Chapter 1

Historical Perspectives on Inland Fisheries Management in North America

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1.1 IMPORTANCE OF HISTORIC ACCOUNTS

The management of inland fisheries and ecosystems is impossible without full appreciation and understanding of the actions and conditions of the past. The material in this chapter provides the reader with a history of the science of and philosophical approaches to inland fisheries management in North America. Contemporary ecosystems are a reflection of historic habitat alterations, fisheries exploitation, and management actions. Therefore, selection of different reference baselines for understanding the historic conditions of populations and ecosystems can lead to various correlations of causative factors (Humphries and Winemiller 2009). The social context of historic fisheries management is also a critical component to understanding and dealing with change. Records of fish, wildlife, landscape management agencies, and historic scientific literature provide important information and insight needed by contemporary managers and scientists. Equally important to understanding our history is recognizing the importance of recording and documenting contemporary management actions for future generations. Steedman et al. (1996) provided a comprehensive review of reasons why fisheries professionals need to understand the historic context of aquatic systems.

- Those who ignore history are doomed to repeat the worst of it.
- Historical information is frequently required during the specification of targets for ecosystem restoration.
- Historical information can be used to modify values and beliefs as they relate to habitat.
- By its very nature, information about natural ecosystem processes needs to be interpreted in a context that is long term and retrospective.
- Humans are not very good at perceiving slow processes or rare events without the help of scientists or historians.
- In culture, religion, and science, humans have often preferred to seek out and preserve stability in the natural world and to filter human perceptions through models grounded on stability or steady-state dynamics.
- The present is the "history of the future."

Early fisheries scientists and naturalists did not have the breadth of information and tools that are available today, but they understood many of the challenges of fisheries management, observed natural systems, and provided accurate documentation. The contemporary student of fisheries management may overlook important historical publications when searching the scientific literature because of the wealth of digital data and contemporary publications are often more easily available. Scientists must be encouraged to pursue historic data and images not yet available through digital resources. Fortunately, historic resources are increasingly being made more accessible via the internet through efforts by public and private entities worldwide, but methods and access have yet to be fully harmonized (Shepherd 2006; Colati et al. 2009; Seadle 2009).

1.2 FISHERIES BEFORE EUROPEAN SETTLEMENT

Native Americans exploited fisheries resources of North America prior to settlement by Europeans, and in many regions fish were central to the culture and economy of aboriginal inhabitants. North America was characterized by large regional variability in fish production, dependent upon factors such as quantity and types of waters, climate, and availability of nutrients, and the extent of use of fish populations by Native Americans varied. Rostlund (1952) synthesized descriptions from early explorers, post-settlement records of commercial catches, and early scientific estimates of fish yields to characterize the regional differences in the availability of fishes in North America. Pacific salmon provided food resources for native peoples from northwestern California to Alaska along the Pacific coast, and in many areas the annual salmon runs were a central element in native cultures. Similarly, fish represented a staple food for many tribes in the Great Lakes region, who used a variety of species and developed fishing cultures analogous to those on the Pacific coast. The fish fauna of the Atlantic coast and Mississippi basin were diverse and abundant, but their importance to Native Americans was not on the scale observed in the Pacific coast and Great Lakes regions. Historians have speculated that this was a result of a higher level of importance of hunting and agricultural activities, with fishing serving to supplement other food sources. Native American fishers used most of the gears familiar to modern fisheries workers, including nets, traps, weirs, spears, fishhooks, and even poisons, although preferred techniques and the degree of technological development varied across the continent.

Even in areas such as the Pacific coast, where fishing represented a primary source of food acquisition, little evidence exists that Native American fisheries exceeded sustainable levels. The apparently limited impact that Native American fisheries had on fish populations is often attributed to low human population densities and inefficient fishing and food storage techniques. More recent evidence suggests that Natives Americans in some areas were technologically capable of overexploiting fish populations, but complex social and cultural traditions tempered harvests and maintained sustainability (Taylor 1999). Native American belief systems typically involved more spiritual connections to nature, particularly with resources important for subsistence. In Native American cultures with strong ties to fisheries resources, fish played a central role in myths and seasonal ceremonies, and traditions developed that acted to prevent overfishing (Taylor 1999; Bogue 2000). European immigrants encountered fisheries resources in an essentially unexploited state but brought a value system that necessitated a more formal system of fisheries management.

Prior to large-scale immigration of Europeans to North America, European travelers to the New World sent back seemingly fantastical tales of the richness of the natural resources. Fisheries resources were no exception, and reports suggested a limitless supply of food fishes. Salmon runs on both coasts were so large they sometimes inspired complaints. Nicolas Denys, French governor of Acadia, said this of the Atlantic salmon in the Miramichi River in 1672 (quoted in Montgomery 2003): "If the [passenger] pigeons plagued us by their abundance, the salmon gave us even more trouble. So large a quantity of them enters into this river that at night one is unable to sleep, so great is the noise they make in falling upon the water after having thrown themselves into the air."

Salmon runs on the Pacific coast were no less spectacular. Ezra Meeker, an early pioneer to the Washington territory, described the abundance of salmon in the Puyallup River in the 1850s (quoted in Montgomery 2003): "I have seen the salmon so numerous on the shoal water of the channel as to literally touch each other. It was utterly impossible to wade across without touching the fish. At certain seasons I have sent my team, accompanied by two men with pitchforks, to load up from the riffle for fertilizing hop fields."

Reports from interior waters suggested that fish of incredible diversity and abundance could be found throughout North America. In the late 1800s, reports came from North Dakota lakes of net hauls "so large that four horses on each side were required to land the catch" (Eastgate 1918). Vanderkemp (1880) described the fish resources of New York's Oneida Lake in 1792 in this way: "Never did I see yet a country, where all kind of fish was so abundant and good: It may be equalled [sic], it cannot be excelled.…It is enough to set out a few lines at evening, to make now and then an excursion to the woods, without sacrificing much of his time, that a settler may supply his family with meat and fish during five or six months." Reports from Hernando de Soto's travels through the lower Mississippi River valley in the early 1500s included accounts of the easy access to fish enjoyed by the Native American, who "everyday…brought fish until they come to be in such plenty the town was covered in them" (quoted in Pearson 1972). Samuel Williams, writing from Vermont in 1794, captured the overall tone of European explorers and settlers across much of North America (quoted in Pearson 1972): "In the production of fish, nature seems to have been extremely prolific, in every part of America. Their species, their multiplying power, and the ages at which they become prolific, are beyond our knowledge and computation. The brooks, rivers, ponds and lakes are everwhere [sic] stored with them. The sea coasts are one continued range of fishing banks, covered with cod, haddock, and other animals of the ocean."

Many of the reports from the New World came at a time when Europe was experiencing rapid population growth. The early stages of the industrial revolution were resulting in increased urbanization, and the demand on natural resources in Europe was beginning to take its toll, resulting in resource depletion near large population centers (Goudie 2005). News of a vast continent of seemingly unlimited natural riches provided a strong attraction. In fact, Fagen (2006) argues that demand for fish fueled by both a growing European population and the spread of Christianity (and its popularity of fish on abstinence days, which accounted for more than half the calendar year in the 13th century) brought largely secretive commercial fisheries to the shores of North America long before John Cabot and the Pilgrims, particularly those operated by Basque fishermen. European immigrants would bring a philosophy that natural resources were a fuel for economic development and religious fulfillment, and this view would ultimately change the nature of the continent's aquatic resources (e.g., Worster 1992).

1.3 EARLY ICHTHYOLOGICAL SURVEYS IN NORTH AMERICA

The North American freshwater fish fauna comprises about 1,060 species, 50 families, and 200 genera (Burr and Mayden 1992). The North American fauna encompasses wide phylogenetic diversity, including representatives from ancient pre-teleostean lineages as well as more modern teleosts; 128 genera are found only in North America. Most of the adaptive radiations contributing to the diversity of freshwater fishes in North America were centered in the Mississippi River basin, which includes the majority of the continent's species. The native fish fauna on the Pacific coast contained only about a quarter of the number of species found in the eastern part of the continent, but a high proportion of species were endemic to the region (Briggs 1986). North American freshwater fishes are among the best understood faunas in the world. The zoogeography and distribution of freshwater fishes in North America are well described in three monumental works: *Atlas of North American Freshwater Fishes* (Lee et al. 1980); *The Zoogeography of North American Freshwater Fishes* (Hocutt and Wiley 1986); and *Systematics, Historical Ecology and North American Freshwater Fishes* (Mayden 1992).

While only a small fraction of North America's fish species would figure in the development of inland commercial and sport fisheries, early scientific activities on the continent focused on describing and cataloging the continent's fauna. Prior to 1800, North American fishes were little studied, and those species that had been described appeared primarily in publications emanating from European museums (Dymond 1964; Myers 1964). The first significant work of American ichthyology published by an American came from New York, where Samuel Latham Mitchell's studies culminated in his 1814 paper on the fishes of New York (Mitchell 1814). The formation of the Academy of Natural Sciences of Philadelphia in 1812 began to attract workers to North America intent on cataloging the continent's wealth of natural resources. Constantine Samuel Rafinesque was one of the more eccentric scientists drawn to the New World. His work included a survey of the fishes of the Ohio River, *Ichthyologia Ohiensis*, which was published in 1820. The monograph included descriptions of fish species drawn from completely fictitious drawings provided to him by John James Audubon as repayment for Rafinesque having destroyed his violin in an effort to collect bats while a guest in Audubon's cabin (Rafinesque 1820; Myers 1964). Charles Alexandre LeSueur arrived in North America about the same time as Rafinesque and concentrated his efforts on Atlantic coast fishes.

The expansion of ichthyological surveys into the western waters of the USA was accomplished in large part through the activities of Spencer Fullerton Baird at the Smithsonian Institution, which was founded in 1846. Baird, who would later become the first commissioner of the U.S. Commission of Fish and Fisheries, served as the Smithsonian's first Assistant Secretary. Baird's efforts at the Smithsonian reflected his desire that the institution become home to a comprehensive collection of natural history specimens. Among Baird's first actions as Assistant Secretary were efforts to attach naturalists to Army exploration crews surveying the boundary with Mexico and various routes for railroads to the Pacific coast between 1848 and 1855 (Goetzmann 1959). The resulting flood of fish specimens returning to the Smithsonian from the various surveys was assigned to Charles Frederic Girard, a former assistant of Louis Agassiz at Harvard University. Agassiz was perhaps the most respected naturalist in North America at the time, with ambitions of writing the definitive work on North American fishes.

Agassiz apparently resented both Girard's departure for the Smithsonian and his access to specimens that Agassiz wanted for his newly formed Museum of Comparative Zoology, and Agassiz openly criticized Girard's publications on new species of western fishes (Jackson and Kimler 1999). Despite criticism by Agassiz, however, Girard's analysis of fish specimens sent to the Smithsonian resulted in the discovery of 146 new species, ranking him second among all ichthyologists working on North American fishes for number of valid species described. Girard's work during the 1850s accounted in large part for the first great pulse of discovery of North American fish species and provided important early documentation of the fauna of the West prior to large-scale European settlement.

