# Changing Philosophies of Fisheries Management as Illustrated by the History of Fishing Regulations in Wyoming

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Inland fisheries management began in the United States in the 1800s with a focus on fish as food and the use of stocking to create new fisheries and replenish depleted stocks. In the early 20th century, recreational fishing came to the forefront and regulations limiting the number and size of fish that could be harvested were enacted. Major trends in the regulation of recreational fisheries included a reduction in creel limits, more complexity in the application of regulations, increasingly restrictive use of baitfish, and limitations on competitive fishing tournaments. In the latter part of the 20th century, fisheries managers embraced a broader perspective that included conservation of native species and control of invasive species. These changes in regulations reflect the evolution of fisheries management philosophy along pathways emphasizing fishing for sustenance, fishing for recreation, and, most recently, biodiversity management. This evolution is illustrated by the history of angling regulations in Wyoming.

## Cambio en la filosofía del manejo de pesquerías ilustrado por la historia de las regulaciones pesqueras en Wyoming

Las pesquerías continentales en los EE.UU. iniciaron en el siglo XIX y consideraban a los peces como fuente de alimento y, por medio de la estabulación, servían para crear nuevas pesquerías y para recuperar poblaciones agotadas. A inicios del siglo XX, apareció la pesca recreativa y entraron en vigor las regulaciones que limitaban el número y tamaño de los peces capturados. Las principales tendencias en cuanto a la regulación de las pesquerías recreativas incluyeron límites a las cantidades de especies capturadas, mayor complejidad en la aplicación de regulaciones, uso cada vez más restrictivo de carnadas y mayores limitaciones en los torneos de pesca. Hacia finales del siglo XX, los administradores pesqueros adoptaron una visión más integral que incluyó la conservación de especies nativas y el control de especies invasoras. Estos cambios en las regulaciones se reflejaron en la evolución de la filosofía del manejo, haciendo énfasis en la pesca de subsistencia, pesca recreativa y, más recientemente, en el manejo de la biodiversidad. Esta evolución es ilustrada por la historia de las regulaciones a la pesca con caña en Wyoming, EE.UU.

## L'évolution des Philosophies de Gestion de la Pêche comme l'Illustre l'Histoire des Réglementations de pêche dans le Wyoming

La gestion de la pêche dans les eaux intérieures a commencé aux États-Unis dans les années 1800, avec un accent sur le poisson en tant que nourriture et l'utilisation des réserves afin de créer de nouvelles ressources halieutiques et renouveler les stocks diminués. Au début du 20ème siècle, la pêche de loisir s'est hissée au premier plan et des réglementations ont été adoptées limitant le nombre et la taille du poisson qui pouvait être récolté. Les tendances majeures de la réglementation concernant la pêche de loisir incluaient la réduction des limites, plus de complexité dans l'application des réglementations, de plus en plus de restrictions quant à l'utilisation du poisson-appât, et des limitations concernant les compétitions de pêche sportive. Vers la fin du 20ème siècle, les responsables de la pêche ont adopté une vision plus large comprenant la conservation des espèces indigènes et le contrôle des espèces invasives. Ces modifications des réglementations reflètent l'évolution des philosophies de gestion de la pêche en suivant les courants qui ont mis l'accent sur la pêche comme nourriture, la pêche comme loisir et, plus récemment, la gestion de la biodiversité. Cette évolution est illustrée par l'histoire des réglementations de la pêche à la ligne dans le Wyoming, États-Unis d'Amérique.

## INTRODUCTION

Regulations are a major aspect of inland fisheries management in the United States. Purchasers of recreational fishing licenses often receive a detailed booklet outlining when and where angling is allowed, which species can be pursued, and how many and what size fish can be harvested. The types and complexity of fishing regulations have changed greatly since the first restrictions on fish harvest in the early 1900s. These changes in regulations reflect the evolution in management philosophy along three main lines: fishing for sustenance, fishing for recreation, and management of biodiversity (i.e., conservation of native species and control of invasive species; Figure 1). Although the time course and relative importance of regulatory changes may differ among states, they represent a common set of responses to challenges facing managers of inland recreational fisheries.

I use the history of fishing regulations in Wyoming to illustrate the evolution of fisheries management philosophies in the United States. Regulations in Wyoming from 1869 through 1938 were obtained from a database of Wyoming statutes (HeinOnline 2014) and from Wiley (1993). From 1939 through 2015, fishing regulations were published in brochures available from the Wyoming Game and Fish Department (WGFD; Cheyenne, Wyoming).

## SUSTENANCE FISHING

Fisheries management in the United States began in the late 1800s with a focus on the use of fish for sustenance. Federal and state fisheries agencies were established with the aim of introducing species to create new fisheries or replenishing exploited wild stocks with hatchery fish. On June 10, 1872, the U.S. Congress passed a bill authorizing the U.S. Fish Commission, the forerunner of the U.S. Fish and Wildlife Service, to commence fish culture and stocking (Moffitt et al. 2010). Stocking by private individuals also became common. For example, by the 1870s, members of the California Ornithological and Piscatorial Acclimatizing Society were already at work introducing eastern Brook Trout *Salvelinus*

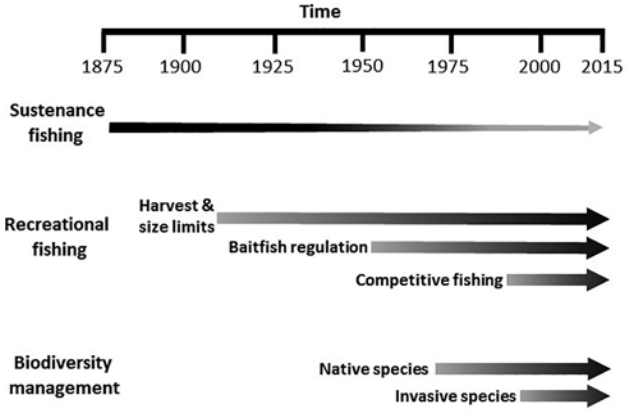


Figure 1. Fisheries management in the United States has evolved along pathways emphasizing sustenance fishing, recreational fishing, and biodiversity management.

