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Chapter 1

History of Inland Fisheries Management in North America

LARRY A. NIELSEN

1.1 INTRODUCTION

Fisheries management is a young profession. Its history—at least the part of greatest practical interest—can be recounted through the personal experience of older fisheries managers still working. After 44 years as a fisheries biologist, Woody Seaman described himself as "a 'starter' of new things. …As you know, I was the first Chief of Fisheries, West Virginia Conservation Commission. Prior to this, it was only a hatchery program. I staffed up a group of fish biologists who tackled the fish management problems of the state" (Seaman 1988). Seaman was describing conditions in 1946, a time when many states and provinces were also just beginning their conservation programs and when many other starters like Woody Seaman were pushing the profession forward. These managers quickly developed most of the strategies and techniques used in fisheries management today. This rapid evolution of fisheries as a profession coincides with the accelerating development of the North American continent and with our increasing concern about the long-term consequences of human action.

The precedents of fisheries management, however, extend back to the origins of European settlement of North America. As is common with all subsets of human activity, the events and attitudes of society have affected fisheries and fisheries managers profoundly. The observation that fisheries management has a political and sociological context, as well as an ecological basis, is as accurate for earlier centuries as it is for today.

Understanding fisheries management, therefore, requires a familiarity with the ideas and events that have shaped the North American personality and landscape.

This chapter has two purposes. First, it connects fisheries management and societal development. It illustrates that fisheries are part of the larger society, validating the obvious fact that fisheries management is, and always will be, subject to the desires of the public and societal leadership. Second, the chapter introduces many of the concepts developed in detail in later chapters. It displays the rich variety of approaches and techniques that make up fisheries management.

The chapter in total provides a conceptual definition of fisheries management. A dictionary style definition might read, "the manipulation of aquatic organisms, aquatic environments, and their human users to produce sustained and ever increasing benefits

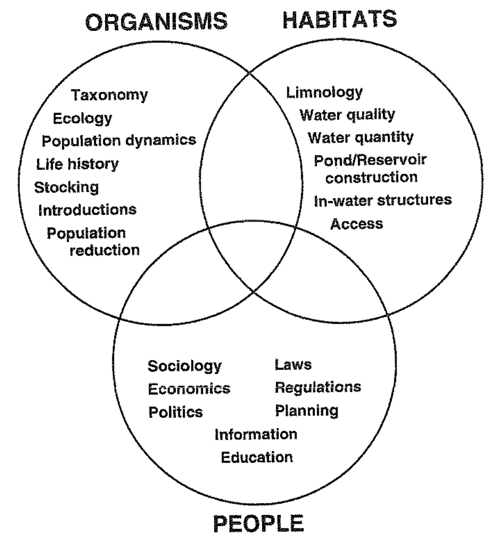

Figure 1.1 Fisheries management depicted as three overlapping circles that represent the three interacting components of fisheries—aquatic organisms, aquatic habitats, and people.

for people." This conception is often illustrated as three overlapping circles that represent the three principal components of fisheries: organisms, habitats, and people (Figure 1.1). Each is important, each affects the other two, and each presents opportunities for enhancing the value of fisheries resources.

1.2 THE HISTORICAL BASIS FOR FISHERIES MANAGEMENT

Fisheries in North America are public resources. State, provincial, and federal governments hold the resources in trust for the general use of their citizens. Although this system is different from the private ownership of fisheries in much of Europe, public ownership in North America derives directly from early English practices.

Ownership of fisheries resources has changed through time to follow the pattern of government. When the feudal system of governance spread across Europe during the Middle Ages, feudal kings and land barons declared themselves owners of the land. They claimed ownership of wildlife as well, not necessarily because wildlife was valuable, but because they wished to keep weapons out of the hands of the people. Later, as the feudal system in England evolved to a national monarchy, royalty expanded their ownership to include all wildlife and fisheries, exercising their assumed right to assign both exclusive and nonexclusive franchises (permission to use) to private individuals (Bean 1977). This system also governed fisheries use and ownership in North America up to the time of the American Revolution.