Another worker with early attachments to Agassiz and Baird was David Starr Jordan, whose career spanned much of the last half of the 1800s and into the early 20th century. Jordan's accomplishments earned him the title, "father of North American ichthyology" (Hubbs 1964), and his work included the initial descriptions of over 200 fish species currently recognized in North America. He also trained many of the leading ichthyologists that followed him, including Carl Leavitt Hubbs; many contemporary ichthyologists can trace their academic lineages to Jordan. Jordan's monumental work with Barton Warren Evermann in 1896, *The Fishes of North and Middle America*, provided a comprehensive and accurate catalog of North American fishes. By the early 1900s, the golden era of ichthyological discovery had ended. New fish species would continue to be discovered as more intensive local surveys were undertaken, but the overall pattern of fish species distributions had been described. While ichthyological research would continue, a new area of fish-related research was developing with efforts to identify causes and remedies for impacts on fish populations resulting from human activities.

Descriptive surveys of fishes, habitats, and pollution were conducted by many state commissions during the 1920s and 1930s (e.g., Belding et al. 1924), mostly with the goal of better understanding how and where to stock fish. Particularly noteworthy was a survey led by the first woman biologist working for the New York State Department of Conservation, Emmeline Moore. She first studied the fish and limnology of Lake George and then went on to conduct surveys throughout state waters. These biological surveys of the surface waters and reports on the watershed characteristics were landmarks in management for their logical and careful sequence of study (Moore 1926, 1927). Moore became the first woman president of the American Fisheries Society in 1927 (Moffitt 2001) and also contributed to understanding fish health (Moore 1923; Michell 2001; Figure 1.1).

1.4 CHANGING CONCEPTS OF MANAGEMENT

Establishing authority for managing inland fisheries was difficult in the early years of both the USA and Canada. During colonial times there was confusion regarding ownership and access to inland aquatic resources. Aristocracy and nobility held property rights, and there was considerable disregard for Native American tribes and their claims to natural resources. At the conclusion of the American Revolution, and establishment of a sovereign representative democracy in the USA, many terrestrial, riparian, and freshwater resources were opened to public use under the public trust doctrine (see Chapter 4, this volume). Laws governing fisheries were put in place (particularly concerning fish passage at dams), but the management paradigm and infrastructures for these laws were neither understood nor clearly defined.

Figure 1.1. Emmeline Moore led many efforts to raise awareness of the importance of science-based management. She was elected the first woman president of the American Fisheries Society in 1927. She is shown at her desk in 1963 (photo courtesy of New York State Department of Environmental Conservation, from the *New York State Conservationist*).

English law regarding ownership of wildlife and fisheries provided the basis for these laws, but the laws regarding fisheries were confusing (Goble 1999, 2005). Many laws in the eastern USA defined riparian zones to fall under private ownership. The failure to manage fisheries resources and access to aquatic systems properly was likely due, in part, to the small European population, which was distracted by the many opportunities for commerce and had a general lack of biological understanding of the vast territory and its resources.

In Canada, ties to European-based systems of nobility and far-away governments made it difficult to initiate fisheries management. Each province had laws regulating fisheries that were held in common. Most fishing regulations targeted anadromous fishes, marine fishes, or estuarine finfish and shellfish resources or fish passage at dams. Canadian citizens recognized that habitat degradation and overfishing affected inland fisheries, but governments were ineffective in stopping exploitation. For example, the Province of New Brunswick authorized strict Atlantic salmon laws in 1845, and local associations of fishers were established to manage harvests; however, there was little compliance with the laws (Johnstone 1977).

Central control of Canadian fisheries began after the Dominion of Canada was established with the provinces of New Brunswick, Ontario, Quebec and Nova Scotia. In 1868, the Canadian Confederation passed the federal Fisheries Act to create a Department of Marine and Fisheries (Box 1.1). Canada's first Minister of Marine and Fisheries was Peter Mitchell, and the Fisheries Act mandated the appointment of federal fisheries officers, creation of federal fishing licenses, closed seasons for some species, and passage for fishes named in the act. These provisions included free passage of fish on Sundays and prohibition of Sunday fishing. The Fisheries Act prohibited pollution in waters frequented by fishes, allowed for creation of fish sanctuaries or fish reserves, and included controls on oyster and shellfish fisheries. The act continues as the policy directive for fisheries in Canada.

Box 1.1. Historical Names of Canada's Federal Fisheries Agencies

The names and missions of federal fisheries agencies in Canada changed over time as a result of governmental reorganizations.

- 1867–1884 Department of Marine and Fisheries
- 1884–1892 Department of Fisheries
- 1892–1914 Department of Marine and Fisheries
- 1914–1920 Department of Naval Services
- 1920–1930 Department of Marine and Fisheries
- 1930–1969 Department of Fisheries
- 1930–1936 Department of Marine[1]
- 1969–1971 Department of Fisheries and Forestry
- 1971–1976 Department of the Environment
- 1976–1979 Department of Fisheries and the Environment
- 1979–present Department of Fisheries and Oceans

[1]The Department of Marine was merged with the Civil Aviation Branch of the Department of National Defense in 1936 to form the Department of Transport.

A federal mandate for fisheries management in the USA began in 1871 when the U. S. Congress authorized the U.S. Commission on Fish and Fisheries (Fish Commission) in response to the decline in fisheries. Similarly, many states established fish commissions for the same reasons at about that time. The first U.S. Commissioner of Fisheries, Spencer F. Baird, was discussed previously (section 1.3) for his contributions to ichthyological surveys. Baird was based in Woods Hole Massachusetts, and the Fish Commission and its succeeding authorities (Box 1.2) established laboratories with field operations at several locations on both coasts, on the Great Lakes, and in the interior of the USA. The primary mission of the Fish Commission was to determine the reasons for declines of fisheries in New England and the Great Lakes and to develop methods for fish culture. The early legislation also provided the Fish Commission with the right to collect specimens from all states and territories and to enlarge the collections of the Smithsonian Institution.

1.4.1 Early Management

Well before federal mandates for fisheries management and fish culture were established, lay people were interested in fish culture as a way to enhance fish production. Entrepreneurial efforts in fish culture included those of Seth Green, who established a fish hatchery in Caledonia, New York, in 1870 (Bowen 1970). Equally enthusiastic about fish culture, residents of Canada developed techniques for fish culture. In 1868 Samuel Wilmot built a fish hatchery on his farm near Newcastle, Ontario, and in 1876 he became the Superintendent of Fish Breeding for the federal government in Ottawa. Wilmot subsequently established hatcheries in Quebec, Ontario, and the maritime provinces of Canada, and a division for hatcheries was retained following his tenure (Huntsman 1938).

Box 1.2. Historical Names of Federal Agencies Responsible for Fisheries Management in the USA

The names and missions of federal fisheries agencies in the USA changed over time as a result of governmental reorganizations.

- 1871 U.S. Commission on Fish and Fisheries (independent)
- 1879 Division of Economic Ornithology and Mammalogy (U.S. Department of Agriculture)
- 1885 Bureau of Biological Survey (U.S. Department of Agriculture)
- 1902 Bureau of Fisheries (U.S. Department of Commerce)
- 1939–1940 U.S. Fish and Wildlife Service (U.S. Department of the Interior)—consolidated the Bureau of Biological Survey and Bureau of Fisheries into one agency
- 1956 U.S. Fish and Wildlife Service contained Bureau of Sport Fisheries and Bureau of Commercial Fisheries
- 1970 Bureau of Commercial Fisheries moved to National Oceanic and Atmospheric Administration, National Marine Fisheries Service

Edward E. Prince was the second Commissioner of Fisheries in Canada and provided strong leadership for providing scientific information for fisheries. Prince (1923) supported the development of laboratories and field explorations. The Canadian government conducted a complete survey of fisheries of boundary waters from the Bay of Fundy to the Puget Sound and in 1899 established the first marine biology laboratory at St. Andrews, New Brunswick. Soon thereafter, the Canadian government started the Pacific Biological Station in Nanaimo, British Columbia (Johnstone 1977). Additionally, the Canadian Fisheries and Biological Board began the Georgian Bay Station on Lake Huron and continued research in fish culture techniques (Clemens 1932).

Fish culture was also a priority for the new U.S. government fisheries agency. Among the congressional trade-offs used to gain approval for the U.S. Fish Commission was an agreement to stock American shad in the Mississippi River drainage (Moffitt 2001). The Fish Commission succeeded as an institution, but American shad did not become established in the Mississippi River drainage. The Fish Commission also built the USS *Fish Hawk* to serve as a floating hatchery and distribution system, capturing fish such as American shad and distributing their spawn (Figure 1.2). Fish culture operations were robust, and millions of small fish were released into the waters each year. The research and survey work used several vessels, including the U.S. Bureau of Fisheries' ship, the *Albatross*, that sailed on exploration cruises and collecting trips along both coasts and into the tropics.

Because of the value of fisheries as a commodity, politics have been intertwined in the development of fisheries management. The American Fish Culturists Association, a group of citizens and professionals interested in fish culture, began in 1870 and discussed fish culture, resource management, and politics. One of the association's first actions was to write letters

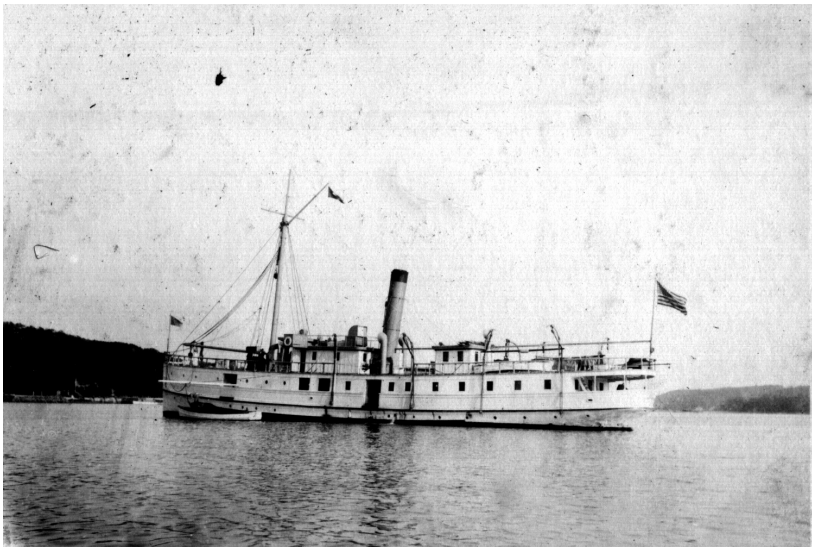

Figure 1.2. The USS *Fish Hawk* was used for distributing eggs of many fish species in an effort to replenish stocks affected by fishing. Photo taken in 1896 by archival photographer Stefan Claesson as part of the Gulf of Maine Cod Project, National Oceanic and Atmospheric Administration, National Marine Sanctuaries (photo courtesy of National Archives).

to the U.S. Congress to urge elevation of federal funding for fisheries because of the clear declines in U.S. fisheries. By 1878, the American Fish Cultural Association provided exhibits at international fisheries exhibitions. In 1885, the American Fish Cultural Association adopted the name of the American Fisheries Society (AFS) with a mission to "promote the cause of fish culture, gather and diffuse information bearing upon its practical successes, and upon all matters relating to the fisheries; the uniting and encouraging of the interests of fish culture and the fisheries, and treatment of all questions regarding fish of scientific and economic character" (Bower 1911).