*fontinalis* into California waters (Halverson 2010). An 1879 article in the Laramie newspaper noted the efforts of anglers who caught trout in Colorado and, in violation of Colorado game laws, surreptitiously transported them into Wyoming for release into the Laramie River, which had no native trout species. Even noted ichthyologist David Starr Jordan recommended stocking nonnative catfishes into tributaries of the lower Colorado River because "the whole great basin of the Colorado contains, excepting the trout, no fish of even second-rate character as food for man" (D. S. Jordan 1889:6).

Because of unregulated harvest and habitat destruction, many fish populations were considered to be in deplorable condition by the late 19th century. Barkwell (1883:6) noted that many Wyoming streams were nearly exhausted of a once bountiful supply of food fish and included among the causes "barbarous methods of taking fish such as the use of giant powder and poisonous drugs." Market hunting—that is, harvesting large numbers of animals to be sold for profit—further contributed to the decimation of wildlife and fish populations (Blair 1987). Regulations were soon enacted to stop the wasteful overexploitation of fish while still allowing for sustenance harvest. In Wyoming, the first law pertaining to fishing was passed by the Territorial Legislature in 1869 and stated that hook and line was the only legal means by which fish could be harvested, thus outlawing the use of dynamite and poisons that allowed large numbers of fish to be harvested at once (Glafcke 1876:363). In 1875, a second law stated that only wildlife and fish in the amount "necessary for human subsistence governed in amount and quantity by the reasonable necessities of the person" could be harvested (Glafcke 1876:362). This law was difficult to enforce and market hunting was more directly targeted by an 1899 law that made the sale of game fish illegal in Wyoming (Van Orsdel and Chatterton 1899). During the late 1800s, other laws mandated fishways at dams, required screening of irrigation ditches, and prohibited sawdust or mining waste from being discharged into waterways. Similar laws were passed throughout North America during this period (Moffitt et al. 2010).

## RECREATIONAL FISHING

### Harvest and Size Limits

It became increasingly apparent by the late 1800s that stocking alone could not compensate for the continuing decline in fish populations. Although legislation had outlawed the use of dynamite, nets, and poisons to catch fish, overharvest from hook-and-line fishing remained a problem in Wyoming and elsewhere (Figure 2). Michigan's first superintendent of fisheries described a similar situation due to the lack of harvest regulations (Jerome 1875, cited in Clark et al. 1981):

> *That waters once abounding with fish can become barren by excessive, or ill-timed, or barbarous fishing, or all together, is too obviously, painfully true. ... Laws, too, prescribing closure times and regulating the utensils and methods of capture, whether by seine or weir, or spear or hook, grow out of the very necessities of the case. ... It is absence or nonobservance of these laws that has depleted many a stream and river, pond and lake, of all their finny wealth and beauty.*

To stem the depletion of fish populations, states began enacting regulations in the early 20th century to limit the harvest of game fish. In Wyoming, the first daily creel limit was established in 1899 at 20 pounds of game fish (generally understood to refer to trout). This remained in effect until 1931 when a limit of 15 pounds or 30 game fish was established (Table 1). The limit was further reduced to 15 pounds or 20 game fish in 1937. In Michigan, the first creel

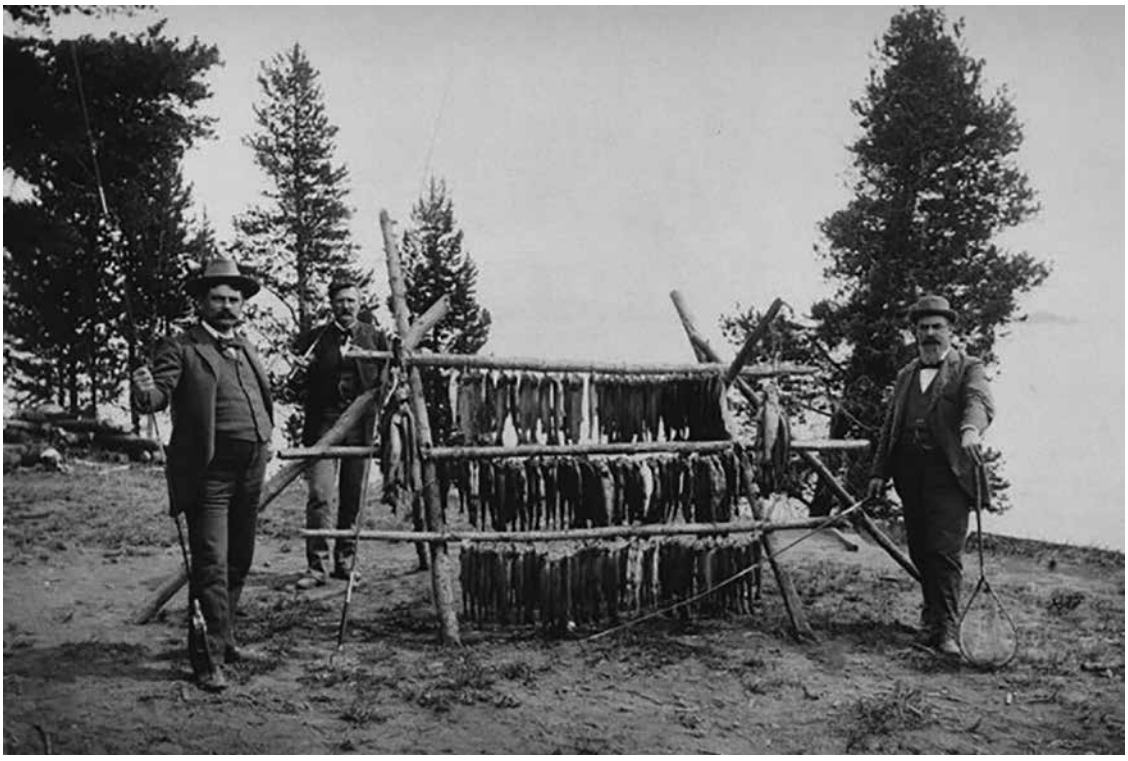

Figure 2. Trout caught by fly fisherman at West Thumb, Yellowstone Lake, Yellowstone National Park, Wyoming, 1897 (Nolan 1983).

limit for trout was 50 per day in 1903 (Clark et al. 1981). In Minnesota, the earliest daily creel limits were 25 for Walleye *Sander vitreus*, Northern Pike *Esox Lucius*, and Largemouth Bass *Micropterus salmoides* in 1910 (Cook et al. 2001). Even in national parks where wildlife preservation is a major goal, creel limits were high; for example, 20 Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* per day from Yellowstone Lake in 1908 (Gresswell and Varley 1988). By today's standards, these creel limits seem incredibly high, but one can only imagine the resentment they must have engendered among anglers accustomed to harvesting fish without limit. Daily creel limits were continually reduced during the 20th century, and today anglers can keep few fish, especially among large-bodied game species (Table 1).

