catostomus latipinnis	Flannelmouth sucker	0	(0)	0.4	(0.1)	0	(0)	0	(0)	0	(0)	0.4	(0.1)	1
Catostomus plebeius	Rio Grande sucker	0	(0)	0.3	(<0.05)	0	(0)	0	(0)	0	(0)	0.3	(<0.05)	1
Chasmistes liorus	June sucker	0	(0)	25.0	(1.7)	0	(0)	0	(0)	0	(0)	25.0	(1.7)	1
Etheostoma cragini	Arkansas darter	0	(0)	1.1	(<0.05)	0	(0)	0	(0)	0	(0)	1.1	(<0.05)	1
Fundulus julisia	Barrens topminnow	4.1	(<0.05)	0	(0)	0	(0)	0	(0)	0	(0)	4.1	(<0.05)	1
Gila elegans	Bonytail	17.0	(3.9)	11.8	(1.1)	0	(0)	0	(0)	0	(0)	28.8	(5.0)	2
Gila nigrescens	Chihuaha chub	4.5	(0.1)	0	(0)	0	(0)	0	(0)	0	(0)	4.5	(0.1)	1
Gila pandora	Rio Grande chub	0	(0)	36.2	(0.1)	0	(0)	0	(0)	0	(0)	36.2	(0.1)	1
Gila robusta	Roundtail chub	0	(0)	15.8	(0.1)	0	(0)	0	(0)	0	(0)	15.8	(0.1)	1
Gila robusta jordani	Pahranagat roundtail chub	2.4	(0.1)	0	(0)	0	(0)	0	(0)	0	(0)	2.4	(0.1)	1
Hybognathus amarus	Rio Grande silvery minnow	93.2	(0.2)	0	(0)	0	(0)	0	(0)	0	(0)	93.2	(0.2)	1
Lampetra appendix	American brook lamprey	0	(0)	0	(0)	0	(0)	0.1	(<0.05)	0	(0)	0.1	(<0.05)	1
Moxostoma robustum	Robust redhorse	0	(0)	0	(0)	0	(0)	0	(0)	34.9	(0.1)	34.9	(0.1)	1
Notropis topeka	Topeka shiner	0	(0)	0	(0)	13.3	(<0.05)	0	(0)	0	(0)	13.3	(<0.05)	1
Oncorhynchus apache	Apache trout	156.5	(17.8)	112.0	(12.8)	0	(0)	0	(0)	0	(0)	268.5	(30.6)	1
Oncorhynchus clarki behnkei	Fine spotted cutthroat	0	(0)	846.3	(28.6)	0	(0)	0	(0)	0	(0)	846.3	(28.6)	3
Oncorhynchus clarki henshawi	Lahontan cutthroat	0	(0)	240.2	(0.2)	0	(0)	0	(0)	0	(0)	240.2	(0.2)	1
Oncorhynchus clarki lewisi	Westslope cutthroat	0	(0)	977.4	(12.5)	0	(0)	0	(0)	0	(0)	977.4	(12.5)	2
Oncorhynchus clarki pleuriticus	Colorado Riv. cutthroat	0	(0)	879.9	(3.0)	0	(0)	0	(0)	0	(0)	879.9	(3.0)	2
Oncorhynchus clarki stomias	Greenback cutthroat	0	(0)	689.9	(0.7)	0	(0)	0	(0)	0	(0)	689.9	(0.7)	1
Oncorhynchus clarki utah	Bonneville cutthroat	0	(0)	142.7	(5.3)	0	(0)	0	(0)	0	(0)	142.7	(5.3)	1
Oncorhynchus clarki virginalis	Rio Grande cutthroat	0	(0)	192.3	(1.5)	0	(0)	0	(0)	0	(0)	192.3	(1.5)	2
Oncorhynchus gilae	Gila trout	6.3	(0.3)	0	(0)	0	(0)	0	(0)	0	(0)	6.3	(0.3)	2
Petromyzon marinus	Sea lamprey	0	(0)	0	(0)	0	(0)	0.1	(<0.05)	0	(0)	0.1	(<0.05)	1
Phoxinus eos	Northern redbelly dace	0	(0)	0.5	(<0.05)	0	(0)	0	(0)	0	(0)	0.5	(<0.05)	1
Phoxinus erythrogaster	Southern redbelly dace	0	(0)	1.5	(<0.05)	0	(0)	0	(0)	0	(0)	1.5	(<0.05)	1
Plagopterus argentissimus	Woundfin	4.4	(<0.05)	0	(0)	0	(0)	0	(0)	0	(0)	4.4	(<0.05)	1