Records of fisheries activities were published in the *Transactions of the American Fisheries Society* and *Bulletin of the U.S. Fish Commission*. Many states also formed commissions or surveys and published bulletins or special publications. Outreach activities for the general public were a part of meetings of fisheries scientists, and the political leaders at national, state, and provincial levels were enthusiastic about the potential for fisheries development. As early as 1873, *Forest and Stream* magazine published the papers and much of the proceedings of AFS meetings (still the American Fish Cultural Association) before the *Transactions of the American Fisheries Society* appeared in print. This magazine was officially connected to AFS until the magazine moved to New York City in 1875 and eventually changed its name to *Field and Stream* (Moffitt 2001). In addition, the American Association for the Advancement of Science and *The New York Times* published reports of the AFS and other fisheries organizations.

Use of cultured fishes and other aquatic organisms was seen as a way to rehabilitate degraded fisheries and re-establish extirpated fisheries to reverse the results of overharvest of fish stocks and destruction of stream habitats from timber removal, mining, industrial development, and introduced species (Whitaker 1892; Farley 1957; Beeton 2002). The Fish Com-

mission published a pivotal book in 1897, *A Manual of Fish-Culture* (U.S. Commission on Fish and Fisheries 1897). This was a compendium of methods to culture more than 30 species or groups of fish, shellfish, and frogs, with descriptions of the general biology of each species, details on incubation of embryos, and advice on choice of food for rearing. The compendium also included information on methods for transportation and described the operation of 25 stations or hatcheries established across the nation for the purpose of propagation and stocking of fishes. Livingston Stone, the first secretary of the AFS, was a major pioneer and lobbyist for fish culture and was Deputy Commissioner of the Fish Commission. He was sent to California to develop the first federal hatchery, which began operations in 1872 on the McCloud River. Development of the hatchery was assisted by McCloud Wintu tribal members (Yoshiyama and Fisher 2001). Chinook salmon eggs or fry from this site were sent to at least 37 states and 14 countries, including destinations as far away as Italy, Japan, Australia, and New Zealand. During the late 1800s, fish harvest and stocking statistics for inland waters were reported in the *Bulletin of the U.S. Fish Commission* and as frequent notes in *Transactions of the American Fisheries Society*. These volumes included combinations of reports from stations and surveys and information on international fisheries (Ito 1886; Weber 1886).

The newly developed railroads provided access to waters for stocking fish. Special railroad cars were developed for transport of fish and eggs (Figure 1.3). In a report for the Fish Commission, McDonald (1896) stated, "Of the above transportation, 26,212 mile were furnished by the railroads gratuitously, and 48,593 mile were paid for at the rate of 20 cents per mile. The Commission is indebted to the personnel and management of the railroads for much courtesy, consideration, and dispatch."

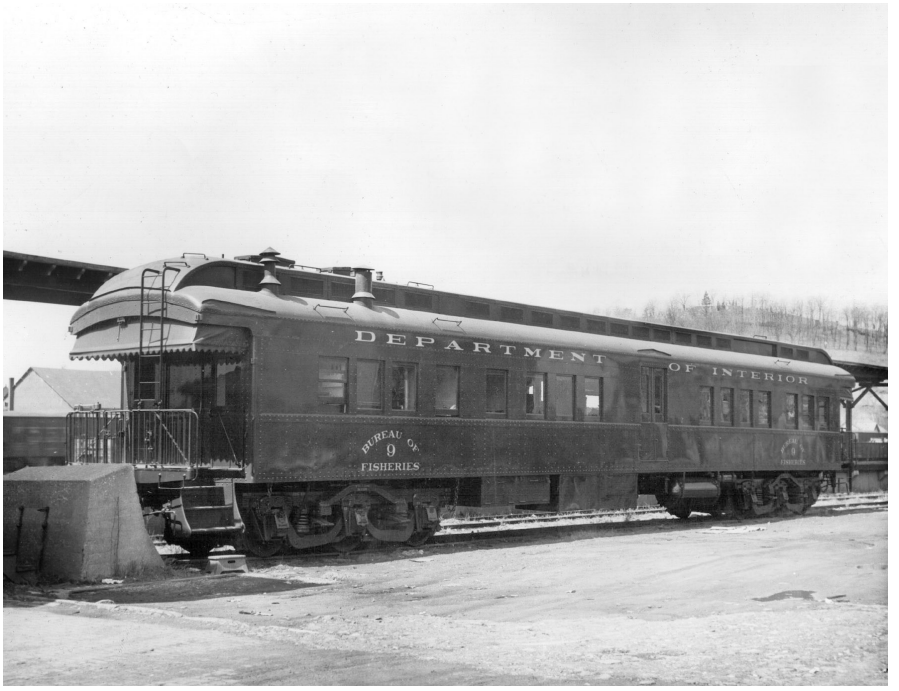

Figure 1.3. The "fish car," a specialized railroad car, was used by the U.S. Department of the Interior (USDI) and also by many states for transporting fishes for stocking in waters across the USA (photo courtesy of USDI).

Development of canning and freezing of fisheries products increased the demand for harvest and subsequently products from Canada and the USA were shipped throughout the world (McArthur 1947; Clark 1985). Specialized fisheries resources developed in different geographic regions. For example, the inland fisheries of the Mississippi River started as subsistence operations, but by the late 1870s the fisheries had developed into organized commercial operations. One of the earliest commercial industries on the Mississippi River was the catfish and buffalo fishery. In 1894 the commercial catch was more than 1.4 million kg (3.75 million pounds) of catfish and more than 2.7 million kg (7.24 million pounds) of buffalo from the upper Mississippi River (Carlander 1954).

Harvests from inland waters were not limited to fishes. Widespread harvest of freshwater mussels from rivers for the button industry, for food, and later for freshwater pearls decimated populations and altered population dynamics of many aquatic species dependent on the mussels (Anthony and Downing 2001). Freshwater mussels had been important protein sources for native peoples living along these rivers. By as early as 1860, mussel harvests were extensive in Arkansas, Florida, Iowa, Kentucky, Michigan, Nebraska, New Jersey, Ohio, Tennessee, Texas, Vermont, Washington, and Wisconsin (Kunz 1893; Kunz 1898; Claassen 1994).

The U.S. Bureau of Fisheries (see Box 1.2) established the Fairport Biological Station in Iowa (Coker 1914) with the mission of learning how to culture freshwater mussels. Between 1914 and 1919 many of the upper Mississippi River and some Great Lakes states adopted harvest regulations, but regulations were too late to save the mussel fisheries and the industry (Figure 1.4). Curiously, interest in freshwater mussels has increased in recent times due to the threatened and endangered status of many species, concerns regarding host fish species that support the glochidial stage of mussels, use of mussel shells as seed material for cultured pearls, and their utility as biological indicators (Neves et al. 1985; Williams et al. 1993).

Figure 1.4. The Fairport Fisheries Station was developed to propagate freshwater mollusks to replace stocks depleted by the button industry and by harvest for food. Photo of station, southwest portion of grounds and principal buildings in 1914 (photo courtesy of USDI).

As the areas along the Mississippi and Missouri rivers developed commercially, "fish rescue" became a management activity. These efforts involved the salvage of sport and commercial species from isolated flood pools after spring floods and the placement of these fishes back into rivers or their transport to other locations. Before completion of extensive flood control efforts, large numbers of fish would be "stranded" each summer in flooded backwater areas of floodplain rivers. Iowa led this program, and other state and federal agencies followed during the 1880s (Box 1.3). Fish rescue activities resulted in introductions of fishes into waters outside their native distributions, but philosophically managers considered sport fish to be important resources to propagate for harvest. The economic advantage of allowing fish to propagate naturally and then moving the juveniles to other locations was highly attractive, and in the 1920s the U.S. federal government adopted fish rescue programs enthusiastically. Near the Fairport Biological Station in Iowa, workers engaged in both fish rescue and mussel propagation. Before rescued fish were released they were exposed to mussel glochidia. By the 1920s, fisheries stations throughout the Mississippi River basin released millions of fish, to which were attached billions of glochidia of commercially-valuable mussel species (Anfinson 2003).

These efforts were designed to sustain commercial mussel fisheries. Unfortunately, overharvest of both fish and mussel populations, municipal and industrial pollution, and siltation from farming and timber practices all contributed to the decline of these resources. Mussel propagation efforts ended by the early 1930s, and at the same time the great era of dam building began to alter fish and mussel habitat across North America. Over the next 40 years dams impounded thousands of river kilometers, fragmented fish and mussel populations, and changed habitat needed by both fishes and mussels.

1.4.2 Regulations and Fish Stocking

The first management actions taken by states and provinces were to enact regulations, mostly regarding access, and to form commissions for management oversight and fish production in hatcheries. The general philosophical approach for management at the time was that fisheries resources could be sustained if they were regulated through harvest or access control and, furthermore, fisheries resources could be enhanced or recovered through stocking of cultured fishes (Bowen 1970). Fish were valued first as food and direct service to humans and secondarily as recreational resources (Viosca 1945). Much of this philosophy was built on agrarian principles by which crops are grown and harvested for human use. The crop could easily be fish, corn, or cattle. With this philosophy, the idea that some species were superior to others was fostered; hence the importation and culture of selected species of commercial or sport fishes and the movement of fishes familiar to European settlers to new locations being settled.

With the development of the concept of conservation of special land resources, the U.S. national park system began with Yellowstone National Park in 1872. For several years Yellowstone was the only park under federal management, and fishing and hunting were allowed because fish and wildlife provided both food and recreation. A fish-stocking program was established for "fishless waters" of the park, and rainbow trout, brown trout, brook trout, and lake trout were stocked. At the same time, eggs from native cutthroat trout from within the park were collected and shipped to many locations across North America. With the expansion of the national parks, similar programs of stocking were begun. The federal management authority for Yellowstone National Park and national monuments rested with the U.S. Army until the National Park Service was established in 1916.