Regulations have become increasingly complicated as managers attempted to maximize the fishing experience based on biological constraints and angler preferences. The first fishing regulations in Wyoming specified limits for "game fish," but the taxa that comprised game fish were not defined until 1945 (Hunt et al. 1945). The number of taxon-specific harvest regulations has increased greatly over the past century (Table 2). A major reason for the increased complexity of regulations

Table 1. Changes in game fish daily creel limits in states for which historical summaries of angling regulations are available. Creel limits are expressed as number of fish unless collective fish weight in pounds is specified. Data from the 2010s are from management agency websites. Historical data are from following sources: Wyoming (current study), Great Smoky National Park (Kulp and Moore 2005), Montana (Montana Fish, Wildlife and Parks, Helena, Montana), North Dakota (North Dakota Game and Fish Department, Bismarck, North Dakota), Michigan (Clark et al. 1981; Diana and Smith 2008), Minnesota (Cook et al. 2001), Yellowstone National Park (Gresswell and Varley 1988), Ohio (Carey Knight, Ohio Department of Natural Resources, personal communication), Maine (R. M. Jordan 2001), Pennsylvania (Weber et al. 2010), and Utah (Drew Cushing, Utah Division of Wildlife Resources, personal communication).

| Period | Wyoming | | | Yellowstone Lake, Yellowstone National Park | Great Smoky Mountains National Park | Maine | Michigan | | Minnesota | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trout | Black bass | Walleye | Yellowstone Cutthroat Trout | Trout | Black bass | Trout | Northern Pike | Walleye | Northern Pike | Large-mouth Bass |
| 1900s | 20 pounds | None | None | 20 | Unknown | None | 50 | None | None | None | None |
| 1910s | 20 pounds | None | None | 20 | Unknown | 25 | 35 | 25 | 25 | 25 | 25 |
| 1920s | 20 pounds | None | None | 20 | Unknown | 25 | 15 | 5 | 15 | 25 | 15 |
| 1930s | 30 | None | None | 10 | 10 | 25 | 15 | 5 | 8 | 10 | 6 |
| 1940s | 12 or 20[a] | 20 | 20 | 5 | 10 | 25 | 15 | 5 | 8 | 3 | 6 |
| 1950s | 12 or 20[a] | None | 12 or 20[a] | 5 | 5 | 15 | 10 | 5 | 6 | 3 | 6 |
| 1960s | 10 | None | 10 | 3 | 5 | 12 | 5 | 5 | 6 | 3 | 6 |
| 1970s | 6 or 10[a] | None | 6–10[a] | 3 | 4 | 8 | 5 | 5 | 6 | 3 | 6 |
| 1980s | 6 | 10 | 10 | 2 | 5 | 5 | 5 | 5 | 6 | 3 | 6 |
| 1990s | 6 | 6 | 6 | 2 | 5 | 1 or 3[a] | 5 | 5 | 6 | 3 | 6 |
| 2000s | 6 | 6 | 6 | 0 | 5 | 1 or 3[a] | 5 | 2 | 6 | 3 | 6 |
| 2010s | 3 or 6[b] | 6 | 6 | 0 | 5 | 1 or 3[a] | 5[c] | 2 | 6 | 3 | 6 |

| Period | Montana | | | North Dakota | Ohio Lake Erie | Pennsylvania | Utah |
|---|---|---|---|---|---|---|---|
| | Trout | Black bass | Walleye/Sauger | Trout | Yellow Perch | Trout | Trout |
| 1900s | None | None | None | 25 | None | None | 10 pounds |
| 1910s | None | None | None | 15 | None | None | 10 pounds |
| 1920s | 40 | 40 | 40 | 15 | None | 25 | 10 pounds |
| 1930s | 15 | 15 | 15 | 15 | None | 10–20[a] | 10 pounds |
| 1940s | 15 | 15 pounds | 15 | 15 | None | 10 | 10 pounds |
| 1950s | 10 | 15 | 15 | 5 | None | 8 | 10 |
| 1960s | 10 | 15 | 15 | 5 | None | 8 | 10 |
| 1970s | 5 or 10[d] | 10–15[a] | 10–15[a] | 5 | None | 8 | 8 |
| 1980s | 5 or 10[d] | 5–10[a] | 5–10[a] | 5 | 50 | 8 | 8 |
| 1990s | 5 or 10[d] | 5 | 5 | 5 | 30 | 8 | 8 |
| 2000s | 5 | 5 | 5 | 3 | 30 | 5 | 4 |
| 2010s | 5 | 5 | 5 | 3 | 30 | 5 | 4 |

[a]Varies by watershed.
[b]Limit is three for streams and six for lakes.
[c]Limit is five for streams but ranges from 1 to 5 in lakes.
[d]Limit is five for streams and 10 for lakes.

is a large increase in geographic and temporal exceptions to state or regional regulations (Table 2). For example, in 1931, there was a single regulation on the number of game fish that could be harvested in Wyoming and a statewide fishing season from April 1 to November 30 except for a later start in two counties. By 1939, dozens of water bodies had exceptions to the statewide fishing season or creel limits. In 1948, Wyoming was divided into five major drainage areas, each with its own fishing regulations, although local exceptions to season and creel limits were common. By 1950, angler age restrictions appeared for various waters. By 1980, gear restrictions allowing only artificial flies or lures were put into place on several streams (Table 2). Catch-and-release requirements appeared by 1990. Of particular note is the advent of mandatory kill requirements in 2014 for game fish species deemed undesirable in particular waters. This regulation is discussed further in the section below on invasive species.

