

Within the United States alone, humans have intentionally or unintentionally introduced more than 4,500 species of terrestrial and aquatic species to areas outside their historical range (U.S. Congress 1993). Although many terrestrial introductions are viewed as beneficial to humans because of economic and social considerations, all but a few intentional aquatic introductions have proven to be mixed blessings (Courtenay and Williams 1992; Steirer 1992; U.S. Congress 1993). No unintentional aquatic introductions have been considered beneficial (Steirer 1992); instead, their environmental consequences are generally harmful and sometimes catastrophic (Taylor et al. 1984; U.S. Congress 1993).

Both intentional and unintentional introductions have enabled nonindigenous fish to become temporary, and often permanent, residents in nearly every U.S. aquatic system. Complete eradication or exclusion is neither economically plausible nor socially justified (U.S. Congress 1993); therefore, nonindigenous fish are and will continue to be components of these aquatic systems. Because nonindigenous fish have the potential to alter significantly the U.S. aquatic ecosystems during the next century and beyond, their interactions within the aquatic community must be monitored and analyzed to ensure that effective management actions are taken before a crisis arises.

To help document the consequences of nonindigenous fish introductions, the National Biological Service monitors the status and distribution of these organisms in U.S. waters (Williams and Jennings 1991). Since 1978, reports and specimens of various nonindigenous fish have been collected, verified, and entered in a geographic information system, which is a computerized mapping and data base system.

Obtaining qualitative and quantitative information on nonindigenous fish for a national assessment requires cooperation by many agencies, organizations, and individuals (Boydston and Benson 1992). We collect much of our ecological and geographical data using a voluntary reporting form. Historical accounts are gathered through review of both scientific and other literature, including natural resource agency publications that often provide accounts of nonindigenous fish, stockings, and discoveries. For our purposes, we established a historic cut-off date for usable nonindigenous fish reports at 1800.

We limited this analysis to only reports of nonindigenous fish from open waters identifiable to species level and recognizable nonindigenous hybrids.

Status of Nonindigenous Fish

We have collected more than 11,000 reports that document 404 unique fish species or hybrids introduced outside their native ranges within U.S. waters. This diverse group of 67 families of fish includes species from every continent except Antarctica. Of the 404 species, 252 (62%) are native to the United States but found outside their native ranges, and 152 (38%) are from other countries. Nonindigenous hybrid fish represent roughly 5% (19) of the total 404 nonindigenous fish species.

Our total is considerably higher than the 127 nonindigenous fish (70 U.S. and 57 non-U.S.) reported in the United States in 1992 by the Office of Technology Assessment (U.S. Congress 1993). Courtenay and Williams (1992) reported 99 exotic (non-U.S.) nonindigenous fish species in the contiguous U.S. waters in 1992, of which 46 were established as sustaining populations. The disparity between our

Nonindigenous Fish

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results and these estimates is most influenced by our intent to include all reported nonindigenous fish that have been found within the United States since 1800, regardless of their current status.

Game and associated forage fish are the most widely distributed nonindigenous fish. These include the salmonids (salmon and trout), ictalurids (catfish), centrarchids (bass and sunfish), percids (walleye and sauger), and cyprinids (minnows). The two most widely distributed nonindigenous fish species are goldfish (*Carassius auratus*) and common carp (*Cyprinus carpio*). Both have been reported or collected from all states except Alaska (Table). Goldfish introductions are the result of the release of bait and aquarium fish and forage fish stocking for game fish. Widespread distribution of common carp is primarily due to the stocking program of the U.S. Fish Commission in the late 1800's and early 1900's and later use of juvenile carp as bait.

Reported Occurrences

All 50 states have reported nonindigenous fish from their open waters (Fig. 1). When considering total diversity of nonindigenous fish species, the top five states are California (114), Texas (96), Florida (96), North Carolina (83), and Nevada (82). In fact, of the total 404 species, 312 (77%) are reported as occurring or having been found within the 11 states crossing or below the 35th parallel (e.g., Hawaii, California, Arizona, New Mexico, Texas, Oklahoma, Arkansas, Louisiana, Alabama, Georgia, and Florida). Although Hawaii was historically without any native freshwater fish, it now has 52 nonindigenous freshwater fish species.