After the United States became a sovereign nation, U.S. courts struck down the exclusive rights previously given by English royalty. They reasoned that under the English law principle, the king held fisheries as a public trust; moving such franchises to private, individual ownership violated that principle. After the revolution, all the rights and responsibilities of being the trustee of public fisheries were transferred to the new governments, specifically the state governments. Since that time, state governments in the United States have been the principal guardians of fisheries resources, vested with the major responsibilities for protecting and managing inland fisheries (Bean 1977).

In Canada, the responsibilities for managing inland fisheries were originally held by the provinces, operating as independent governments. Since the Confederation Act of 1867, however, by which the Canadian provinces agreed to join under a federal government, fisheries have been shared by provincial and federal governments. The provinces own most inland fisheries, holding them in trust and managing the distribution of fisheries benefits. The federal government holds the responsibility to protect inland fisheries. This dual authority over Canadian fisheries management, which has produced a complicated legal history, has evolved through time; most responsibility now lies with the provincial governments (Thompson 1974). Management of Mexican resources is conducted primarily by the federal government, which assumed control of wildlife resources in the 1910 revolution (Beltran 1972).

The question of how a public trustee should treat fisheries has also been answered by a tradition as old as government itself: fisheries are common property. Common properties are those resources owned by the entire populace, without restriction on who may use them and, at least in earlier times, on how they may be used. The principle of common property was established formally in 1608, when the Dutch statesman Hugo Grotius proffered the Doctrine of Freedom of the Seas. The open ocean, including its fishes, was declared the property of all people. This seemingly idealistic principle was actually just a statement of fact. In 1608, no one could control the oceans because defining boundaries and then protecting them was essentially impossible. Ownership was not necessary in any case because the wealth of the oceans was believed to be inexhaustible—the oceans held more fish than anyone could ever imagine needing or being able to catch (Nielsen 1976). The Doctrine of Freedom of the Seas has been modified throughout history but has remained the principle for the management of fishes, both marine and inland, as common property to this day.

The common property principle is a good one—under certain conditions. As long as the productivity of a fishery exceeds the demand for its products, common property provides an efficient and equitable allocation system. When demand gets too high, however, the productive capacity of the resource declines, and everyone suffers. For centuries, fisheries did supply all the food that people sought, and little or no attention was paid to managing the resource. Within the past century, however, the demand for fish has exceeded the available supply in place after place around the world.

Fisheries management was born of a need to balance the supply–demand equation. The modern history of fisheries is basically a chronicle of individual and governmental attempts to control the exploitation of common property fisheries. Over the past century, scientists and public officials have struggled to develop suitable objectives for managing fisheries—objectives that preserve the time-honored ideal of free access to fisheries and that preserve the productive capacity of fish populations. In pursuing these objectives, they have also developed the technical capacity to enhance fisheries productivity and to reduce the influence of other human activities on fisheries resources.

1.3 THE PRELUDE TO FISHERIES MANAGEMENT

To European colonists, North America truly was a new world. The continent was populated at such a low density and was so naturally productive that early colonists faced a land entirely beyond their experience. Resources were seemingly limitless. Of the Chesapeake Bay, Robert Beverly wrote in 1705:

> As for fish, both of fresh and saltwater, of shellfish, and others, no country can boast of more variety, greater plenty, or of better in their several kinds...In the spring of the year, herrings come up in such abundance into their brooks and fords to spawn that it is impossible to ride through without treading on them....Thence it is that at this time of the year,...the rivers...stink of fish. (Quoted in Wharton 1957.)

It is little wonder that the principle of common property and an attendant lack of concern for conservation were the standards for conduct.

European settlers approached the new continent aggressively. The untamed landscape was viewed as an enemy that had to be subdued in order to provide a suitable human environment. Various explanations of this aggressiveness have been offered, including the Judeo–Christian ethic and the rise of democracy, but the prevailing forces must surely have been necessity and opportunity. The colonists were strictly utilitarian, and their early laws were developed to govern only the commercial aspects of natural resource use (Kawashima and Tone 1983).