Also contributing to the increased complexity of angling regulations was the trend to adjust creel limits, size restrictions, and gear restrictions depending upon local productivity, fishing pressure, and the public's desire for particular fishing experiences. Consider the North Platte River in central Wyoming. In 1947, the statewide creel limit of 12 trout applied to the entire river except from the city of Casper to the inlet of Seminoe Reservoir where the creel limit was five trout. In 1988, size limits and gear restrictions differed among three sections of the river, although the creel limit was consistent at six fish. By 2014, the river was divided into 10 sections with different creel limits, size limits, and gear restrictions. Regulations were least restrictive in reservoirs where hatchery fish supported a harvest-oriented fishery. By contrast, sections of the river that supported fisheries renowned for large wild trout were managed with low creel limits and a flies-and-lures-only restriction to facilitate the catch-and-release fishery practiced by many anglers using those areas.

## Baitfish Regulations

Seining had been outlawed in 1869 in Wyoming to protect game fish, but that law did not allow for collection of baitfish. As a concession to anglers who wanted to use live fish as bait, the law was changed in 1931 to allow seining for baitfish provided that seining was not done in waters frequented by game fish. The general trend since then has been increasing restrictions on

Table 2. The increasing complexity of angling regulations in Wyoming. Gamefish categories refers to the number of game fish taxa that have their own creel limits. An asterisk denotes the listing of waters with an exception to the state or area-wide regulations for fishing season, creel or size limit, age of anglers, gear restrictions, catch-and-release fishing only, or mandatory kill of undesirable species.

| Year | Gamefish categories | Fishing season | Creel or size limit | Angler age restriction | Gear restriction | Catch and release | Mandatory kill | Comments |
|---|---|---|---|---|---|---|---|---|
| 1900 | 1 | — | — | — | — | — | — | Gamefish not defined but assumed to be trout species. |
| 1910 | 1 | — | — | — | — | — | — | Gamefish not defined but assumed to be trout species. |
| 1920 | 1 | — | — | — | — | — | — | Gamefish not defined but assumed to be trout species. |
| 1930 | 1 | * | — | — | — | — | — | Gamefish not defined but assumed to be trout species. |
| 1940 | 1 | * | * | — | — | — | — | Gamefish not defined except in a few waters with limits for certain trout species. |
| 1950 | 2 | * | * | * | — | — | — | Regulations for general game fish and Burbot *Lota lota.* |
| 1960 | 5 | * | * | * | — | — | — | Regulations for general game fish, Mountain Whitefish *Prosopium williamsoni*, Brook Trout *Salvelinus fontinalis*, Burbot, and Grayling *Thymallus arcticus.* |
| 1970 | 5 | * | * | * | — | — | — | Same as 1960. |
| 1980 | 8 | * | * | * | * | — | — | Regulations for general game fish, Mountain Whitefish, Brook Trout, Burbot, Grayling, Walleye/Sauger *Sander canadensis*, black bass *Micropterus* spp., and Northern Pike. |
| 1990 | 10 | * | * | * | * | * | — | Regulations for general trout, Brook Trout, Mountain Whitefish, black bass, Walleye/Sauger, catfish, Burbot, Northern Pike/Tiger Musky *Esox lucius* × *E. masquinongy*, sturgeon *Scaphirhynchus platorynchus*, and panfish. |
| 2000 | 10 | * | * | * | * | * | — | Same as 1990. |
| 2010 | 11 | * | * | * | * | * | * | Regulations for general trout, Brook Trout, Mountain Whitefish, black bass, Walleye, Sauger, catfish, Burbot, Northern Pike/Tiger Musky, sturgeon, and panfish. |
| 2015 | 12 | * | * | * | * | * | * | Regulations for general trout, Brook Trout, Lake Trout Salvelinus namaycush , Mountain Whitefish, black bass, Walleye, Sauger, catfish, Burbot, Northern Pike/Tiger Musky, sturgeon, and panfish. |

where baitfish can be used, which species can be used as bait, and how baitfish can be procured (Table 3). A major reason for baitfish regulation was to prevent the introduction of non-game species that might be detrimental to game fish (Remmick 1982). In 1946, WGFD noted that anglers had introduced suckers (Catostomidae) into numerous Wyoming lakes, where they grew too big to provide forage and were thought to eat the eggs of game fish (Spratt 1946). It is interesting that, in many cases, the game fish of concern were not themselves native species but had been stocked in mountain lakes or low-elevation reservoirs that lacked fish species of interest to anglers.

To reduce the chances that baitfish would become established outside their native drainages, WGFD in 1951 required that baitfish had to be used in the waters where they had been collected. The use of live baitfish was banned in the Green River and Bear River drainages in 1971 to protect highly valued trout fisheries from the negative effects of illegally introduced non-game species. Also in that year, anglers possessing live baitfish had to produce a sales receipt or copy of their seining permit to verify the origin of the fish.

A major change occurred in 1974 when the use of live baitfish was restricted to a subset of drainages east of the Continental Divide in Wyoming (Table 3). Fisheries management in those drainages had expanded from a focus on trout to include coolwater and warmwater nonnative species such as Walleye and black bass *Micropterus* spp. that had become naturalized in these systems. Using live baitfish was a preferred method of angling for these species. To regulate the sale of baitfish more effectively, vendors were required to obtain a bait dealer's license, allow inspection of their facilities, and maintain records of sales. However, there were no restrictions on the sources or species of baitfish that could be imported from other states.

Baitfish regulations were further tightened in 1996 when only Fathead Minnows *Pimephales promelas* and Golden Shiners *Notemigonus crysoleucas* could be imported by baitfish dealers (Table 3). Dealers were required to notify WGFD 72 hours prior to importation so that baitfish shipments could be inspected. Anglers could keep commercially purchased live baitfish for 10 days, after which the fish had to be killed. Concerns that baitfish shipments from out-of-state sources might be contaminated with other fish species led to a ban on the importation of all baitfish in 1999. Since then, there have been further restrictions on how baitfish can be obtained, and in 2012 vendors could purchase only Fathead Minnows from licensed hatcheries for sale as live baitfish (Table 3).

## Fishing Tournaments

In Wyoming, competitive fishing tournaments have been around since 1983 when the Saratoga Chamber of Commerce sponsored an ice fishing derby to stimulate business during the slow winter season. Early tournaments focused on trout, but competitive fishing did not become widespread until 1990 with the advent of events focused on Walleye. In response to the growing number of tournaments, WGFD published the first regulations for fishing contests in 1990. A fishing contest was defined as "any competitive angling event conducted on waters in the State of Wyoming for the purpose of awarding prizes, or for personal gain or promotional consideration." Such events required written approval by WGFD at least 10 days prior to the event.