Polyodon spathula	Paddlefish	66.5	(6.8)	0	(0)	2.1	(<0.05)	2.4	(1.3)	54.6	(36.9)	125.6	(45.1)	8
Ptychocheilus lucius	Colorado pikeminnow	280.5	(0.3)	5.3	(0.2)	0	(0)	0	(0)	0	(0)	285.8	(0.5)	3
Scaphirhynchus albus	Pallid sturgeon	20.9	(0.6)	5.6	(0.5)	0	(0)	0	(0)	0	(0)	26.5	(1.1)	4
Scaphirhynchus platorynchus	Shovelnose sturgeon	0	(0)	72.5	(<0.05)	0	(0)	0	(0)	0	(0)	72.5	(<0.05)	1
Thymallus arcticus	Arctic grayling	0	(0)	269.6	(7.2)	0	(0)	0	(0)	0	(0)	269.6	(7.2)	3
Xyrauchen texanus	Razorback sucker	63.1	(9.7)	15.5	(2.4)	0	(0)	0	(0)	0	(0)	78.6	(12.1)	3
Total rare or declining		**5,785.6**	**(40.9)**	**4,544.1**	**(78.1)**	**81.0**	**(0.7)**	**10,837.7**	**(1.4)**	**2,438.7**	**(37.1)**	**23,687.1**	**(158.2)**	
FORAGE														
Catostomus commersonii	White sucker	0	(0)	0	(0)	1,601.6	(1.5)	0	(0)	0	(0)	1,601.6	(1.5)	1
Cyprinidae spp.	Minnows	0	(0)	0	(0)	0	(0)	0	(0)	159.8	(0.1)	159.8	(0.1)	1
Dorosoma cepedianum	Gizzard Shad	0	(0)	0.8	(0.3)	0.6	(0.1)	0	(0)	0	(0)	1.4	(0.3)	3
Dorosoma petenense	Threadfin shad	0	(0)	0	(0)	30.8	(<0.05)	0	(0)	0	(0)	30.8	(<0.05)	1
Erimyzon oblongus	Creek chubsucker	0	(0)	0	(0)	0	(0)	0	(0)	0.9	(0.1)	0.9	(0.1)	1
*Menidia beryllina*audens*	Mississippi inland silverside	0	(0)	0	(0)	0	(0)	0	(0)	15.6	(0.1)	15.6	(0.1)	1
Notemigonus crysoleucas	Golden shiner	0	(0)	0	(0)	1.6	(<0.05)	5.0	(0.1)	0	(0)	6.5	(0.1)	2
Pimephales promelas	Fathead minnow	0	(0)	1.0	(<0.05)	2,326.7	(195.9)	73.5	(0.1)	276.2	(0.2)	2,677.4	(196.3)	10
Total forage fish		**0**	**(0)**	**1.8**	**(0.3)**	**3,961.3**	**(197.6)**	**78.5**	**(0.1)**	**452.5**	**(0.5)**	**4,494.0**	**(198.5)**	
MARINE														
Sciaenops ocellatus	Red drum	334.8	(0.1)	0	(0)	0	(0)	0	(0)	0	(0)	334.8	(0.1)	1
Total marine		**334.8**	**(0.1)**	**0**	**(0)**	**0**	**(0)**	**0**	**(0)**	**0**	**(0)**	**334.8**	**(0.1)**	
OTHER														
Ctenopharyngodon idella	Grass carp	0	0)	0	(0)	58.3	(0.6)	0	(0)	8.9	(5.6)	67.3	(6.1)	7
Ctenopharyngodon idella (3)	Grass carp (3)	0	(0)	0.5	(0.1)	0.5	(0.2)	0	(0)	5.8	(13.0)	6.8	(13.2)	5
Total other		**0**	**(0)**	**0.5**	**(0.1)**	**58.9**	**(0.7)**	**0**	**(0)**	**14.7**	**(18.6)**	**74.1**	**(19.3)**	
GRAND TOTAL		**108,832.9**	**(2,126.1)**	**424,820.2**	**(10,804.8)**	**748,602.1**	**(2,107.4)**	**355,460.4**	**(2,315.6)**	**111,766.8**	**(2,684.0)**	**1,749,482.3**	**(20,037.8)**	