Native Americans, in contrast, lived more harmoniously with nature. Natural resources, including fishes, were the base of their existence, and virtually all Native Americans lived largely by subsistence fishing, hunting, and gathering (Swanton 1946). Their mythology often ascribed human qualities to natural objects, thus compelling an ethical treatment of their environment. Where Native American populations were dense, as in coastal California, Native Americans restricted their fish harvests in ways that sustained high productivity for centuries (McEvoy 1986). In most areas, however, their population density was low; at the time of European colonization, fewer than 12 million humans occupied North America. The sparse population, coupled with the low-technology forms of agriculture and fish harvest Native Americans practiced, never made significant impacts on the continent's resources.

The aggressiveness of the colonists could not be sustained long without local problems. Local resource depletion and environmental problems, like those long experienced in Europe, developed rapidly in North America. Pastures were overgrazed, forests were overharvested, streams were overburdened with wastes, and fisheries were overexploited. Laws to correct and prevent local degradation became common in colonial governments, beginning with a 1652 Massachusetts law restricting fish catches (Stroud 1966). By the time of the American Revolution, hundreds of statutes restricted the times, places, and mechanisms for harvesting fishes, precursing the variety of similar laws in force today.

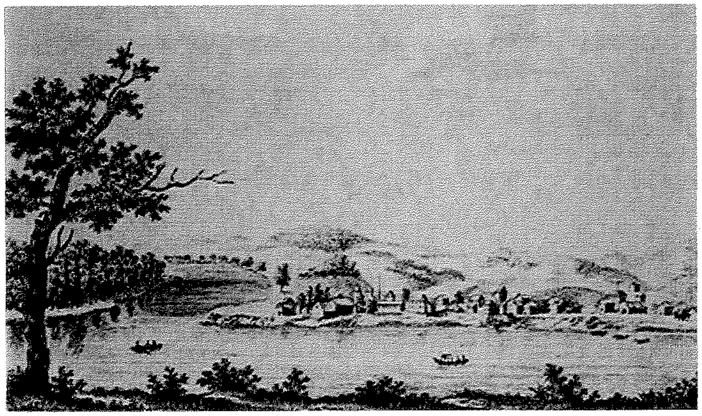

Figure 1.2 The westward colonization of North America used rivers as liquid highways. The Ohio River was perhaps the most important highway because its westward flow carried settlers and cargo across the rugged Appalachian Mountains. Drawing is courtesy of the U.S. Army Corps of Engineers, Huntington, West Virginia.

The answer to resource depletion and environmental degradation, however, was not yet to be found in good management. The United States' answer was immortalized in the words of Horace Greeley, "Go West, young man!" Westward expansion of the new nation was a dominant goal of the United States' leaders, most notably Thomas Jefferson. Jefferson envisioned a nation of small landowners—hardworking, stable, and dedicated to preserving the nation. Federal land policy, from the Louisiana Purchase in 1803 to the Homestead Act of 1862, reflected the Jeffersonian doctrine of expanding, subdividing, and settling the frontier (Cox 1985).

Water played a dominant role in western settlement as a liquid highway transporting people and goods across the eastern mountains. The Ohio River was the primary route of immigrants embarking at Pittsburgh for destinations in the Northwest Territory (Figure 1.2). River travel was difficult and dangerous, interrupted by portages around rapids, strandings in shallow water, and damage from floating debris. Waterway improvements, therefore, also became national priorities, and the United States' first federally supported public works were for improved navigation on the Ohio River (Smith 1971). By 1824, under the guise of improving national defense, the U.S. Army Corps of Engineers was actively and continuously modifying the Ohio and Mississippi rivers by digging canals, removing snags, and deepening the channels. Since then, water development projects have become a dominant feature in U.S. domestic policy and have modified the fisheries of virtually every major U.S. river system (see Chapter 20).