Box 1.3. Locations of Fish Rescue Operations in the Mississippi River System

Fish rescue involved the salvage of sport and commercial species from isolated flood pools after spring floods and the placement of these fishes back into rivers or their transport to other locations. Below are locations and dates of fish operations within the Mississippi River system based on data from Carlander (1954).

State and station name	Dates of operation
Iowa	
Bellevue	1903–1938
Fairport	1917–1938
Gordon's Ferry	1922
Gutterberg	1921–1923, 1939
Montpelier	1923
North McGregor (renamed Marquette)	1904–1939
Illinois	
Andalusia	1928–1930
Cairo	1919–1922
Galena	1917
Lake Cooper	1917
Meredosia	1894–1904, 1918–1922
New Boston	1918
Quincy	1889–1921
Rock Island	1922–1928
Louisiana and Mississippi	
Various	1917–1930
Minnesota	
Brownsville	1921–22
Dakota	1922
Hastings	1924
Homer	1911–1938
Lake City	1917
Latsch Estate	1921–1922
Minneiska	1917, 1922
Minnesota City	1921–1922
Red Wing	1918
Richmond	1917
Winona	1917, 1922
Missouri	
Candon	1919
Clarksville	1919–1920
Hannibal	1920

(Box continues)

Box 1.3. Continued.

State and station name	Dates of operation
Wisconsin	
Ferryville	1921–1923
Fountain City	1917–1921
La Crosse	1904–1938
Lake Pepin	1917–1918
Lynxville	1917–1918
Genoa	1917, 1922–1923, 1931, 1938
Prescott	1921–1922
Trempealeau	1917

In Canada, conflicts regarding authority between national and provincial governments led to the Imperial Fisheries Judgment of 1898. This judgment ruled that jurisdiction and making of laws regarding fisheries were vested in the federal government, and the federal government was the ultimate agent for conservation. The governmental policy was to manage resources to allow maximum production for use and guarantee the supply in perpetuity. Public harbors and fisheries in these waters were also vested in federal control. The judgment declared that property rights, leases, and licenses were vested in the provinces, but the federal government had the right to impose a tax on fisheries licensed by provinces (Young 1952).

Establishment of national parks occurred in Canada with Banff National Park in 1887 via the Rocky Mountain Park Act. As was the case in the USA, from the early 1900s to 1980 fishless lakes in Canadian parks throughout the Rocky Mountains were stocked with fish. Fishes stocked included cutthroat trout, rainbow trout, and brook trout (Donald 1987), and stocking peaked in the 1960s (Solman et al. 1952). The value of fish stocking in the USA and Canada began to be questioned in the late 1800s (Bahls 1992), as in many cases few fish survived and the transfer of nonendemic species to new areas caused alterations of the aquatic systems.

Livingston Stone called for the formation of a National Salmon Park in 1889 as he recognized the importance of preserving a natural environment for native fish populations to reproduce. As a result of Stone's work, Afognak Island, Alaska, was set aside in 1892 as a forest and fish cultural reserve. Stone (1892) wrote "artificial breeding can do a great deal, and has done a great deal, but it cannot be relied upon for a certainty."

1.4.3 Public Trust Doctrine

Conflicts between private and public interests in fisheries have been dynamic and continue to affect fisheries management. Early fisheries management practices were to limit access during certain times of the year and protect breeding areas, but controversy existed regarding these practices given a debate over the benefits of fish culture versus wild spawning of fishes. Dickenson (1898), Commissioner of Fisheries for the state of Michigan, wrote the follow-

ing regarding the public trust doctrine and conflicts in the Great Lakes between commercial interests and public rights: "While the catching and marketing of commercial fish should for the most part be left to private enterprises…The public should be empowered to say, through its authorized agents, whether the title to public property should pass."

Early fisheries managers clearly recognized the tremendous effects from lack of regulation of pollution, dam building, and gear types used for fishing, and many doubted the role that hatchery production could play in rehabilitation. Many of these individuals understood the lack of political will to intervene in the degradation of aquatic habitat effectively and realized that their only tool was fish stocking, even with its limitations. Spangler (1893) described the decimation of fisheries and fish habitats: "What adds to the incomprehensibility is the fact that within the memory of many now living, those streams, lakes, and coasts, almost without exception, teemed with food-fishes. Some of them are still prolific in that respect, but it is a deplorable truth that a very large proportion of them—those inland especially—have been either almost entirely depleted, or their productiveness so diminished as to practically amount to depopulation." He commented on the success of hatchery stocking with some disappointment: "These well-meant endeavors to arrest further diminution have, unfortunately, been only partially successful. This failure has been largely disappointing, for great results were expected from the carefully framed and very stringent statutes, as well as from the distribution of millions of young fish annually from the state hatcheries and from the national hatcheries under the control of the U. S. Fish Commission." Finally, Spangler recommended directives to reclaim control of these waters and increase protection through public education of lawmakers (Box 1.4).

Titcomb (1917) wrote about the need for a permanent stocking policy (Box 1.5) and the conflicting options for increasing yields of fish for consumption. Some of his comments provide an interesting reflection of the role of self-interest and the conflicts of common property versus individual resources.

> Just at this crisis in our history the fishery resources of the country are receiving especial attention and many impractical recommendations have been made by well intentioned persons who are not familiar with the subject, as well as by some who, from selfish motives, want to let down the bars to conservation and to disregard the laws of nature which are the basis for regulations in regard to the methods and seasons for taking fish.
>
> College professors have come forward with recommendations to loosen up on the laws for the protection of fish during the present war. Incidentally I may say that similar appeals are being made to those in authority with reference to the taking of all kinds of game. (Titcomb 1917)

The debate on how far the interaction between the public trust doctrine should encroach on the private rights is something that continues to this day. In 1933 Gordon wrote: "How far should we go in acquiring fishing rights by lease and purchase as Connecticut has done? How far can we go in the improvement of fishing on privately-owned waters? And how far should we go toward encouraging private initiative in the production of fishing for the angler? These are all matters upon which we can agree if we try, but we can't do it without an acceptable policy."

Even within federal authority, there was confusion about who had the responsibility to manage within national forests and where the regulative authority resided. Davis (1935) reported: "The Bureau of Fisheries assumes responsibility for conducting research necessary

Box 1.4. Spangler's Policy Directives regarding Fisheries Management in Public Waters

The following eight policy directives were aimed at reclaiming authority for management over public waters, increasing protection of public waters through education of lawmakers, and defining responsibilities (Spangler 1893).

1. The inculcation, to the extent of a full comprehension, of the truth that the fish in the public waters of a State are the property of that State, and the taking of them, by any means, a privilege.

2. That the guardianship of such waters and their finny inhabitants is the sworn duty of the people's representatives, just as is the guardianship of any other kind of public property.

3. That the laws enacted in order to make that guardianship effective are binding upon and demand implicit obedience from all.

4. That it is the sworn duty of sheriffs, magistrates, constables, and fish wardens, as far as they have cognizance and jurisdiction, to arrest or cause to be arrested and tried, and without fear or favor, any and all offenders against the restrictive statutes.

5. That it is a patriotic obligation resting upon all citizens to aid the authorities in their endeavors to restore the original fecundity of American waters, for the reason that such restoration would benefit the country annually to the extent of millions of dollars.

6. That it is the duty of the people's representatives in Congress to enact laws that will place the menhaden and other coast fisheries under such restrictions as will prevent the edible fishes from being so largely and wastefully diminished in numbers as they have been for years past, and still are.

7. That artificial propagation, judicious distribution, and the thereafter protection of edible fishes should be prosecuted to the fullest needed extent by every State and Territory.

8. That fish-protective associations, being potent helpers in the work of restoring edible fish fruitfulness to our waters, should be warmly encouraged in every State, and the powerful aid of the newspaper press of the entire country evoked in its behalf.

Box 1.5. Recommendations for Fish Stocking Policy

Titicomb (1917) saw the need for a permanent stocking policy and recommended the following.

1. List the waters under your jurisdiction and establish a permanent policy as to the species with which you will specialize in each.

2. Prohibit the introduction of any species of fish foreign to the waters, unless approved by the commission and also the introduction of any species contrary to the established policy; this to include connecting privately stocked and controlled waters.

3. Co-operate with the United States Bureau of Fisheries in the adherence to a permanent policy as to the selection of species for restocking waters in which both authorities are interested.

4. Give the commissioners power to exterminate and market rough fish at any time and by any means, either directly or by the issuance of licenses. By rough fish is meant those kinds which are antagonistic to the maintenance of a successful permanent policy already decided upon. It is immaterial for statistical results whether fish are taken by nets or by hook and line. How fish are taken should be regulated according to local conditions and effects upon property values. In this connection the value of recreation, as an asset in its effect upon property values, must not be under rated.

5. The selection of species for planting in any water system should be determined with reference to a permanent policy, in the hope that our successor will continue the policy which we have established.

6. A campaign of education as to the importance of care in planting should be waged in order to save wastage.

7. Educate the public also to appreciate private property rights in fish when privately propagated entirely under the control of the owner.

8. In the present crisis, conservation of our resources is of greater importance than at any previous time in our history, and proper regulations for the protection of fishes is as important as fish propagation.

9. The farming of our waters should be with a view to maximum annual production of the kind of fish crop that, after careful investigation, it is decided to specialize in.

10. The retention in office of men conversant with the propagation and protection of fishes is essential to insure the best results.

(Box continues)

Box 1.5. Continued.

11. Finally, build for the future generations regardless of present political conditions. Leave a monument for yourselves by setting an example for your successors whether of the same political faith or not. Set a pace for them and turn over to them such complete records of your work that there can be no excuse for not following the permanent policy which you have established.

to lay the foundations for fishery management throughout the national forests and will also provide the fish required for stocking forest waters. On the other hand the Forest Service assumes responsibility for the administration and operation of management plans and will also undertake stream and lake improvement and all stocking work under instructions and recommendation provided by the Bureau of Fisheries." This agreement ceded public trust doctrine authority for regulating the fishery in the forests to the respective states.

1.4.4 A Critical Turning Point in Defining Management

Between 1910 and 1970 many dams were constructed on major rivers of North America for power, flood control, transportation, and irrigation with little consideration to the environmental effects of this development. Federal power development was instrumental in providing efficient and inexpensive power for rural areas (Figure 1.5). The combination of river development and overfishing was particularly pronounced in the Columbia River, and attitudes regarding fisheries and other uses for the river were mixed. As early as the 1870s, the U.S. Army Corps of Engineers altered the Columbia River to make it more navigable. The development of a large industry of salmon canneries reached peak harvest in the 1880s and again during World War I. Chapman (1986) estimated the likely catches at the peak of the fishery (mostly 1880s) included 1.7 million summer Chinook salmon; 382,000 steelhead; 1.1 million fall Chinook salmon; 400,000 spring Chinook salmon; 476,000 coho salmon; 1.9 million sockeye salmon; and 359,000 chum salmon. During this time, a general lack of regulation of the fisheries resulted in overfishing of stocks, as gas engines and refrigeration made vast areas of the world's ocean possible for fisheries exploitation. More federal assistance for fisheries was requested from both fishers and states.