The trend has been for regulation of fishing tournaments to become more prescriptive. In 1992, a fishing contest was more precisely defined as "any event for catching game fish from waters open to public use where an entry or participation fee of $5.00 or more is charged per angler, 50 or more anglers participate on a given date, or total prizes exceeding $1,000 in cash or merchandise are awarded." Contests had to be approved 30 days prior to the event, and sponsors were required to submit a summary report. In addition, written approval was required to release fish in a live-release fishing contest. This was done to ensure that live-release contests would only be held under

Table 3. History of regulations regarding the use of baitfish in Wyoming.

| Year | Regulations |
|---|---|
| 1869–1930 | No regulations regarding use of baitfish. |
| 1931 | Legal to seine for baitfish except in waters frequented by game fish. |
| 1948 | Illegal to have in possession while fishing any "live bait fish or rough fish." Legal to seine for minnows except in waters frequented by game fish. |
| 1951 | Legal to use live baitfish only in waters where they were collected. |
| 1969 | Same as 1951 except that a permit was required to seine baitfish. |
| 1971 | Legal to use live baitfish only in waters where they were collected. Exception: live baitfish not allowed in Green River and Bear River drainages. Permit required to collect bait fish. Persons with live bait in possession must have receipt or permit verifying origin of fish. Ban on importation of all live fish except with authorization. |
| 1974 | Use of live baitfish restricted to selected drainages. Where legal, live baitfish have to be collected in drainage where they will be used and a seining permit is required. Commercial sale of live baitfish allowed through a baitfish dealer license and any species can be imported from out of state. Anyone using live baitfish must have sales receipt or seining permit. |
| 1996 | Where legal, live baitfish must be collected in drainage where they will be used and a seining permit is required. Only Fathead Minnow *Pimephales promelas* and Golden Shiner *Notemigonus crysoleucas* can be imported from out of state by baitfish dealers. Baitfish shipments subject to inspection. Commercially purchased live baitfish can only be kept for 10 days. |
| 1999 | Importation of all baitfish from out of state banned. |
| 2000 | Fathead Minnow and Golden Shiner can be used statewide wherever live baitfish allowed. |
| 2004 | Possession of live Brook Stickleback *Culaea inconstans* prohibited. Illegal to import amphibians, reptiles, crustaceans, or mollusks as live bait. Mollusks and crustaceans caught in Wyoming can be used as live bait only in waters where collected. |
| 2008 | Commercially purchased live baitfish can be kept for 15 days except that Fathead Minnow and Golden Shiner can be kept for 30 days. |
| 2012 | Commercial baitfish dealers can purchase only Fathead Minnows from licensed hatcheries and sell them anywhere live bait is legal. |

conditions conducive to survival of fish that had been held in live wells and then weighed prior to being released. Because fishing tournaments in Wyoming are concentrated on relatively few reservoirs, conflicts arose between tournament anglers and members of the public who did not appreciate having to share their favorite fishing spots with numerous competitive fishers. To lessen this conflict, a "Special Fishing Contest Provision" was adopted in 2006 whereby certain water bodies would have at least two weeks that were free from fishing contests each year. The most recent regulation requires anglers to harvest the Walleye they catch in tournaments after July 1 because high water temperatures in summer result in high mortality of Walleye released after being weighed (Hoffman et al. 1996).

## BIODIVERSITY MANAGEMENT

### Protecting Native Species

Throughout the first half of the 20th century, there was little recognition by anglers or fisheries managers as to whether game fish species were native or nonnative. Consequently, nonnative species such as Rainbow Trout *O. mykiss* were widely stocked throughout the United States to provide fish for the creel (Halverson 2010). In addition, it was common to combine similar taxa for regulatory purposes; hence, creel and size limits were often set for categories such as "trout" that did not distinguish between native and nonnative species. But in the 1970s, interest in conservation of declining native trout species in the western United States began to develop (Behnke and Zarn 1976). In Wyoming, conservation efforts began for several subspecies of native Cutthroat Trout *O. clarkii*. Early efforts involved habitat improvements, but in 1984, in response to population declines, some Wyoming streams with Cutthroat Trout were closed to fishing. Protection for Cutthroat Trout was expanded in 1990 when numerous streams throughout the state were converted to catch-and-release fishing. Harvest regulations were further tightened in 2008 to allow only two of the six total trout creel limit to be Cutthroat Trout within their native range in Wyoming. Another native game fish that has received regulatory attention in Wyoming is Sauger *Sander canadensis*. Prior to 2008, the creel limit was six fish for any combination of Sauger and Walleye, the latter being nonnative to Wyoming. The two species were separated in 2008, and the creel limit for Sauger was set at only two fish, whereas the creel limit for Walleye remained at six fish.

Passage of the Endangered Species Act of 1973 and a growing awareness of the importance of protecting biodiversity in all of its forms led natural resource management agencies to add non-game fishes and aquatic taxa such as mussels and crayfish to their management responsibilities (Schramm and Hubert 1999). An important first step in management of non-game species is to recognize their value in ecosystems. Early fishing regulations in Wyoming defined creel and season limits for game fish and listed qualifying species by their common name. All other species were classified as "rough, coarse, or non-game species." Starting in 1973, species not specifically listed as game fish were simply referred to as "non-game fish." An effort to remove terms such as "rough fish" or "trash fish" from the lexicon of fisheries biologists was also occurring elsewhere in the United States (Martin 1976; Woodling 1985). This change in terminology for fish not utilized as game species was an important event in the evolution of fisheries management philosophy because it indicated a turning point in how non-game species were viewed by biologists. Use of terms such as rough or coarse fish by a state management agency reinforces the public's perception that these species have little value and therefore makes it difficult to engender support for conservation of non-game taxa that are declining such as species of suckers or minnows (Cyprinidae).

Regulations can promote fish conservation goals by creating protected areas where no fishing or bait collecting is allowed. For example, Kendall Warm Springs in northern Wyoming was closed to fishing and bait collecting starting in 1978 to protect the endemic Kendall Warm Springs Dace *Rhinichthys osculus thermalis*.