Fisheries in the nineteenth century were primarily subsistence and commercial. The subsistence use of fisheries is poorly recorded, but it certainly provided substantial food supplies for local communities. Commercial fisheries, which had been based on marine fishes in colonial times, began to grow in freshwaters. The Great Lakes

commercial fisheries were well established by 1835, with expectations of much greater possible harvests as the century progressed (Whitaker 1892). The state of Iowa reported a commercial fish catch of more than 1.8 million kilograms in 1886, or close to 1.4 kg per person (Carlander 1954). The Mississippi River was well used for commercial and subsistence fishing, although not everyone agreed that the river offered either palatable food or enjoyable sport (see Box 1.1).

Giving the western lands to eastern migrants also meant taking it away from Native Americans. During the first half of the nineteenth century, scores of treaties between Native American nations and the U.S. government traded millions of hectares desired by settlers for more distant lands currently not desired. As the frontier pushed westward, so did the treaty lands, removing Native Americans progressively farther from their homes and disrupting their ties with the land and its resources. The continuing efforts of the U.S. government to accommodate western settlement progressively stressed relocation, separation, and assimilation of Native Americans, policies that did not improve Native American lifestyles or protect their rights. During this time, however, a body of Native American law developed and a series of treaty-based promises accumulated. Modern interpretation of these laws and promises shows that in many cases Native Americans retain ownership of the natural resources, including fishes, on their aboriginal and treaty lands (Busiahn 1985). Recognition of those rights is reshaping the governance and use of many fisheries today and will continue to do so for the foreseeable future (see Chapter 4).

1.4 THE BIRTH OF FISHERIES MANAGEMENT

The completion of the U.S. transcontinental railway in 1869 signified both practical and symbolic ends to the frontier ethic. The continent had been tamed by the railroad, which allowed fast and convenient transportation across the formerly treacherous landscape. The question was no longer if the land would yield to human development, but how that development would proceed. The last half of the nineteenth century represents the period when North Americans of European descent began to exert their influence broadly on natural resources, including fisheries, and when they developed a unique New World character tied closely to the character of their environment.

1.4.1 The Cultural Basis for Natural Resource Management

The wilderness of the New World had a deep effect on its settlers. While carving homesteads out of the wilderness, the pioneers also developed a kinship with the expansiveness and wildness of the land. After 1850, that kinship flowered into a North American personality, reflected in many aspects of human endeavor. The culture emphasized the natural environment, represented in philosophy by the transcendentalism of Ralph Waldo Emerson; in art by the Hudson River school of landscape artists, most notably Thomas Cole; and in literature by romanticists such as William Cullen Bryant (Figure 1.3). The worldwide recognition of this cultural growth legitimized the place of nature in the arts, and it welded an appreciation for the natural environment to the growing surge of land development.

BOX 1.1 LIFE ON THE MISSISSIPPI

The Mississippi River was a dominant force in the lives of riverside communities. Harriet Bell Carlander (1954) chronicled the history of the river's fisheries, quoting examples of the wonder, inspiration, and indignation of river watchers.

Thomas Jefferson was an early champion of the Mississippi, as he recorded in his *Notes on Virginia*:

> The Mississippi will be one of the principal channels of future commerce for the country westward of the Allegheny.... This river yields turtle of a peculiar kind, perch, trout, gar, pike, mullets, herrings, carp, spatula fish of fifty pound weight, catfish of one hundred pounds weight, buffalo fish and sturgeon.

Estwick Evans swam in the Mississippi in 1818 and noted the sediment in the water with mixed emotion:

> It is, however, not very unpalatable and is, I think, not unwholesome. The fish in the river are numerous and large; but they are too fat to be delicate.

Mark Twain quotes an English sea captain who visited the Mississippi in 1837 and was less ambivalent:

> It contains the coarsest and most uneatable of fish such as catfish and such genus.... There are no pleasing associations connected with the great common sewer of the western America which pours out its mud into the Mexican Gulf, polluting the clear blue sea for many miles beyond its mouth.

