Under water and out of sight:
Invasive fishes in the United States
Implications for national parks

By Walter R. Courtenay, Jr., and Pam L. Fuller

The National Park Service (NPS) has been concerned with introductions of nonnative (foreign and domestic transplants) species in park areas since 1933 (Dennis 1980). Such introductions were recognized then as potential threats to maintaining areas under NPS jurisdiction as undisturbed as possible. Most activities since then to remove, reduce, or control introduced species in the National Park System have targeted terrestrial species, with only limited focus on aquatic organisms.

Shortly after Yellowstone was established as the first national park in 1872, the U.S. fish commissioner assigned an ichthyologist to assess it for native fishes and advise what nonnative fishes should be introduced for angling purposes (Jordan 1891). For many decades thereafter, NPS policy was to stock nonnative fishes in many national park units for sport fishing. The policy was challenged in the 1940s (Hubbs 1940, Hubbs and Wallis 1948, Hubbs and Lagler 1949) and later (Miller 1963) when sport fishes were recognized as a threat to native fishes in the national parks. What was unimagined then was that nonnative fishes introduced outside park boundaries would invade shared waters as new introduction pathways evolved. For example, visitors to Everglades National Park, Florida, taking time to look into water at Anhinga Trail now see more fishes from Africa, Central and South America, and Asia than native fishes.

In 1989 Courtenay reported at least 20 species of exotic (foreign) fishes known or reported to be established as reproducing populations in waters within or bordering units of the National Park System. That number did not include fishes native to the United States that had been transplanted and became established beyond their native ranges of distribution. Had U.S. transplants been included, the total number of nonnative fishes within or near the national parks would have been vastly higher. The National Park Service maintains a database of nonnative fishes in natural resource parks based on voluntary park input that presently includes 118 species of which 33 are exotics (James T. Tilmant, personal communication, 2003). The data suggest the probability that no national parks are without introduced fishes (fig. 1)

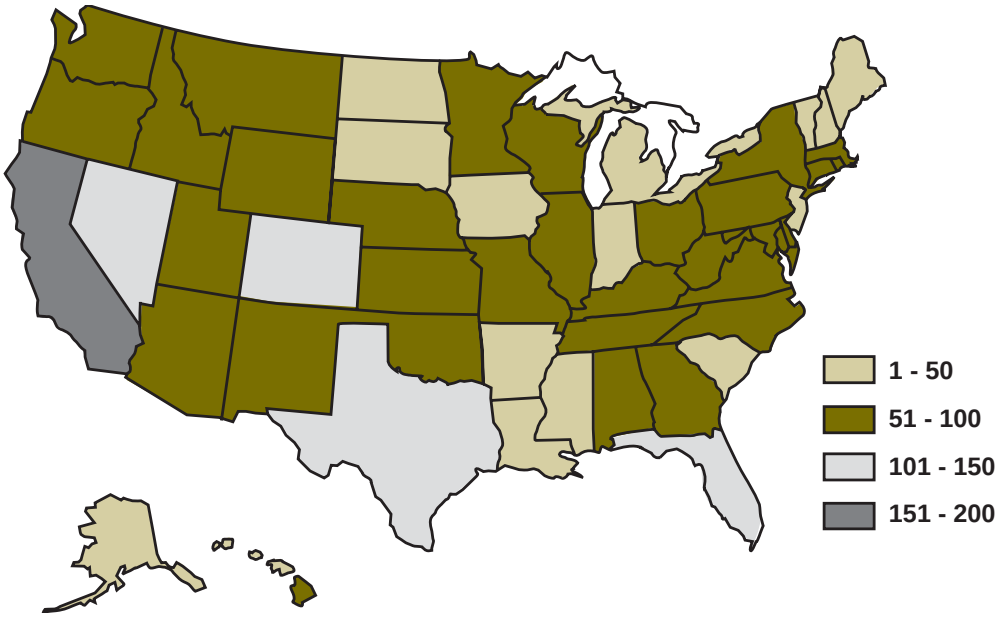

Figure 1. Number of fish taxa introduced by state, including both established and non-established populations. USGS NONINDIGENOUS AQUATIC SPECIES DATABASE, 2004

Fuller et al. (1999) reported nonnative fishes as having been introduced to all 50 states, with 536 taxa found beyond their native ranges (fig. 2). Although many failed to become established, those fishes came from all continents, including North America, except Antarctica.