### Managing Invasive Species

Invasive species are nonnative species whose introduction to an ecosystem is likely to cause environmental or economic harm or harm to human health (Kolar et al. 2010). In Wyoming, concern about invasive fish species was evident by the middle of the 20th century when managers noted the harmful efforts of illegal introductions on sport fisheries (Spratt 1946). Later, concern about invasive species was extended to include their harmful effects on native, non-game species, such as Bluehead

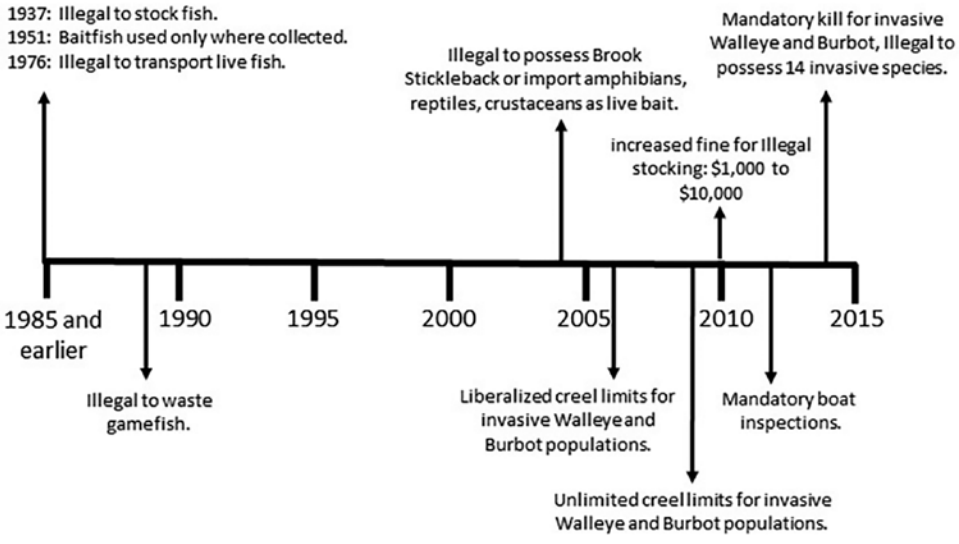


Figure 3. Evolution of angling regulations in relation to the control of aquatic invasive species in Wyoming.

Sucker *Catostomus discobolus*, Flannelmouth Sucker *C. latipinnis*, and Roundtail Chub *Gila robusta* (discussed in Bezzerides and Bestgen 2002). Fishing regulations can play a role in preventing introduction of invasive species and in controlling their population size after they have become established. A regulation passed in 1937 made it illegal to stock fish in Wyoming without a permit (Figure 3), but release of live baitfish persisted. This led to increasingly restrictive regulations on the use of baitfish beginning in 1951 (Table 3). Although baitfish regulations were largely enacted to prevent harm to game fish, they had the added benefit of protecting native non-game fishes from invasive species. In an effort to prevent fish stocking by the public, a regulation was enacted in 1976 that made it illegal to transport live fish, even if the fish had been legally harvested. In 2004, possession of Brook Stickleback *Culaea inconstans* was outlawed and it became illegal to import amphibians, reptiles, crustaceans, or mollusks as live bait.

The year 2006 marked a new development in the use of regulations to manage invasive fish species in Wyoming. For the first time, game fish species that had been illegally introduced to waters where their presence was deemed detrimental were targeted for removal by anglers. In the Green River and Bear River drainages of southwestern Wyoming, the creel limit for Walleye and Burbot *Lota lota*, considered invasive species in these drainages, was liberalized to 25 fish and all individuals captured had to be killed immediately (Figure 3). This meant that anglers fishing for other species or who captured small fish were required to kill Walleye and Burbot even if they did not intend to consume them. Unfortunately, this regulation conflicted with a 1988 regulation that made it illegal to "take and leave, abandon or allow any game fish … to intentionally or needlessly go to waste." The mandatory kill aspect of this regulation was removed in 2008, and the creel limit was made unlimited. In the meantime, biologists worked to have the Wyoming Legislature pass a law that allowed game fish to be reclassified as non-game fish in waters where they were considered to be invasive. As a result, in 2014, Burbot, Yellow Perch *Perca flavescens*, Northern Pike, and Walleye were classified as non-game species in the Green River, Bear River, and Little Snake River drainages of western Wyoming with unlimited creel limits and a mandatory kill designation. In that same year, Walleye in Buffalo Bill Reservoir outside of Yellowstone National Park was classified as a non-game species with an unlimited creel limit and mandatory kill designation.

Three other regulations were enacted recently in an effort to reduce the introduction of nonnative species in Wyoming waters. In 2004, it became illegal to import amphibians, reptiles, crustaceans, or mollusks as live bait. In addition, mollusks and crustaceans collected in Wyoming could only be used as bait in the waters where they were collected. In 2010, the fine for illegal fish stocking was increased from $1,000 to $10,000 to provide a stronger deterrent to anglers releasing live baitfish or surreptitiously stocking game fish into a water body. In 2012, it became mandatory for all boats to stop at inspection stations operated by WGFD along major highways entering Wyoming. The main objective was to prevent boaters from bringing nonnative mussels *Dreissena* spp. and aquatic plants into Wyoming. Because live-wells in boats are inspected, the program also prevents live fish from being transported into Wyoming.

## DISCUSSION

Fishing regulations in Wyoming have evolved in response to three major philosophies guiding inland fishing management (Figure 1). The regulatory trends seen in Wyoming occurred in other parts of the United States as well (Clark et al. 1981; Cook et al. 2001; Isermann and Paukert 2010). The earliest regulations were minimal and reflected a generous allowance for harvesting fish as food. Methods such as dynamite or poisons that killed large numbers of fish without regard to species or size were outlawed. These were analogous to the practice of market hunters who slaughtered big game animals in large and unsustainable numbers in the 19th century. But as fishing developed into a recreational pastime in the late 1800s and early 1900s in the United States, there was increasing concern about the quality of the fishing experience and less tolerance for anglers who justified large fish catches on the basis of sustenance. Although subsistence fishing is not a major activity in Wyoming, it still occurs in some areas of North America (Moffitt et al. 2010).