Table. Nonindigenous fish introduced into 10 or more states, 1800-1994.

Common name (scientific name)	No. of states reported outside native range
Goldfish (<i>Carassius auratus</i>)	49
Common carp (<i>Cyprinus carpio</i>)	49
Brown trout (<i>Salmo trutta</i>)	47
Rainbow trout (<i>Oncorhynchus mykiss</i>)	47
Grass carp (<i>Ctenopharyngodon idella</i>)	44
Largemouth bass (<i>Micropterus salmoides</i>)	41
Walleye (<i>Stizostedion vitreum</i>)	40
Smallmouth bass (<i>Micropterus dolomieu</i>)	38
Brook trout (<i>Salvelinus fontinalis</i>)	36
White crappie (<i>Pomoxis annularis</i>)	36
Bluegill (<i>Lepomis macrochirus</i>)	33
Northern pike (<i>Esox lucius</i>)	33
Striped bass (<i>Morone saxatilis</i>)	32
Green sunfish (<i>Lepomis cyanellus</i>)	31
Black crappie (<i>Pomoxis nigromaculatus</i>)	31
Yellow perch (<i>Perca flavescens</i>)	29
Channel catfish (<i>Ictalurus punctatus</i>)	29
Coho salmon (<i>Oncorhynchus kisutch</i>)	28
Rock bass (<i>Ambloplites rupestris</i>)	26
Lake trout (<i>Salvelinus namaycush</i>)	26
Threadfin shad (<i>Dorosoma petenense</i>)	26
Western mosquitofish (<i>Gambusia affinis</i>)	25
Fathead minnow (<i>Pimephales promelas</i>)	24
Rainbow smelt (<i>Osmerus mordax</i>)	23
Chinook salmon (<i>Oncorhynchus tshawytscha</i>)	22
White bass (<i>Morone chrysops</i>)	22
Atlantic salmon (<i>Salmo salar</i>)	22
Golden shiner (<i>Notemigonus crysoleucas</i>)	21
Redear sunfish (<i>Lepomis microlophus</i>)	20
Muskellunge (<i>Esox masquinongy</i>)	20
Sockeye salmon (<i>Oncorhynchus nerka</i>)	19
Pumpkinseed (<i>Lepomis gibbosus</i>)	19
Blue catfish (<i>Ictalurus furcatus</i>)	19
Alewife (<i>Alosa pseudoharengus</i>)	18
Tench (<i>Tinca tinca</i>)	18
Rudd (<i>Scardinius erythrophthalmus</i>)	18
American shad (<i>Alosa sapidissima</i>)	17
Brown bullhead (<i>Ameiurus nebulosus</i>)	15
Chain pickerel (<i>Esox niger</i>)	15
Flathead catfish (<i>Pylodictis olivaris</i>)	15
Black bullhead (<i>Ameiurus melas</i>)	15
Spotted bass (<i>Micropterus punctulatus</i>)	15
Warmouth (<i>Lepomis gulosus</i>)	15
Lake whitefish (<i>Coregonus clupeaformis</i>)	14
Cutthroat trout (<i>Oncorhynchus clarki</i>)	14
White catfish (<i>Ameiurus catus</i>)	14
Bighead carp (<i>Aristichthys nobilis</i>)	13
Arctic grayling (<i>Thymallus arcticus</i>)	13
Mozambique tilapia (<i>Tilapia mossambica</i>)	13
Redbreast sunfish (<i>Lepomis auritus</i>)	13
Guppy (<i>Poecilia reticulata</i>)	12
Piranha (<i>Serrasalmus</i> spp.)	12
Blue tilapia (<i>Tilapia aurea</i>)	12
Tiger muskellunge (<i>Esox lucius</i> x <i>masquinongy</i>)	12
Golden trout (<i>Oncorhynchus aguabonita</i>)	11
White perch (<i>Morone americana</i>)	10
Green swordtail (<i>Xiphophorus helleri</i>)	10
Sauger (<i>Stizostedion canadense</i>)	10
Redbelly tilapia (<i>Tilapia zilli</i>)	10