Table 2. Categories of fish stocked by the state and federal governments between 1931 and 2004 . The first number represents the reported number of fish in millions. The number in parentheses represents weight in thousands of kilograms. Data were not available for all states in all years. Where the data were not available it is marked by a dash. [1]Numbers in this row represent the available data. [2]Numbers in this row represent the total number and weight of fish stocked by the federal government and the 33 states for which data was available for all represented years. The percent stocked by the federal government was calculated using the numbers from the adjusted total for 33 states. Since it does not include all states, the percentage is higher than it would be if all states were included and should be viewed only as a trend indicator. See text for source information.

Category	1931	1936	1947	1958	1965	1973	2004
Coldwater sport fish	592.3 (-)	715.6 (688.0)	360.7 (2,937.4)	192.3 (5,657.6)	- (-)	579.0(11,728.8)	171.6 (12,931.1)
Coolwater sport fish	602.8 (-)	3,221.9 (85.5)	1,378.5 (65.7)	498.7 (81.2)	- (-)	93.1 (24.9)	1,121.8 (293.5)
Warmwater sport fish	504.9 (-)	316.4 (283.5)	112.7 (603.7)	125.6 (392.6)	- (-)	98.4 (531.9)	135.1 (1,012.5)
Salmon and steelhead	265.2 (-)	79.5 (190.3)	115.0 (282.1)	172.5 (750.4)	- (-)	167.8 (1,227.7)	292.4 (5,424.5)
Forage	8.8 (-)	3.0 (9.0)	29.3 (285.1)	4.6 (6.7)	- (-)	2.2 (5.8)	4.5 (198.5)
Rare or declining	2.0 (-)	16.5 (33.8)	5.2 (3.2)	1.4 (0.7)	- (-)	0.9 (50.0)	23.7 (158.2)
Marine or anadromous	12,296.3 (-)	7,016.2 (153.1)	1,157.2 (26.6)	3.5 (0.3)	- (-)	0 (0)	0.3 (0.1)
Other	318.1 (-)	67.2 (14.6)	6.3 (92.6)	0.7 (1)	- (-)	0.8 (13.3)	0.1 (19.3)
Total[1]	**14,590.4 (-)**	**11,436.5 (1,457.8)**	**3,164.9 (4,296.4)**	**999.3 (6,892.7)**	**1,724.4(10,161.4)**	**942.1(13,582.4)**	**1,749.5 (20,037.8)**
Adjusted Total[2]	**10,638.8 (-)**	**11,428.2 (1,451.4)**	**3,090.5 (3,851.6)**	**953.4 (6,324.1)**	**1,644.7 (9,319.4)**	**898.2(12,325.8)**	**1,521.5 (15,277.3)**
% Stocked by federal government	**66.9 (-)**	**71.5 (39.0)**	**42.5 (12.5)**	**18.7 (14.2)**	**14.9 (21.4)**	**40.2 (26.1)**	**7.6 (15.2)**

Figure 1. Total number (x 10^9) and weight (kgs x 10^6) of fish stocked by the state and federal governments. The circles represent the number (gray) and estimated weight (black) of fish stocked by the federal government and the 33 states for which data was available in all the represented years. The diamonds represent the total number (gray) and estimated total weight (black) of fish stocked by the federal government and all 50 state governments in the United States in 2004.