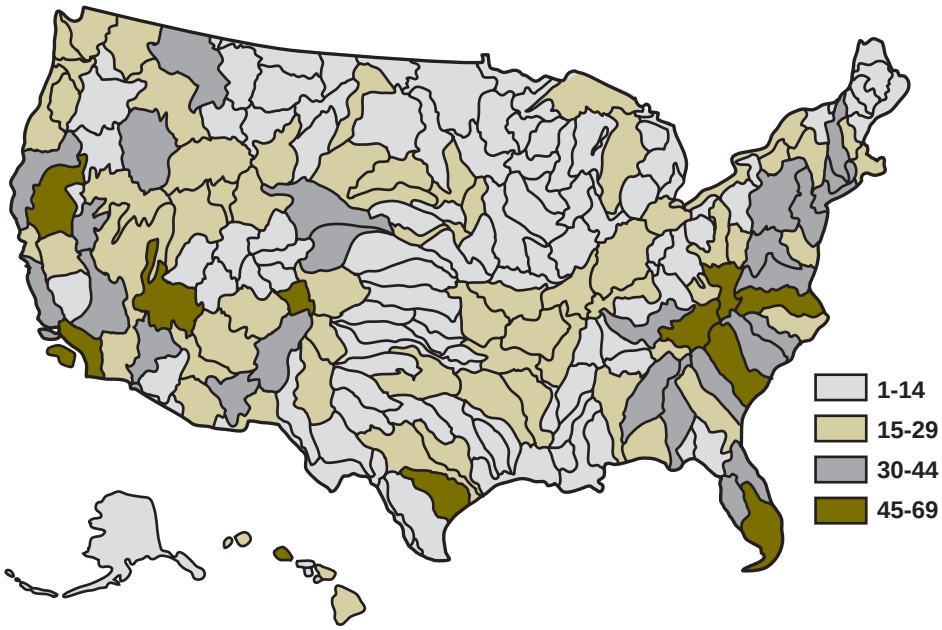

Figure 2. Approximate number of exotic and transplanted native fish taxa by drainages (USGS 4-digit hydrologic unit code). Includes established and non-established introductions. AFTER FULLER ET AL. 1999.

Pathways of introductions

Fishes are moved to ecosystems and habitats novel to them via a variety of pathways (fig. 3). These include authorized introductions for sport fishing, forage enhancement for sport fishes, or for biological control. Unauthorized intentional introductions have also occurred for sport fishing and through the release of bait fishes by anglers, unwanted "pet" fishes by aquarists, and, in a few instances, research fishes by scientific or maintenance personnel. Some introductions may have been made in hopes of establishing new food resources for people. In recent years, live food fishes from abroad, usually Asia, have been imported for sale in fish markets. These live food fishes are often sold at or near sexual maturity, and some have been released for unknown reasons into natural waters.

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Unintentional introductions have occurred through escapes from food-fish aquaculture facilities and aquarium fish farms, stock contamination and ballast water discharges from ships. Canals connecting separate drainage basins also facilitate introductions of fishes. For example, construction of the Welland Canal in the late 1800s and subsequent modifications of its design in the early 1900s allowed the predaceous sea lamprey *(Petromyzon marinus)* access into the upper Great Lakes from Lake Ontario. This resulted in devastation of native lake trout *(Salvelinus namaycush)* in waters including Lake Superior where Isle Royale National Park is located.

Of the pathways mentioned, the largest number of introductions that have resulted in established, reproducing populations, many of which became invasive, are sport-fishing related (Fuller et al., 1999). Establishment resulted from deliberate stocking of angling species, providing forage fishes to enhance survival of those species, and releases of bait fishes. Fishes stocked for sport angling are always predators, for example, trout. Rainbow trout *(Oncorhynchus mykiss)*, native to extreme western Canada and the northwestern United States west of the Cascade Range, have been established in Great Smoky Mountains National Park for more than a century; brook trout *(Salvelinus fontinalis)*, native to north-central, northeastern, and southeastern states, occur in several western units of the National Park System, results of intentional introductions of sport species. In Great

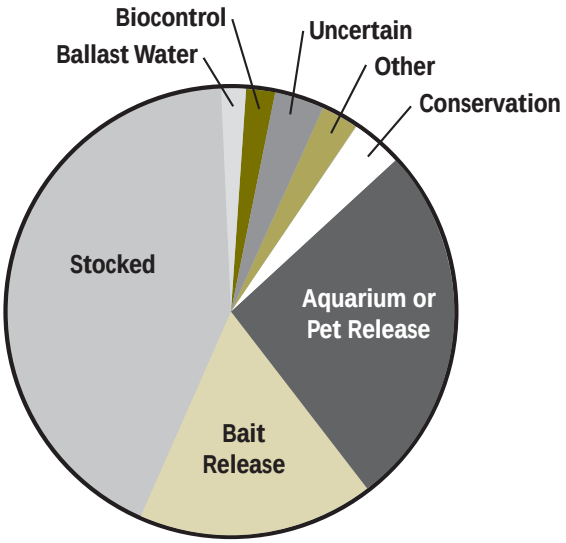

Figure 3. Methods of introduction for fishes nationwide. AFTER FULLER ET AL. 1999.

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Smoky Mountains National Park, rainbow trout have caused substantial declines of native brook trout. In addition, brown trout *(Salmo trutta)*, native to northern Eurasia and north Africa, occur in many national park areas and compete with native trouts. Lake trout, native to northern Canada, Alaska, New England states, and the Great Lakes basin, recently introduced illegally in Yellowstone National Park for sport, have become established in Yellowstone Lake, threatening native Yellowstone cutthroat trout *(Oncorhynchus clarki bouvieri)*. The lake trout has been present for several decades in Flathead Lake, Montana, and has spread into several of the large glacial lakes along the western side of adjacent Glacier National Park. Where lake trout have become established in these lakes they have virtually eliminated native cutthroat and bull trout *(Salvelinus confluentus)*. They have also replaced native cutthroat trout in deep lakes of the Rocky Mountains including Grand Lake, which borders the western edge of Rocky Mountain National Park, Colorado.