In 1930, the Mitchell Act in the USA provided funding for management improvement, fisheries engineering, and fish culture in the Columbia River basin. This legislation approved construction of more than 25 fish culture stations, three new laboratories, and two fish distribution railroad cars over the next 5 years. The results from these fish culture operations were mixed, and fisheries recovery was complicated by increased habitat alterations associated with river development, particularly water withdrawal for agriculture and urban areas and new dams for hydropower, irrigation, transportation, and flood control. For many years, the development of the river for human use rather than natural fish production was favored (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1999). Initially, two major dams were built, Bonneville and Grand Coulee dams. In 1937, the Bonneville Power Administration was established within the Department of the Interior to manage these projects. From 1932 to 1975, 19 major dams were built on the Columbia and

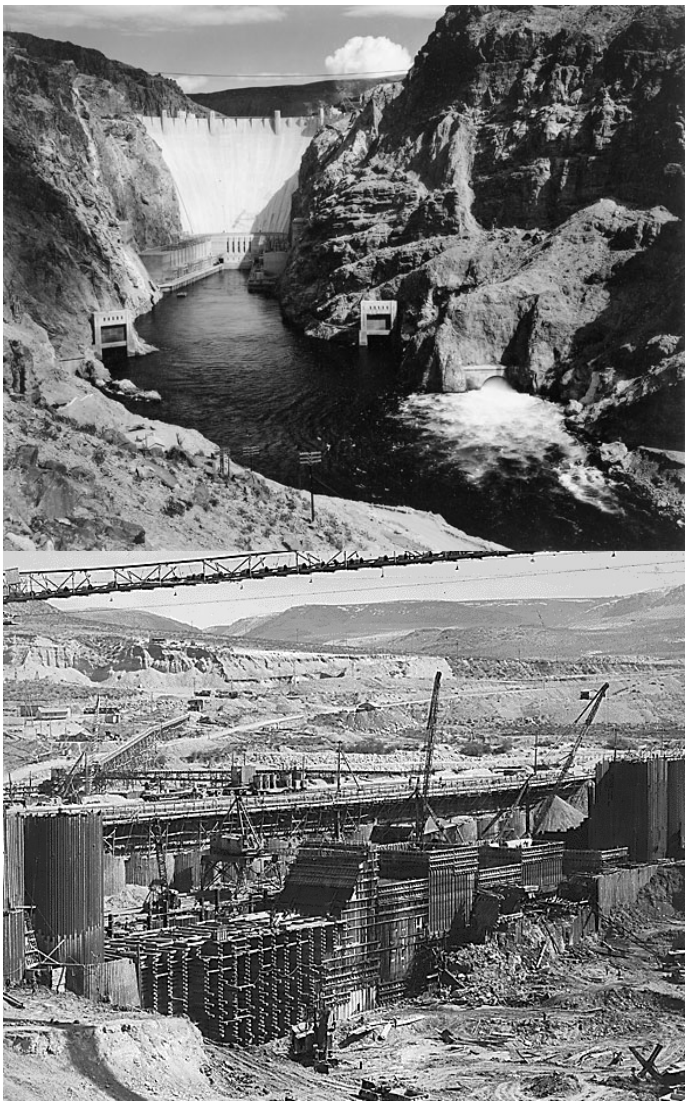

Figure 1.5. Building of dams has occurred throughout history, but during the early to mid 1900s in the USA the efforts were increased to provide rural electrification, flood control, irrigation water supply, and navigation. These two dams altered major river systems of the west: **(top)** Boulder Dam (renamed Hoover Dam) on the Colorado River between Arizona and Nevada (photo by Ansel Adams, courtesy of the National Park Service, USDI) and **(bottom)** excavation behind coffer dam during construction of the Grand Coulee Dam on the Columbia River in Washington in 1936 (photo courtesy of Bureau of Reclamation, USDI).

Snake rivers, and many more dams were built on tributaries. These dams not only caused problems for fish passage but also altered instream flows and biological productivity. Adult salmon passage via fishways was provided at dams on the main stem of the Columbia River downstream from Chief Joseph and Hells Canyon dams, but the problem of juvenile salmon downstream passage was not addressed, except with more hatcheries as mitigation (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1999).

In contrast, development of the nearby Frazier River, British Columbia, was debated, and plans to erect dams throughout the drainage were not implemented. These fish populations remained intact and self-sustaining, and the economy of the region moved in a different direction (Evenden 2004).

In the first half of the 20th century, the most influential act to protect fisheries in the USA was the Fish and Wildlife Coordination Act of 1934. This act provided the first basic authority for the secretaries of Agriculture and Commerce to provide assistance to federal and state agencies to protect game and fur-bearing animals and to study the effects of pollution on wildlife. The definition of wildlife was formally defined to include birds, fish, mammals, and other classes of wild animals and aquatic and terrestrial vegetation upon which wildlife depends. The act authorized protecting and surveying wildlife resources on public lands. It also directed the Bureau of Fisheries to use water resources for fish culture stations and migratory bird resting and nesting areas and required federal agencies to consult with the Bureau of Fisheries prior to the construction of any new dams and to provide for fish migration.

The first half of the 20th century was a critical turning point in defining management priorities and values, and the AFS took a lead to help establish the first North American Fish Policy, adopted by the AFS in 1938 and embraced by states and provinces through their governmental associations. This policy outlined state, provincial, national, and international relations; the roles of administration and research; and the need for management. The policy recognized that change was inevitable, and practices would evolve. The policy document also contained the wording that "fish are crops, capable of being conserved, restored, and increased through sound management practices" (*Transactions of the American Fisheries Society* 68:40–51). This established the economic and social roles of fish and fisheries: "fishery resources were important elements of national wealth and not a minor incident in the development of power, flood control, drainage, irrigation, reclamation, and recreational projects, as has been done in the past." A further component of this document was the "objective of fisheries research," which included guidance for lake and stream surveys, fisheries statistics, and other standard practices. It included suggestions that stocking should not occur in waters that had good fishing opportunities for native fish species.

In 1940, the Bureau of Fisheries and Bureau of Biological Survey were consolidated into the U.S. Fish and Wildlife Service and placed in the Department of the Interior. Through the authority of the Fish and Wildlife Coordination Act the new agency was required to consult regarding water resource projects and their effects on fish and wildlife resources. In 1946, this act was amended to require consultation with the U.S. Fish and Wildlife Service and the fish and wildlife agencies of states where any body of water was controlled or modified by any federal agency in order to prevent loss and damage of wildlife resources. However, the amendments specifically exempted the Tennessee Valley Authority from these provisions. Additional amendments were added in 1958 to define and require equal consideration and coordination of wildlife conservation with other water resource development programs. At this time, the act also authorized the Secretary of the Interior to provide public fishing areas and accept donations of lands and funds.

In Canada prior to 1930, the federal government controlled all Crown lands in Manitoba, Saskatchewan, and Alberta. In 1930, the Constitution Act transferred control of Crown lands and public trust resources via the Natural Resource Transfer Act to each of the three prairie provinces, with the exception of remaining tracts of Crown lands such as First Nation reserve lands and national parks. Wording from the Canadian Constitution Act affirms this move and

states "Except as herein otherwise provided, all rights of fishery shall, after the coming into force of this agreement, belong to and be administered by the Province, and the Province shall have the right to dispose of all such rights of fishery by sale, license or otherwise, subject to the exercise by the Parliament of Canada of its legislative jurisdiction over sea-coast and inland fisheries."

1.4.5 Interjurisdictional Management

There have been many debates about how to manage shared resources such as the Great Lakes. Contributions written by Joslyn (1905) reflect some of the dilemma that the states faced: "[E]fforts of a single state, no matter how well directed, were wholly inadequate to meet the demands and accomplish practical results." He later referenced the take of lake sturgeon in unregulated fashion and commented on "imported Russian caviar" that was made and put up at Grand Haven, Michigan, from lake sturgeon harvested from the Great Lakes. This industry carried on to such an extent that lake sturgeon was almost exterminated from these waters.

In 1909, the Boundary Waters Treaty established the International Joint Commission of Canada and the USA. The treaty created a process for cooperation in the use of all the waterways that crossed the border between the two nations, including the Great Lakes. However, it was nearly 40 years later that a bi-national fisheries management agreement was negotiated. The 1955 Convention on Great Lakes Fisheries created the Great Lakes Fishery Commission, one of the most successful models for joint fisheries management in the world.

The USA and Canada have had several interjurisdictional disputes regarding fishing rights. In 1870, the Canadians forbade foreign fishermen from fishing in Canadian waters. The Washington Treaty was drawn in 1873 to allow U.S. fishermen access to inshore waters of Canadian fisheries in return for Canadian access in the USA, including U.S. fishing rights on the Grand Banks and free entry of Canadian fish to U.S. markets. The Great Lakes was a site of conflict regarding harvest, and limited markets in Canada were a problem and source of misunderstanding between the countries (Bogue 2000).

The concept of reciprocity was established early on with a mutual reduction of duties charged on goods exchanged between Canada and the USA. The movement toward reciprocity began in 1846–50 in Canada's west and the maritime colonies, particularly New Brunswick. British diplomats negotiated in Washington, D.C., without success, when a dispute developed over the rights of American fishers in British coastal waters in North America. Both governments became anxious for a comprehensive settlement to dispose of the reciprocity and the fisheries issues. Even today, many fisheries negotiations include issues of reciprocity.

1.4.6 Contemporary Management Goals

The environmental, social, and economic value of different fishes, and whether they were considered native or introduced species, has changed over time (Lucas 1939; Dill and Cordone 1997; Fuller et al. 1999; Rahel 2002). For many years, the nongame or noncommercial native fishes were considered "rough or trash fish" and were removed from systems to enhance desirable game fish. Reports such as counts of the number of trout eggs found in the stomachs of bullheads and suckers (Atkinson 1931) and the observations of predation on fish by piscivorous birds and reptiles (Salyer 1933; Huntsman 1938) supported predator removals.

The consequences of the wide introductions and selective removal of different aquatic species were not considered critically until more recent times. Management programs organized in many locations to reduce or eliminate specific fish populations produced various outcomes (Meronek et al. 1996; Clarkson et al. 2005; Chapter 8, this volume). Selective fish removal activities continue to be used and evaluated as tools for different management objectives, with some directed at removing nonnative species to restore ecosystems and others focused on native species that have increased in numbers due to habitat alterations (e.g., Beamesderfer 2000; Weidel et al. 2007; Herbst et al. 2009). Today over 200 nonindigenous fish species have been stocked in waters of North America, and the management goals for fisheries have evolved (Nelson 1965; Benson 1970; Leach and Lewis 1991).