Charles Lanman, a New Englander who wrote about the river in 1856, also was dubious about catfishes:

> ...This fish is distinguished for its many deformities and is a great favorite with all persons who have a fancy for muddy water. In the Mississippi they are frequently taken weighing upwards of one hundred pounds...but it has always seemed to us that it requires a very powerful stomach to eat a piece from one of the mammoths of the western waters.

The editor of the *Muscatine Journal* assessed fishing in 1869:

> Fishing parties are fashionable now-a-days. For our part we should prefer lighter employment, such as sawing wood or carrying a hod to the seventh story of a building.

The truth about the Mississippi, however, is probably best recorded by Mel Ellis, writing in the *Milwaukee Journal* in 1949:

> If you haven't fished Ol' Man Mississip, forget about any preconceived notions you may have as far as rivers are concerned. Because Ol' Man River isn't really a river at all. In fact, he's a hundred rivers and a thousand lakes and more sloughs than you could explore in a lifetime. He is creeks, bayous, ditches, puddles, and thousands and thousands of impenetrable lotus beds that break big yellow flowers out above green pads.

This linkage between the human and the natural landscapes was first tied to resource management through the writings of George Perkins Marsh. Marsh's 1849 book, *Man and Nature,* showed how human activity affected the physical environment and how both could be improved by applying scientific and aesthetic principles. He denounced the destructive effects of human exploitation and anticipated the development of the natural sciences of biology, geology, and chemistry (Nash 1987). His work aimed landscape design in a new naturalistic direction, one that would be implemented in full form through the genius of Frederick Law Olmsted, the architect of New York's Central Park and of the first U.S. national parks.

While Marsh was changing landscape architecture, a transformation also occurred in natural science. Until the mid-1800s, natural science had been an avocation. Amateur scientists collected bizarre and grotesque animals or spent their lives classifying animals, plants, and geological specimens. The application of physical and biological sciences to human endeavors, however, was like the touch of flame to oil. The pace and magnitude of human affairs exploded. As depicted in the United States' 1876 Centennial Exposition in Philadelphia, the industrial revolution unfolded in an array of machinery and engines. Natural science radiated into useful specialties. The application of zoology to agriculture was mandated in the United States by the creation of land grant colleges in 1863 (these same universities house many of the U.S. fisheries programs today). The science of ecology began to take form at about the same time; the encyclopedic observations of Canadian and U.S. naturalists provided the basis for its theoretical development (Fry and Legendre 1966). Charles Darwin's *Origin of Species*, published in 1859, was the precursor to ecology, a term formally defined by Ernst Haeckel in 1866 (Egerton 1976).

Fisheries and other natural resources were also subject to the modernization brought by the industrial revolution. Modifications of the landscape were more massive and ubiquitous, multiplying and merging the local environmental impacts of previous generations. Power dams were built on many rivers; by 1849 on the Connecticut River, these dams had blocked the spawning migrations of Atlantic salmon and American shad. The combination of mill dams, deforestation, and pollution had virtually exterminated Atlantic salmon from the St. Lawrence system by the mid-1800s. Throughout the continent, the use of waterways for power, transportation, mining, and waste disposal and the use of watersheds for rapid exploitation of timber and minerals and for crops were destroying the capacity of aquatic environments to sustain fish populations.

1.4.2 The First Steps for Fisheries Conservation

Fisheries exploitation had always been a local industry, but the industrial revolution of the late 1800s allowed rapid expansion of exploitation for an ever growing market. The demand for fishes increased as the human population grew and as spreading railroad lines made possible rapid transportation of fishes to distant cities. Fish processors developed better canning and refrigeration techniques, which led to massive exploitation of concentrated fish stocks. On the Sacramento River in California, for example, the chinook salmon fishery expanded from 2,500 cases of canned fish in 1874 to 200,000 cases in 1882, caught by 1,500 boats and pro-