Reasons for concern

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Just because introduced species are under water and out of sight does not mean they are not causing problems! Introduced fishes present a spectrum of ways in which ecosystems and habitats may be altered. Direct predation, especially on invertebrates, is one way, particularly where native fishes are few in number and especially in waters historically devoid of native predators. Competition for food, space (particularly spawning areas), and different behavioral patterns can also negatively impact native fish faunas. Food webs can be altered, affecting not only fishes but also invertebrates and plants upon which fishes depend. (See the article on pages 68–70 about impacts of nonnative fishes on two salamander species in Mount Rainier and North Cascades National Parks.) Additionally, transplanted species are likely to hybridize with related native fishes, causing pollution of native fish gene pools, which in turn results in the demise of endemic native species. And introduced species carrying parasites or diseases are always a threat because they could negatively affect native fishes, at worst drastically rearranging species composition.

The degree to which native fishes and habitats are impacted depends on which species are introduced and the native biodiversity of the affected ecosystem. Although some people believe that introductions increase biodiversity, the increase is artificial. Moreover, "good" or "bad" aspects of introductions are subjective. Those who profit financially from introductions or see introductions as enhancing aquatic habitats view the world differently from conservation biologists who believe better management and restoration of disturbed habitats is the wise and safe approach.

Who regulates introductions?

Fish introductions are generally regulated by state agencies; however, the National Park Service regulates introductions in the National Park System. The federal government has no authority regarding introductions except on federal lands, but it does have authority over importation into the United States and interstate transportation. That authority exists under the Lacey Act of 1900 and its subsequent amendments.

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For example, transportation of a species into states that prohibit possession of live individuals of that species is a violation of the Lacey Act. The act also contains an "injurious wildlife" provision under which the U.S. Fish and Wildlife Service, after proposing to list species as injurious followed by a period of public review and commentary, can prohibit importation and interstate transport of listed species. The only fishes listed to date as injurious under the act are salmonids (salmons and trouts) and their eggs (to prevent potential introduction of salmonid diseases), walking catfishes (Family Clariidae), and, most recently, snakehead fishes (Family Channidae). Black carp *(Mylopharyngodon piceus)* is under review, and silver carp *(Hypophthalmichthys molitrix)* and bighead carp *(H. nobilis)* may be added for listing.

Virtually all states prohibit introduction or release of nonnative fishes without a permit. The state permitting agencies, however, always retains the right to make introductions without seeking permission from any federal authority and without peer review by other states. Traditionally most state game and fish agencies also have had authority to control what fishes are imported into a state. In an effort to prevent unwanted species introductions, many states have developed lists of fishes that are prohibited from importation to state waters. However, these lists often differ between states. Thus, permissible importation and release of a species into state waters

presents the potential for that species to spread via interconnected drainage basins into a neighboring state that prohibits the same species. Moreover, commercial aquaculture has recently sought exemption from state game and fish agency regulations by having aquaculture placed under jurisdiction of state agriculture departments. This trend avoids regulation of importation or introductions by agencies that historically have had this authority and a legal commitment to conserve state natural resources.

The "bottom line" for the National Park Service

In many national parks fishes are being monitored and managers are developing policies for the control of unwanted species to the extent that their budgets allow. Unless park managers aggressively work to prevent introductions of new exotics, park areas will continue to receive introductions. Some of the unwanted species will become invasive, while others will fail or become only temporary park residents. That is the "*bad news*."

The "*good news*" is that since 1968, National Park Service policy has been to disallow fish stocking in the national parks and to prohibit introductions of nonnative fishes. Additionally, the National Park Service is actively removing nonnative fishes in several park units and, in some areas, introductions of native species are being used to reestablish natives that have declined (James T. Tilmant, personal communication, 2003). For example, Yellowstone National Park conducts a gill-netting operation on Yellowstone Lake in an effort to control nonnative lake trout (see page 23). At Great Smoky Mountains National Park, volunteers and part staff have removed nonnative rainbow trout. In Great Basin National Park, resource managers have been working to expand the range of native Bonneville cutthroat trout *(Oncorhynchus clarki utah)* in the park. Similar projects are being planned or are under way in other park units.

In addition to these efforts, the National Park Service is better equipped than any federal agency to educate the public as to the dangers of introductions of nonnative species, terrestrial or aquatic. Many personnel have the educational background, experience, and training to point out not only the many wonderful, natural features of the national parks, but also that introduced species have potential to cause dramatic changes to those and other systems. Park visitors, including those from other nations, commonly take advantage of the educational programs of the National Park Service to learn about what they assume to be "natural places." The opportunity for the Park Service to warn them about the consequences of introductions should not be missed.

Acknowledgments

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