Unfortunately, fisheries and water resources were not considered at more holistic community and ecosystem levels until the modern conservation movement. During the late 1960s to 1970s, increased awareness of threats to environmental and human health resulted in substantial national legislation in the USA, including the Endangered Species Act, National Environmental Policy Act, Clean Air Act, Coastal Zone Act, and Fisheries Conservation and Management Act. These active U.S. public laws are organized under 49 titles of the U.S. Code, with Title 16 focused on conservation. However, legislation appears elsewhere; for example Title 33 contains laws regarding navigable waters, including the Federal Water Pollution Control Act Amendments of 1972, thereafter called the Clean Water Act. Title 50 concerns most specific codes written for fish and wildlife.

The Canadian Environmental Protection Act was passed in 1999 and regulates toxic substances and ocean dumping (Boyd 2003). According to Boyd (2003), federal and provincial governments have nonbinding water quality guidelines that establish the maximum allowable concentrations of substances in water for particular uses. Under the Fisheries Act, the federal government of Canada can call for minimum flows for fishes and fish passage and regulate substances that can be harmful to fishes. Water rights in western Canada are allocated on a first-come, first-served basis; in eastern Canada, water rights are based on property ownership, meaning property owners enjoy riparian rights to use adjoining waters. These regional differences are similar to those in the USA (see Chapter 4). The Species at Risk law was passed in 2002 and protects all aquatic and terrestrial species on federal lands. The provinces are directed to protect species that are on provincial and private lands.

1.4.7 Aboriginal Rights

Many native peoples' rights to healthy lives, their territory, and their fishing resources were disregarded during the European settlement until some key social factors and legal decisions mandated new ways of thinking (e.g., Scott 1923; Lurie 1957; Landeen and Pinkham 1999). A representative example of the attitude toward development of land and disregard for Native American rights in the USA is provided in the wording of the Pacific Railway Act of 1862 (12 U.S. Statutes at Large 489, section 2):

> That the right of way through the public lands be…granted to said company for the construction of said railroad and telegraph line; and the right…is hereby given to said company to take from the public lands adjacent to the line of said road, earth, stone, timber, and other materials for the construction thereof; said right of way is granted to said railroad to the extent

> of two hundred feet in width on each side of said railroad when it may pass over the public lands, including all necessary grounds, for stations, buildings, workshops, and depots, machine shops, switches, side tracks, turn tables, and water stations. The United States shall extinguish as rapidly as may be the Indian titles to all lands falling under the operation of this act.…

An active role for indigenous American people in fisheries management emerged in the 1970s and challenged existing paradigms for fisheries management. In the USA, because of formal signed treaties with many Indian nations, rights for fish and wildlife resources have been slowly recovered and defined through the courts. As a result of this process, values of traditional knowledge and cooperative management techniques have been recognized as key parts of management decisions, and aboriginal Americans have emerged as important forces in inland fisheries management.

Landmark Native American rights decisions in the USA occurred in association with Columbia River and Puget Sound Indian tribal challenges. The basis for these decisions came from the fact that Isaac Ingalls Stevens, the first governor and Superintendent of Indian Affairs of Washington Territory, had summoned the tribes to a series of meetings in 1854 and 1855 at which they were invited to sell their lands to the USA at a price of something less than half a cent per acre. Governor Stevens was provided this authority to negotiate treaties because of the Donation Land Law Act of 1850 for homesteading. In treaties negotiated with tribes, wording was provided as follows for Indian fishing rights: "The right of taking fish, at all usual and accustomed grounds and stations, is further secured to said Indians, in common with all citizens.…" Since the tribal members did not speak English, all negotiations for these treaties were translated into Chinook (a language used by many tribes for trade) by an interpreter and translated again into the various languages of the tribes. These few words quoted above have been debated by lawyers, and throughout this debate courts agreed that only a general meaning of these words could have been conveyed to the Indians by the two-stage translation process from English through the Chinook trade language. Also important in understanding the context of the negotiations for native claims at this time is to recognize that nearly three-quarters of the population in the region were indigenous peoples (Clark 1985). Therefore these rights were not minority issues.

The challenges by Native American tribes for fishing rights in states included *Sohappy v. Smith*, filed in U.S. District Court for the District of Oregon to secure the rights of the Columbia River Indian tribes to harvest salmon. This challenge was based on the Nez Perce Treaty of 1855, signed by Washington Territorial Governor Isaac Stevens, General Palmer, and Chief Looking Glass in Walla Walla, Washington. Governor Stevens also signed three other treaties with Columbia Basin tribes during 1855: Umatilla, Warm Springs, and Yakima. Federal Circuit Court Judge Robert Belloni ruled in 1969 that states could not restrict Indian fishing except for clearly defined conservation reasons and Indians were entitled to a fair share of the fishery. *Sohappy v. Smith* was the first of a series of cases known as *U.S. v. Oregon* (Marsh and Johnson 1985; Landeen and Pinkham 1999).

In challenges brought by treaty tribes from Puget Sound, also Stevens' Treaty tribes, Federal Circuit Court Judge George Boldt in *U.S. v. Washington* ruled in 1974 that "fair share" was half the allowable catch destined for usual and accustomed fishing places. Currently, each year of the season, negotiations with tribal harvest biologists of the Stevens Treaty tribes and state and federal agencies determine the precise number of fish allowed for the 50% take in these waters. This decision on allocation has been upheld in many challenges and has been extended to the rights to harvest shellfishes by the Puget Sound tribes (Combs 1999).

In the 1955 Convention on Great Lakes Fisheries that resulted in the establishment of the Great Lakes Fishery Commission, the concerns of aboriginal American and Canadian tribes were not considered. Native American rights were originally established in lakes Superior, Huron, and Michigan in 1836 through a treaty between the U.S. government with five Chippewa and Ottawa tribes. However, it was not until 1985, through the challenge of the *U.S. v. Michigan* (Western District Court of Michigan 1985), that fishing rights of Bay Mills Indian Community, Sault Ste. Marie Tribe of Chippewa Indians, Grand Traverse Band of Ottawa and Chippewa Indians, Little River Band of Ottawa Indians, and Little Traverse Bands of Odawa Indians were established. Recently, these rights were renegotiated via an extensively mediated process in a 2000 consent decree to establish fishing allocation, management, and regulation in lakes Michigan, Huron, and Superior ceded waters (Western District Court of Michigan 2000). The consent decree provided for joint fisheries management on Great Lakes areas within the 1836 treaty-ceded waters. In 2007, 1836 treaty-ceded fisheries harvest rights were extended to inland waters with another consent decree. Both of these consent decrees follow similar allocation rules of the Pacific coast adjudications, as do other court cases regarding Indian treaty areas in Wisconsin and Minnesota.

Although the tribal rights of indigenous peoples in the USA are better recognized, the First Nations rights in Canada are still under negotiation and evolution, and Canadian federal control allows provinces to retain public trust ownership of lake and riverbeds and riparian rights to fishes. In Canada, resolution of First Nations' rights has been more complex as treaties were not established, and documents and authorities are in continual deliberations. In British Columbia, First Nations fishing rights were summarized by Jones et al. (2004). They detailed the three different categories of fisheries in aboriginal settings: (1) a fishery for food, (2) social and ceremonial fishery (aboriginal food fishery), and (3) commercial fishery. The aboriginal food fishery is recognized by the Supreme Court of Canada as a right enshrined in the constitution and thus has priority over all other fishing rights. The commercial aboriginal fishery allocations are negotiated on a case-by-case basis, depending on the respective stock assessment and allocation.

The concept of co-management of fisheries with aboriginal Americans is now fully recognized as the proper approach for managing most tribal claims; however, the methods and approaches are varied and in development both in Canada and the USA. Management approaches include cooperative management, collaborative management, and management by community (Busiahn 1989; Tipa and Welch 2006). In 2007, the U.S. Bureau of Indian Affairs listed 561 tribal entities within the contiguous 48 states that have status as Indian tribes (U.S. Federal Register 2007), and each has a stake in co-management of fisheries.

1.4.8 Sport Fish Management

Fishing as sport was brought to North America from Europe. Even though authority for sport fish management was established for the states and provinces, there was little money available for inland fisheries research and monitoring early in the 20th century. The financing was generally derived from license sales, and there was difficulty in establishing infrastructure in both states and provinces. Palmer (1912) wrote that licenses for hunting game for sport, as distinguished from market hunting licenses, were gradually adopted after the beginning of the 20th century. By 1912, fishing licenses were required of residents in 34 states and 6 provinces, and nonresidents were required to purchase licenses in all states and provinces

(Palmer 1912). At that time, several of the states exempted women and children from fishing license requirements.

During the days of the state and provincial fish commissions in the early 20th century, fisheries surveys were conducted within each state or province, but few of these governments had fisheries management plans or cohesive strategies. A pivotal point for developing infrastructure in states for fisheries management was the passage of the Federal Aid in Sport Fish Restoration Act of 1950, also known as the Dingell–Johnson Act. The Wildlife Restoration Program had begun in 1938 following the passage of the Federal Aid in Wildlife Restoration Act, often called the Pittman–Robertson Act. As a result of the Pittman–Robertson Act, states began to develop wildlife management programs to restore, conserve, manage, and enhance wildlife resources and to provide for public use and benefits from these resources. After World War II, this philosophy was expanded to include fisheries restoration and enhancement via the Dingell–Johnson Act. As a result of this funding, the staffs of state agencies dealing with freshwater fisheries increased from a few hatchery workers to include fisheries managers and researchers by the mid-1950s. The act was a tremendous success, and by 1979 the total budgets for 50 state fisheries agencies were US$143 million dollars (Sullivan 1979). The expansion of the federal aid in sport fish restoration program occurred in 1984 with the passage of the Wallop–Breaux Act, which increased revenue even further by including excise taxes on additional fishing equipment and federal taxes from small boat fuels. This program today provides funds to restore and manage sport fishery resources and to provide public use and benefits from these resources. In a survey conducted in 2001, inland fisheries management programs in individual states employed an average of 106 full-time permanent employees, varying from 6 in Delaware to 416 in Minnesota, and states spent an average of $9,994,571 annually on their inland fisheries programs, varying from $432,000 in North Dakota to $39,276,052 in Minnesota (Gabelhouse 2005).