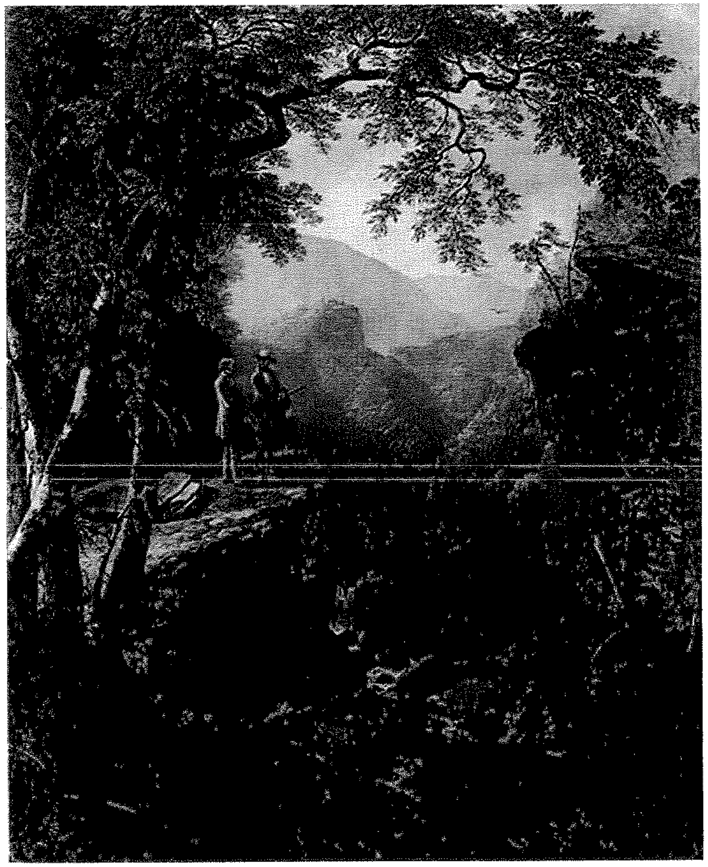

Figure 1.3 The harmony between the North American personality and its wild natural environment is the subject of this 1849 painting by Asher Durand. Entitled *Kindred Spirits*, it depicts Thomas Cole, the foremost natural landscape artist of the time, and William Cullen Bryant, a naturalistic poet and journalist, in a setting like those that inspired them. Photograph is courtesy of the New York Public Library.

cessed in 21 canneries. Fishers responded by improving their own technology. Steam replaced sail as the power for fishing vessels in the 1880s, permitting larger vessels and more reliable fishing schedules. The effectiveness of fishing equipment advanced regularly—for example, the otter trawl and the deep trap net were developed in the late 1860s.

Concern for the decline of fisheries was building throughout this period. In addition to a general society-wide interest in natural resources, fishers, scientists, and government officials began to doubt that fisheries—in either marine or freshwaters—were inexhaustible. The Sacramento River salmon, for example, responded to heavy exploitation by producing regularly declining spawning runs; after 1882, the fish harvests declined as well. The United States institutionalized its concern in 1871 by creating the U.S. Fish Commission for the express purpose of investigating the decline in commercial fisheries (Allard 1978). Similar actions were underway around the world, with national investigations in Russia, Germany, and England during this time (Nielsen 1976). Provinces and states began establishing their own fisheries agencies, beginning with Quebec in 1857, New York in 1868, and California in 1870. In 1870, a small group of fish culturists formed the American Fish Culturists' Association (now the American Fisheries Society) to promote fish culture as a cure for the widespread destruction of fisheries (Thompson 1970).

Although the modern techniques of fisheries management were used in rudimentary form during the late 1800s, most people believed that the future belonged to fish culture. In its second year of operation, the U.S. Fish Commission was given the added task of raising fishes and distributing them throughout the United States for the promotion of commercial fisheries. Spencer Baird, the first U.S. Fish Commissioner, hired Livingston Stone in 1872 to carry American shad to the West Coast and, once there, to establish salmon culture stations for Pacific salmon eggs to be transported back East.