After establishing hook and line as the only legal means of fishing, fisheries managers turned their attention to creel and minimum size limits at the beginning of the 20th century. However, the earliest creel limits were excessively high and unsustainable, necessitating a continual trend toward reduced harvest limits (Table 1). Regulations have also been adjusted to reflect variation in biological productivity and angler desires. Fisheries biologists have experimented with a variety of regulatory innovations involving gear restrictions, catch and release, and mandatory kill of undesired species. As a result, fishing regulations now include numerous exceptions to the general regulations (Paukert et al. 2001, 2007; Isermann and Paukert 2010). This complexity and the occasional exclusion of entire classes of anglers from some fisheries has led to some backlash; hence, fisheries agencies now try to balance the need for biological specificity and legal clarity with social equity and simplicity (Thurow and Schill 1994; Cooke et al. 2013).

Regulations regarding the use of live baitfish have become more restrictive in Wyoming (Table 3) and throughout North America. Currently, nine Canadian provinces and seven U.S. states either ban or greatly restrict the use of live baitfish (Drake and Mandrak 2014). Earlier concerns dealt with the effects of baitfish on sportfish, especially species such as Common Carp *Cyprinus carpio* and suckers that obtain large sizes and compete with game species (Remmick 1982). Today, there is increasing concern about nonnative baitfish as disease vectors and as invasive species. In surveys of bait dealers' tanks, nontarget species are often present, including species known to be invasive (Drake and Mandrak 2014). Despite public education programs and regulations prohibiting release of live bait, the practice remains common. For example, 30% of anglers illegally released live baitfish in Ontario and 65% of anglers did so in Maryland (Kilian et al. 2012; Drake and Mandrak 2014). Because a segment of the fishing public appears refractory to efforts to stop the release of live bait, increasingly stringent regulations on use of baitfish appear likely in the future.

In the latter part of the 20th century, fisheries managers added preservation of biodiversity to their ongoing efforts to enhance recreational fishing. Often this meant stringent harvest limitations on game fish of conservation concern such as Cutthroat Trout and Bull Trout *S. confluentus* (Erhardt and Scarnecchia 2014). Although closing a fishery may be the most effective way to recover declining fish species, it disenfranchises

anglers whose expenditures and enthusiasm for outdoor recreation contribute to conservation programs (Cooke et al. 2014). Therefore, catch and release or reduced creel limits are a compromise that protects species while maintaining the support of recreational anglers.

Increasingly, management agencies are also restricting collection of non-game species of conservation concern. In Colorado, it is illegal to take 24 non-game fish species, including species considered undesirable or rough fish in the past. This trend will undoubtedly continue as agencies recognize more species as being of conservation concern.

One of the more interesting shifts in regulations involves mandatory kill of invasive fishes that are highly valued in other parts of their distribution. A good example is the Burbot in Wyoming. This species is native and of conservation concern in the Missouri River drainage of Wyoming. Creel limits are restricted and efforts are underway to increase Burbot populations in this area. By contrast, Burbot is not native across the Continental Divide in the Colorado River drainage. There, Burbot, along with Walleye, Northern Pike, and Yellow Perch, are considered invasive species and must be killed when caught by anglers. This duality of species being considered desirable in some areas but undesirable in other areas will increase as fisheries managers use all avenues to stem the tide of illegal fish introductions. Unlimited harvest limits and mandatory kill regulations have also been used to help control invasive populations of Lake Trout *S. namaycush* in Yellowstone Lake and other Western U.S. waters (Martinez et al. 2009). Even where mandatory kill regulations do not have a major impact on the abundance of invasive species, they send an important message to the public that illegal stocking is harmful and will not be rewarded by managing the invasive species as a desirable game fish (Johnson et al. 2009).

## SPECULATIONS ON THE FUTURE OF FISHING REGULATIONS IN THE UNITED STATES

How will management philosophies and fishing regulations be affected by human demographic trends or changing beliefs held by the public? Will a growing human population put more recreational angling pressure on fish populations, or will angling pressure decline because of "nature deficit disorder"; that is, reduced participation in nature-based recreation in an increasingly urbanized society (Pergams and Zardiac 2008; Arlinghaus et al. 2015). A declining number of anglers coupled with increased voluntary catch-and-release practices would mitigate the need for the increasingly restrictive harvest limits that characterized the 20th century (Table 1). Conversely, some forms of angling, such as fly-fishing, have grown in popularity and increased the pressure on some fisheries. Expanded catch-and-release regulations would seem to be the best way to ensure a quality experience in these fisheries. Segmentation of fisheries into areas with different angling regulations will also likely increase as managers try to satisfy the expectations of different angler groups (Thurow and Schill 1994).

A regulation that may become more widespread is a closure on angling for trout during periods of low stream flows and warm water temperatures. High temperatures and accompanying low oxygen concentrations are stressful to coldwater fish and increase the likelihood of mortality due to angling. To prevent mortality, streams in Montana and Yellowstone National Park are closed to fishing between 2 p.m. and midnight when maximum water temperatures reach at least 22.8°C for three consecutive days. Fisheries biologists in Colorado can close waters to fishing when average daily water temperatures exceed 22.2°C or daily minimum oxygen levels are below 5 ppm. The WGFD recommends that anglers stop fishing for trout when water temperatures exceed 21.1°C, but this has not been codified into a regulation. With many studies predicting increased stream water temperatures due to global warming, regulations mandating fishing closures due to high water temperatures will likely become more common.

Changing attitudes about animal welfare may challenge current thinking about fishing regulations. Although many anglers consider catch and release to be the epitome of ethical fishing, some people believe that the only justification for subjecting fish to the stress and pain of being caught with a hook is to provide human sustenance (Arlinghaus et al. 2007). Strong opposition to catch-and-release fishing exists in Germany and Switzerland, where fish of legal size that are captured must be harvested (Arlinghaus et al. 2007). In the future, anglers and managers might find it difficult to justify catch-and-release fishing in the face of opposition from the animal welfare movement (Arlinghaus et al. 2012).