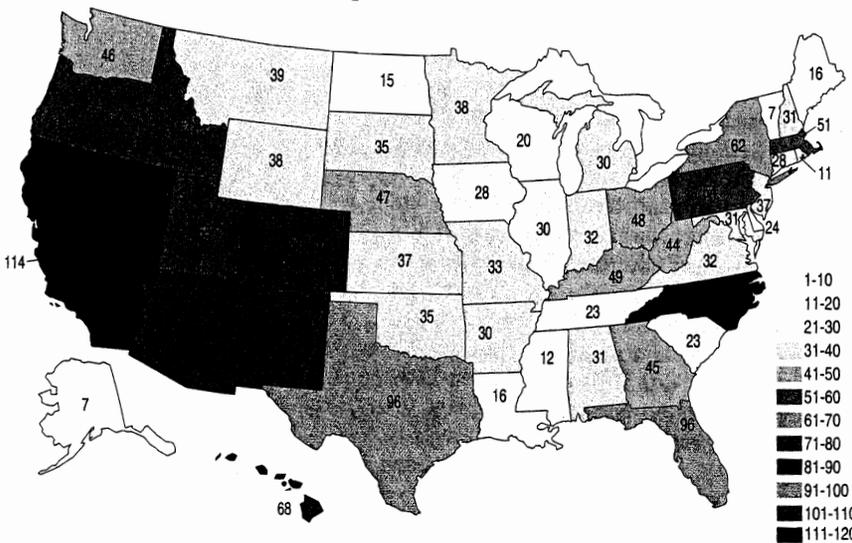


Fig 1. The number of nonindigenous fish species reported by state, 1800-1994. Some species may not be established or have been eradicated.

Trends

The first fish translocation effort began in the early 1870's with an attempt to introduce several eastern species to the west coast and to stock chinook salmon in the East. Fish that were introduced to the West included eels, brook and lake trout, lake whitefish, northern pike, striped

bass, American shad, yellow perch, catfish, bullheads, sunfish, black bass, and crappies. Most of these introductions resulted in established populations that still persist today. At this same time brown trout, tench, and carp were being stocked throughout the country. A resurgence of stocking occurred around 1950 when many state agencies began stocking game fish. The popularity of home aquaria and the availability of foreign fish have also contributed to an increase in the number of species introduced in the past 40 years (Courtenay and Williams 1992; Fig. 2).

The Future

The presence of nonindigenous fish will continue to alter U.S. aquatic resources. These species compete with or prey on native game and nongame fish, often with severe negative effects on aquatic ecosystems. Nonindigenous fish that survive the initial introduction and subsequently become established are often tolerant of adverse or altered environmental conditions, including habitat disturbance. This tolerance has been used to justify nonindigenous fish introductions rather than to restore disrupted environments. The environmental tolerance of nonindigenous fish combined with increasing habitat disruption in streams and lakes assures their continued dispersal into formerly unoccupied areas. If the introduction and establishment

of nonindigenous fish continue at their present rates, distribution and survival of native aquatic organisms could be drastically affected. These introductions can also profoundly change biological diversity and composition of habitats and ecosystems, which could result in substantially increased rates of extinction of native aquatic species.

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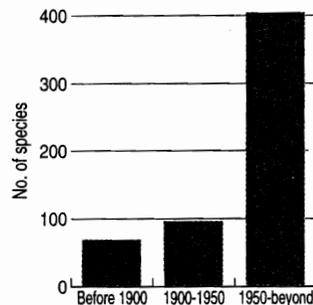


Fig. 2. Diversity of fish introductions over time.

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