Federal aid for fisheries was patterned after the Pittman–Robertson Act for wildlife and used the 10% excise tax initiated during World War II on fishing rods, reels, lures, baits, and flies for dispersal to state fisheries agencies and required matching funds from states to support all aspects of recreational fishing. Allocation to states was based 60% on the number of licensed sport anglers and 40% on the land and water area of the state. The expansion of money for fisheries brought with it a dilemma of success. At the outset, there was the question of whether or not a public conservation agency should employ only management technicians and "farm out" its research problems to colleges and universities. In the 1940s and 1950s there were debates in the AFS as to the best role of fisheries agencies and whether research should be more removed from management agencies. Universities were happy to invite research into their infrastructure (Harkness et al. 1950), but most state agencies chose to develop their own research infrastructure with support from universities. Federal support for research and training for fisheries biologists came with the addition of Cooperative Fishery Research Units to the successful Wildlife Research Units. The Cooperative Units Act (P.L. 86–686) was passed by the U.S. Congress in 1960 and authorized the unit program as a separate budget item within the U.S. Fish and Wildlife Service. Starting in 1961, the fishery units increased opportunities for training of fisheries professionals. These and other training programs have successfully trained fisheries and aquatic biologists that are now in private, public, and tribal agencies and institutions throughout the world. Today, recreational and commercial fisheries are assessed and evaluated by state fisheries agencies that have extensive research infrastructure and receive external funding for additional research.

1.4.9 Evolution of Scale and Complexity in Management

As a result of growing demands for natural resources by expanding human populations, changing human values toward the environment, and accompanying legislative mandates and regulations (Box 1.6), the complexity of fisheries management changed rapidly from the 1960s to the turn of the 21st century and beyond. Marine and inland fisheries management moved from its traditional single-species focus on maximum sustainable yield and optimum sustainable yield to more holistic science-based approaches mandated by legislative authorities to consider the linkages between terrestrial and aquatic systems. These new paradigms included incorporation of ecosystem considerations, environmental fluctuations, and socioeconomic factors (Caddy 1999). The stock–recruitment tools for exploited stocks provided by the deterministic models of Beverton and Holt (1957) and Ricker (1975) were improved and modified with a suite of models and multidimensional approaches (Walters and Korman 1999; Quinn 2003; Walters and Martel 2004). Since the 1990s, inclusion of Bayesian and time series methods in stock–recruit models have allowed for explicit specification of uncertainty (Quinn 2003; Koen-Alonso 2009). These new approaches in management include tools to understand and integrate differences in genetic stock structures, changing species structures and predator–prey dynamics, bioenergetics, ecosystem dynamics, and human values (Walters et al. 1997; Caddy 1999; Rothschild and Beamish 2009).

Because of species introductions, xenobiotics, and trophic changes, fish stocks in the Great Lakes and other systems that were depleted from overharvest have not recovered by simply reducing fishing mortality or stocking (Coble et al. 1990; Holey et al. 1995; Mercado-Silva 2006). The increased pressures from human alterations of habitat, nonpoint and point source pollution, and species introductions have led to restructured habitats and altered ecosystem dynamics with enormous consequences (Hatch et al. 2001; Anderson 2009). Conflicts over freshwater resources have emerged as key driving forces in inland fisheries management (Reisner 1989; Postel et al. 1996; Postel 2000). In the USA, the Clean Water Act of 1972 called for improved water quality and restoration of ecosystem services such as recreation and fish habitat (Brown et al. 2009). In Canada, Fisheries and Oceans Canada (DFO 1986) began enforcing a principle of no net loss of habitat under its authorization via the Fisheries Act, section 35(2) (Harper and Quigley 2005). The results of these mandates and economic and social conflicts led to major restoration and mitigation programs across the inland and coastal landscapes, and such programs continue to emerge to restore the ecological functions of aquatic systems (Poff et al. 1997; Naiman et al. 2000; Palmer et al. 2009). Prominent programs established with interagency and public agreements include the Columbia River Basin Fish and Wildlife Program, developed in the early 1980s (Williams et al. 1999); the California Central Valley Project and CALFED Bay–Delta Program, which evolved in the late 1980s (Schick and Lindley 2007; Brown et al. 2009); Mississippi Interstate Cooperative Resource Agreement, established in 1989 (Montgomery 1991); the Colorado River Basin Restoration in the mid-1990s (Gloss et al. 2005; Adler 2007); and the Klamath River Basin mitigations currently underway (Committee on Endangered and Threatened Fishes in the Klamath River Basin 2004; Committee on Hydrology, Ecology, and Fishes of the Klamath River 2008).

In addition to recognition of the complex biological and hydrological cycles, restoration projects expanded the role for social sciences in management and increasingly acknowledged the footprint of the human environment on the greater ecosystem (Stevens et al. 1997; Van

Box 1.6. Selected U.S. Legislative Acts

Below are summaries of selected U.S. legislative acts that provided authority for conserving or managing fish, fish habitat, or related environmental components. The acts are organized in chronological order.

The Rivers and Harbors Act (1899). Passage of this legislation aimed at prohibiting the obstruction of navigable waters gave the U.S. Army Corps of Engineers (ACE) increased authority to regulate activities in the U.S. rivers. The construction of bridges, dams, or dikes across navigable waters required approval by the Chief of Engineers, the Secretary of the Army, and the consent of the U.S. Congress, and the law outlawed the deposit of refuse in these waters. In 1905, ACE established a permit system to implement this congressional act. Anyone who wished to change the course, location, condition, or capacity of a water body now had to apply for permission from the local ACE district office.

The Antiquities Act (1906). This bill set to preserve all objects of historic or cultural interest that are situated upon lands owned or controlled by the government of the USA. As with natural parks such as Yosemite and Yellowstone, the governing prerequisite behind the preservation of what this bill called "national monuments" was that the land in question offered no economic value beyond that of scenic interest. The Antiquities Act granted exclusive decision-making power to the President, and it was through this piece of legislation that Theodore Roosevelt earned the lasting admiration of the preservationists.

The National Park Service Organic Act (1916). This act was a historic departure from previously unregulated land development activities in the West. This legislation established the National Park Service, and stewards were charged with the duty to conserve the scenery, the natural and historic objects, and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as would leave them unimpaired for the enjoyment of future generations.

Federal Food, Drug, and Cosmetic Act (1938). This is the nation's major law regulating contaminants in food, including pesticides. The Food and Drug Administration (FDA) implements most of this law; the Environmental Protection Agency (EPA) carries out its pesticide standard setting provisions (with FDA enforcement). See also Food Quality Protection Act.

Federal Insecticide, Fungicide, and Rodenticide Act (1947). This law controls the sale, distribution, and application of pesticides; it was amended in 1972, 1988, and 1996. See also Food Quality Protection Act.

(Box continues)

Box 1.6. Continued.

Atomic Energy Act (1954). This legislation was passed because of the government's keen interest in monitoring the commercial and national defense uses of atomic energy. Government concerns included radiation hazards and the disposal of radioactive waste. The act established a general regulatory structure for construction and use of nuclear power plants and nuclear weapons facilities. Unlike most environmental statutes, it does not permit citizen suits and affords only limited opportunities for suits by public interest groups.

The Wilderness Act (1964). In this act, Congress recognized that the expansion of human activities posed a threat to the existence of natural lands and gave a legal definition to wilderness and protection to lands so designated.

Wild and Scenic Rivers Act (1968). The act established the policy that certain rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. The act both identifies specific river reaches for designation as wild or scenic and provides criteria to be used for classifying additional river reaches.

National Environmental Policy Act (1970). The first of the modern environmental statutes, this act became effective 1 January 1970. The National Environmental Policy Act created environmental policies and goals for the country and established the President's Council on Environmental Quality. Its most important feature is its requirement that federal agencies conduct thorough assessments of the environmental impacts of all major activities undertaken or funded by the federal government. Many states have enacted similar laws governing state activities.

Clean Air Act (1970). This legislation sets goals and standards for the quality and purity of air in the USA. By law, it is periodically reviewed. A significant set of amendments in 1990 toughened air quality standards and placed new emphasis on market forces to control air pollution.

Clean Water Act (1972). This legislation establishes and maintains goals and standards for U.S. water quality and purity. It has been amended several times, most prominently in 1987 to increase controls on toxic pollutants, and in 1990, to address more effectively the hazard of oil spills.

Coastal Zone Management Act (1972). This act provides a partnership structure allowing states and the federal government to work together for the protection of U.S. coastal zones from environmentally harmful overdevelopment. The program provides federal funding to participating coastal states and territories for the implementation of measures that conserve coastal areas.

(Box continues)

Box 1.6. Continued.

Marine Mammal Protection Act (1972). This law seeks to protect whales, dolphins, sea lions, seals, manatees, and other species of marine mammals, many of which remain threatened or endangered. The law requires wildlife agencies to review any activity—for example, the use of underwater explosives or high-intensity active sonar—that has the potential to "harass" or kill these animals in the wild. The law is our nation's leading instrument for the conservation of these species and is an international model for such laws.

Endangered Species Act (1973). This legislation is designed to protect and recover endangered and threatened species of fish, wildlife, and plants in the USA and beyond. The law works in part by protecting species habitats.

Safe Drinking Water Act (1974). This act establishes drinking water standards for tap water safety and requires rules for groundwater protection from underground injection; it was amended in 1986 and 1996. The 1996 amendments added a fund to pay for water system upgrades, revised standard-setting requirements, required new standards for common contaminants and included public "right to know" requirements to inform consumers about their tap water.

Federal Land Policy and Management Act (1976). This act provides for protection of the scenic, scientific, historic, and ecological values of federal lands and for public involvement in their management.

Fisheries Conservation and Management Act (1976). Better known as the Magnuson–Stevens Act, this legislation governs the management and control of U.S. marine fish populations and is intended to maintain and restore healthy levels of fish stocks and prevent overharvesting.

Resource Conservation and Recovery Act (1976). This legislation seeks to prevent the creation of toxic waste dumps by setting standards for the management of hazardous waste. Like the Comprehensive Environmental Response, Compensation and Liability Act (see below), this law also includes some provisions for cleanup of existing contaminated sites.

Toxic Substances Control Act (1976). This law authorizes the EPA to regulate the manufacture, distribution, import, and processing of certain toxic chemicals.

Surface Mining Control and Reclamation Act (1977). This act is intended to ensure that coal mining activity is conducted with sufficient protections of the public and the environment and provides for the restoration of abandoned mining areas to beneficial use.

(Box continues)

Box 1.6. Continued.

Comprehensive Environmental Response, Compensation and Liability Act (1980). Commonly referred to as "Superfund," this law requires the cleanup of sites contaminated with toxic waste. In 1986, major amendments were made in order to clarify the level of cleanup required and degrees of liability. This legislation is retroactive, which means it can be used to hold liable those responsible for disposal of hazardous wastes before the law was enacted in 1980.

Coastal Barrier Resources Act (1982). The act (reauthorized and amended in 1990) established a policy that coastal barriers, in certain geographic areas of the USA, and their adjacent inlets, waterways, and wetland resources are to be protected by restricting federal expenditures that have the effect of encouraging development of coastal barriers. The act provided for a Coastal Barrier Resources System, which identified undeveloped coastal barriers along the Atlantic and Gulf coasts, including islands, spits, and bay barriers that are subject to wind, waves, and tides, such as estuaries and nearshore waters. These areas were outlined on a set of maps dated 30 September 1982 and approved by the Congress.