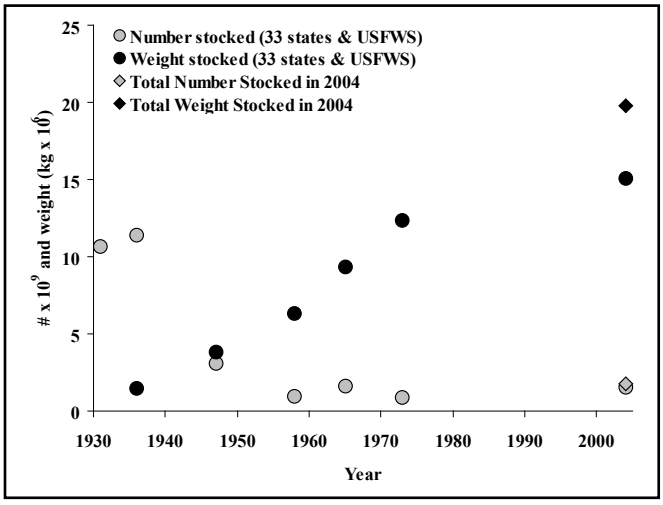
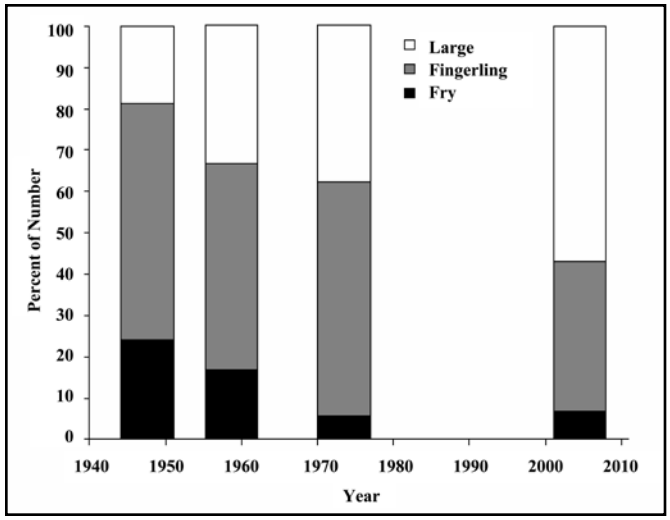


Figure 2. Estimated percent of the number of rainbow trout (*Oncorhynchus mykiss*) stocked as fry (< 2.5 cm), fingerlings (2.5 to 15.2 cm), and large (> 15.2 cm) fish between 1947 and 2004 by the state and federal governments.

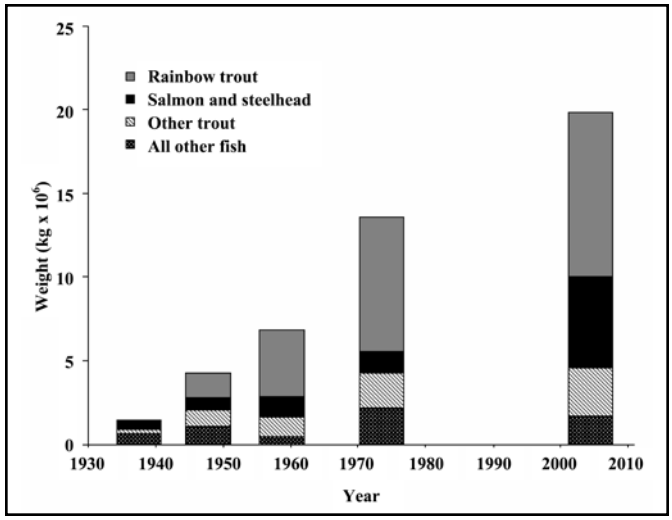


those exhibited by the government agencies as a whole. About 96% by weight of the fish stocked by the federal government in 2004 were salmonids and more than 40% by weight of the fish stocked by the federal government were rainbow trout (Table 1).

Geographically, distinct patterns emerged. By weight, about 60% of the fish stocked by state and federal agencies were in the Western Division states. These included about 65% of the total salmonids stocked and about 60% of the rainbow trout. Carps and minnows (cyprinidae), perches, and pikes (esocidae) were primarily stocked in the North Central Division states and catfishes (ictaluridae), sunfishes (centrarchidae) and temperate basses (moronidae) were primarily stocked in the Southern Division states. The most widely stocked fish was rainbow trout, which was stocked in every state except Alabama, Florida, Louisiana, Mississippi, and South Carolina.

In summary, although fisheries managers have gone to great pains in recent decades to emphasize the idea that fish stocking is a tool, not a panacea, the fact remains that it is still one of the largest and most important activities in which fisheries managers engage (Heidinger 1993). It should, and most likely will, continue to be the subject of debate, not just within the fisheries management community, but also in the halls of Congress, aca-

Figure 3. Total estimated weight (kg x 10^6) of selected varieties of fish stocked between 1937 and 2004 by the state and federal governments.



demia, and among interested citizens and private organizations. Hopefully, this article will help make these debates fruitful and constructive while at the same time emphasizing the need for fisheries management agencies to make their stocking data—both numbers and sizes—standardized and publicly accessible. ♋

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