Regulations related to invasive species will likely increase. Johnson et al. (2009) suggested that the low fines associated with illegal fish stocking should be increased given the high cost of controlling invasive species. This happened in Wyoming when fines for illegal stocking were increased 10-fold in 2010. Johnson et al. (2009) also suggested that a reward system be implemented to encourage people to turn in individuals who illegally stock fish. This would be an interesting throwback to the earliest days of fisheries management in Wyoming when the Territorial Legislature established a $50 fine for violation of game laws, with one-quarter of the fine awarded to the informer (Glafcke 1876). Regulations regarding which species are illegal to possess will almost certainly become more prescriptive to make it easier to prosecute violators. Fishing regulations in Wyoming in 2012 stated that it was illegal to stock or possess aquatic invasive species, but there was no list of species considered to be invasive. In 2014, this lack of clarity was eliminated when 14 taxa (including six species of fish) were listed as aquatic invasive species. Such lists will likely be expanded as agencies identify more species they want to prevent from becoming established within their jurisdictions.

The primary focus of inland fisheries management changed from providing sustenance to providing recreational opportunities in the early 20th century. But could the pendulum swing back to put more emphasis on fish as a food resource? Changing immigration patterns in the United States mean that more people come from cultural backgrounds that emphasize consumptive uses of fish, including taxa such as carps and suckers that were not historically targeted by recreational anglers (Arlinghaus et al. 2007). In addition, might economic hardship and a trend to utilize local food sources (the locavore movement; Tidball et al. 2013) contribute to increased interest in harvesting fish for consumption? Angling regulations have tracked changing philosophies of fisheries management over the past 150 years, and it will be interesting to see how regulations will evolve in response to future challenges to provide recreational and sustenance fishing opportunities while protecting biodiversity in aquatic ecosystems.

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# Running Silver: Restoring Atlantic Rivers and their Great Fish Migrations

John Waldman. Lyons Press. Guilford, CT. 2013. 284 pages. US$26.95 (hardcover), $12.50 (Kindle).

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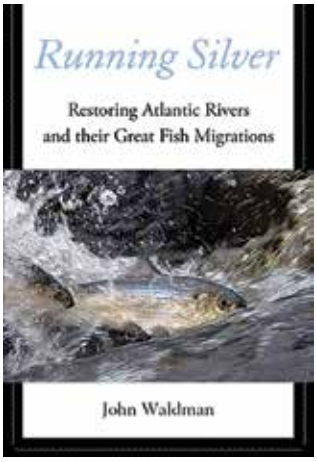


Anadromous salmon in the Pacific and Atlantic oceans are iconic species that have been the subjects of numerous natural science texts that narratively describe their common plight. Among my favorites is Bruce Brown's *Mountain in the Clouds: A Search for Wild Salmon*. Reading this book is one reason that I became passionate about wild salmon conservation. However, there has been a gap in this narrative for the eastern United States, where Atlantic Salmon *Salmo salar* is only part of a mosaic of ocean-going species. *Running Silver* is an intriguing read that fills this void. The book weaves the story of the plight of Northwest Atlantic diadromous fish with source material as varied as Thoreau and Atlantic States Marine Fisheries Commission management actions. Despite the diverse sources, this narrative achieves the author's goal of explaining the demise of this complex of species while trying to restore biological and cultural awareness of what has been lost … and could be restored. John Waldman's passion and dedication to the sea run fish community (both the fish and the people) is apparent in each of the book's 20 relatively short 10-20 page chapters. Although they are woven together into a compelling story, most of the chapters are largely independent, allowing easy reading in small doses. The text transitions between number heavy text needed to explain harsh facts of lost abundance and hectares of concrete that block Atlantic Ocean rivers to very personal narrative observations of fish and river systems. I particularly appreciated the frequent conversational text where Waldman related discussions and observations of river keepers, managers, and scientists. The reader feels as if they are at the table or the river's edge.

The first four chapters set the stage and describe the fish species and river systems of the Atlantic realm. Chapter 3, The Seasonal Parade, was a favorite. Waldman uses the annual sequence of migration to introduce the reader to both the primary diadromous species and some that may be better characterized as euryhaline wanderers. This chapter was concise yet nuanced in its description of diversity within and among diadromous fish in their ecology and habitat use. And who knew there were anadromous whitefish!

It is at this point that the author inserts the first of two interludes. It is 1600, and a female American Shad *Alosa sapidissima* is beginning her trip to the ocean in a free-flowing river system. Waldman's insights into the sights, sounds, and hazards faced by this single fish in massive schools, follow her journey to sea and back. This paints a stark contrast with Interlude II (after Chapter 18) that follows a fish's journey in 2013. Together these two interludes effectively provide a "fish-eye view" of the modern challenges of river and ocean life.

Between the interludes, Chapters 5 through 18 thoroughly and informatively cover the primary challenges to sea run fish, what are often called the four H's in salmon circles—Habitat, Hydropower, Harvest, and Hatcheries. I enjoyed the way these hazards were covered with stories, case studies, and narratives by passionate professionals and fish advocates. We learn more about river herring, sturgeon, Striped Bass *Morone saxatilis*, etc., as we explore the challenges the fish face and the people that work to save them. The story is balanced and scientifically accurate; we see and feel the impacts of development on these fish populations. However, it is not a preachy and scolding narrative. The book is an honest and compelling true story that needed to be assembled in one book. In addition to the four H's, two modern and emerging threats are well documented and described—climate change and ecosocial anomie. With climate change, he describes the realities facing fish at the southern edge of their range and the changes and shifts that face the more broadly distributed species such as river herring. He also introduces a new hurdle: ecosocial anomie—a challenge caused when managers lack accurate baselines and the public has forgotten the utility, and beauty, of these species. This hurdle seems very difficult to address. These six challenges to diadromous fish are mentioned and reinforced throughout the book—this solidifies these challenges and puts the reader on notice that solutions are needed. Beyond the bad news, there are stories of hope such as the Striped Bass story. It is comforting to know that when science finds an answer to population decline and managers are able to prescribe a direct solution to the problem, the fish will respond.

The final two chapters provide a description of optimistic changes in attitudes and river connectivity that have occurred in the last decade and finally a way forward towards better stewardship of these resources. The author's prescription for recovery is outlined in 10 steps. While the challenges seem insurmountable, a book like this is essential to starting the conversation and starting a fire. As Brown's 1982 salmon book did for me, I suspect that John Waldman's book will foster an obsession for river herring and other sea run fish in some readers that might have a career ahead in saving Atlantic rivers and their great fish migrations. AFS