Emergency Planning and Community Right-to-Know Act (1986). This law requires companies to disclose information about toxic chemicals they release into the air and water and dispose of on land.

Oil Pollution Act (1990). Enacted a year after the disastrous Exxon Valdez oil spill in Alaska's Prince William Sound, this law streamlines federal response to oil spills by requiring oil storage facilities and vessels to prepare spill-response plans and provide for their rapid implementation. The law also increases polluters' liability for cleanup costs and damage to natural resources and imposes measures—including a phase out of single-hulled tankers—designed to improve tanker safety and prevent spills. This law will be prominent in litigations following the BP oil spill in the Gulf of Mexico in 2010.

Food Quality Protection Act (1996). This legislation is designed to ensure that levels of pesticide residues in food meet strict standards for public health protection. Under this law, which overhauled the Federal Food, Drug, and Cosmetic Act and the Federal Insecticide, Fungicide, and Rodenticide Act, the EPA is required to protect infants and children better from pesticides in food and water and from indoor exposure to pesticides.

Winkle et al. 1997; Adler 2007). New modeling approaches used spatially explicit approaches and attributes and incorporated variation in models of complex phenomena (Burke et al. 2008; Cressie et al. 2009; Sharma et al. 2009). Recognition of the consequences and challenges of global climate change on inland lake and river systems has been well documented in studies of the Great Lakes and Canadian lakes (Magnuson et al. 2000; Casselman 2002; Latifovic and Pouliot 2007) and more recently in reviews of river ecosystems and associated fish populations (Reist et al. 2006; Palmer et al. 2009; Williams et al. 2009). The increasing extent of harmful algal blooms has been shown to be associated with many human activities, especially with invasive species that are transported in ballast water and toxic compounds that are released with industrial, agricultural, and sewage effluents and transported into rivers and coastal waters (Anderson 2009).

1.5 USE OF HISTORIC INFORMATION IN CONTEMPORARY MANAGEMENT

A variety of historic resources should be considered by contemporary fisheries biologists and managers to provide inferences on past conditions. A number of historic fisheries information sources are obvious and include agency management and research reports, including fishery management plans. Frequently overlooked sources of information are the early reports of various state, provincial, and federal fish commissions. These reports frequently contain detailed observations and data on the condition of fisheries resources starting around 1870. Annual or biannual reports provide information on the location of early fish stocking, stocking success, habitat impairments, and fisheries surveys. Most of the early fish commissions sponsored special reports on specific aspects of fisheries resources. County and local histories along with early plat and survey maps, while more difficult to access, can provide a landscape context along with the specific changes that European colonization made to the landscape. Frequently, county and local histories along with surveyor notes have detailed accounts of fisheries and landscapes that are particularly valuable for unique and easily-identified fishes such as lake sturgeon. Other overlooked sources of historic fisheries information are tax ledgers, commercial records, or other community record keeping of fish harvests. This is particularly true in the original 13 U.S. colonies, and this information is frequently found in state or county historical society archives. Another source of information on fish harvest can be obtained from cannery records, often available in local archives.

Key sources of historic habitat condition of waters and their riparian zones can be found in early surveyors' journals. Many early journals are very detailed and include information on plant species, observed fishes, lake and wetland locations, and stream widths. Surveyors were keen observers of the natural world, and one of their tasks was to inventory qualitatively natural resources along survey lines. An easy way to access historic data is to contact state, provincial, or federal archives to determine their current fisheries-related holdings along with historic photos of waters. County and local historical societies are rich and inexpensive sources of information and photos that are often overlooked.

Fisheries workers also can overlook the holdings of many museums that have data from archaeological middens and archived samples. Environmental historians and archaeologists can provide assistance with archaeological information through contacts with state or provincial historical societies. A number of museums have large shell collections that can provide

information on historic conditions in lakes or river systems. Museum collections of archived fish samples can provide information on what fishes were found historically in a system.

Some cautions on the use of historic information are warranted and include understanding that historic information can often be biased by values held at the time. Knowing the cultural context can inform the user of reasons for decisions made through time. An excellent example of documentation of the evolution of social values is provided by Reuss (2005), who followed water management and development framed by social reasons over time. Reuss maintained that only after World War II did public attention shift in favor of a more inclusive ecological approach to water development, partly because large dam projects had forced basin inhabitants from their homes, chemical and nuclear pollutants threatened the environment, and urban populations sought opportunities for recreation.

Historic data cannot be used as direct replacement for experimentation, but they are valuable sources for generating hypotheses and providing complementary information. However, there are some situations in which historic information may be the only source of information, such as processes that can be examined only over very long time periods; unusual events that require historic context; unplanned experiments where systems are affected by unplanned events and require historic information to interpret; chronicles of historic patterns in a water or system; or determination of past conditions for modeling waters or systems (Gould 1986; Steedman et al. 1996). No one tool will be sufficient for most historic interpretation, and combinations of tools will be needed to maximize success. The most powerful analyses use multiple tools to collaborate and verify multiple data sources.

1.5.1 Records of Habitat Conditions, Species Population Size, and Distribution

Hooke (1997) provides an excellent checklist on the use of historic fluvial geomorphologic data that can be adapted to assist users of historic information desiring "replicate" data sets. This process includes obtaining all historic information from complimentary data sources to allow cross checking. Background information about the reliability of source data should be pursued, especially investigating document quality, accuracy, and applicability, with verification through secondary data sources. If historic data are going to be used, assessment of data accuracy can be accomplished through comparisons with other data in the same area and time frame. Once data are considered accurate, a time sequence of conditions should be developed using both qualitative and quantitative methods, and finally a field analysis and check of the data should be conducted if possible.

Historical fisheries and landscape information have been used in many ways for establishing contemporary management goals, such as understanding historic river and landscape conditions. Archaeological and human artifacts can be used to examine the geomorphology of river basins (Brown et al. 2003). Many resources can be used to date locations and provide information on how river dynamics have changed over time including pottery, coins, hearths, bones, earthworks, middens, stonework, structures (e.g., buildings, bridges, wharves and jetties, wells, or aqueducts), and mining debris. Mining debris can also provide specific mineral tracers to help locate and date sediment deposits. Brown et al. (2003) provided four case studies to illustrate the use of residue information obtained from excavations: (1) reconstructing river channels from bridge structures (2) using mining slag, bed load, and hydraulic sorting to examine river movement; (3) using artifacts to describe floodplain deposition and erosion; and (4) using metal mining and their residues to examine fluvial responses over time.

Many resources are useful in understanding river dynamics. Potential tools include land surveys, botanical collections, general surveys and travel accounts, bridge surveys, channel surveys, building locations, historic ground photos, topographic records, navigation surveys, lake sediments, reservoir storage changes, diaries and journals, and water level and flood records on buildings (Gurnell et al. 2003).

To develop rehabilitation options adequately for aquatic species whose populations are threatened or badly degraded in numbers, information is needed regarding historic population sizes or harvests so targets for rehabilitation can be determined. An example of the use of historic information to estimate historic population size from replicate information is found in Holzkamm and McCarty (1998), who used isinglass records from Hudson's Bay Company Lac la Pluie District to estimate Obijway harvest of lake sturgeon from the Rainy River and Lake of the Woods. Reconstructions of Pacific salmon populations in the Columbia River system have been estimated using cannery data (Gresh et al. 2000) and a diverse number of historic data sets (Northwest Power Planning Council 1986).

Historic population and production data have been key data in the U.S. Endangered Species Act listing processes. As part of the processes dictated by the Endangered Species Act, historic stock status and distribution are pivotal pieces of information required for species rehabilitation actions and legal proceedings. There are a number of examples of such studies, including Hamilton et al. (2005) on the distribution of salmon in the Klamath River system and Kaczynski and Alverado (2006) and Adams et al. (2007) on the southern extent of coho salmon in California. In these cases, historic information including residue and replicate information was used to develop best estimates of historic stock status and species distributions.

Some states in the USA are currently developing databases that will catalog historic stocking of fishes in their jurisdictions to facilitate analyzes of historic genetic stock structures. Historic fish stocking data provide information on the locations where fish have not been stocked, so wild fish presumably still have the historic fish genetic structure and could be used for future broodstocks for rehabilitation efforts. Other analyses will combine the fish stocking database with broodstock source information to determine where unique genetic strains of fish have been stocked. For example, reef-spawning populations of walleye in Saginaw Bay of Lake Huron are believed to be extinct at this time, but an analysis of historic fish stocking information, citizen accounts, and broodstock source references in Michigan Fish Commission reports indicate this walleye strain was stocked into Lake Gogebic in the western Upper Peninsula and no other walleye have been stocked. The self-sustaining population of reef-spawning walleye in Lake Gogebic may be a broodstock source for future rehabilitation efforts in Saginaw Bay.

1.5.2 Preservation for the Future

Resource agency personnel often get placed into interagency relationships that are confrontational without knowledge of the history of the interactions among agencies. This history can frequently color interactions among agencies for decades and examinations of their earliest interactions can provide insight into current relations. The history of fisheries on the Great Lakes is replete with interactions among different resource agencies that illustrate the conflicts between interests and agencies supporting commercial fishing, recreational fishing, transportation infrastructure, agriculture, natural resource extraction, and industrial develop-

ment of the watershed (Bogue 2000). These historic interactions help explain how agencies may act and react to positions and assist fisheries managers to a better job.

While much of this chapter details the importance of historic fisheries information, it is critical for current fisheries managers to record in detail current conditions and the rationale and processes for management decisions for use by managers and scientists in the future. Written information on fisheries projects, management decisions, and condition of systems should be provided to federal, state, or provincial archives in paper copies for long-term storage in consultation with professional archivists. Digital records systems are increasing in prevalence, but to date, potential loss of information from lack of redundancy and adequate storage systems provides many challenges. In addition, photographs and video data are important resources that should be preserved, and documentation of the date, time, location, and subject as well as geo-reference data should be included to allow future placement on the landscape. One method to document habitat conditions is to take time series photographs or videos from fixed locations. Equally important to preservation of fisheries information is the preservation of individual fisheries workers' materials. Most fisheries workers have information that likely has not been placed in agency files, archives, or publications. Personal photographs, videos, field log books, work diaries, papers, and other media could be critical in understanding the context of decisions, system conditions, or how work was conducted. Fisheries workers should either provide their materials to archival locations upon their retirement or give directions to family members for the long-term storage of their materials in their wills. Potential archival locations include federal, state, or provincial archives along with archives managed by the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration. In addition, the AFS Fisheries History Section has begun a process to provide a series of recommendations for archiving of information.

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