These early fish culture operations were enormously successful, and they spawned an era of unrestrained enthusiasm for raising and stocking fishes throughout the continent (Regier and Applegate 1972). Striped bass were shipped from New Jersey to California in 1879 and developed into a commercial fishery in California by 1889 (Craig 1930). Rainbow trout were first distributed into the eastern United States in 1880, and by 1896 many states east of the Rocky Mountains boasted self-sustaining populations of rainbow trout (Wood 1953). European introductions were equally popular; common carp was imported from Germany in 1877 and brown trout in 1883. Missouri built its first hatchery in 1881 for the production and distribution of common carp (Callison 1981). The belief that fish culture could sustain commercial fisheries was the established position of the U.S. government throughout this period. A 1900 law, for example, required fishers in Alaska to establish sockeye salmon hatcheries on every river they fished (Roppel 1982). The technical improvements of the time also enhanced fish stocking activities. Long-distance transportation of fishes was accomplished in specialized railway cars, first used in 1873 and finally retired in 1947 (Leonard, no date). The initial transfers used milk cans to carry eggs, but soon the cars were outfitted with specialized fish-holding cans (Fernow pails) and later with tanks carrying ice and aeration devices (Figure 1.4).

Fish rescue operations provided another major source of fishes for stocking and redistribution, especially in the midwestern United States. Annual flooding of the Mississippi River and its major tributaries stranded multitudes of fishes as the waters receded. State officials reasoned that the death of these fishes reduced fish abundance in the river. In 1876, therefore, Iowa began an annual program of rescuing fish, a program that continued until 1930 (Carlander 1954). Most of the fishes were returned to the

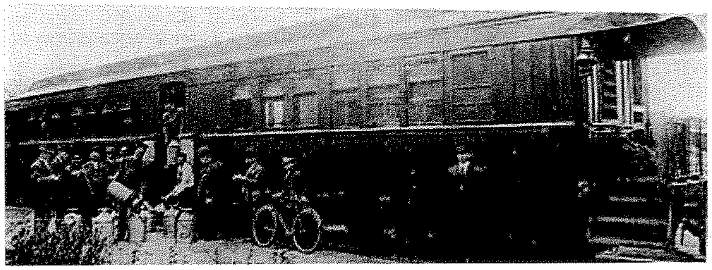

Figure 1.4 Railroad cars, like this one, were specially adapted to transport fish and fish eggs across the continent. Long-distance transport by rail continued well into the 1940s. Photograph is courtesy of the U.S. Fish and Wildlife Service.

main channel of the river, but game fishes were kept for distribution into other waters throughout the region. The work was difficult—weeks of seining in shallow, silt-bottomed ponds in hot weather. The death of one young worker after several years of fish rescue work prompted an infamous epitaph on his Iowa gravestone (Figure 1.5).

Fishing regulations proliferated during the latter nineteenth century, generally in response to the declining fisheries and the desire to protect stocked fishes. Most laws regulated either the seasons or methods of commercial fishing. Based on the implicit belief that spawners were needed to assure future yields, closed seasons were implemented to protect spawning fishes. Regulation of fish-catching methods, however, was usually politically motivated, designed to restrict the effectiveness of some fishers while enhancing the effectiveness of others (Nielsen 1976). Riddled with loopholes and contradictions, such regulations were usually ineffective for fish conservation. Early commercial fishing laws also provided no means for enforcement, other than the efforts of ordinary police. The few regulations that did exist for sportfishing were even less likely to be enforced. Among the first law enforcement officers specifically hired for natural resource work were those in California, authorized in 1876, and in New York, authorized in 1883.

At the end of the nineteenth century, fisheries were experiencing the worst conditions in history. Fish populations had been badly depleted throughout the developed world. Environmental degradation tied to industrial frenzy, and overfishing tied to insatiable demand, had affected freshwater and anadromous fisheries to the point that some commercially exploited fishes were extinct and many were economically useless. But a new attitude was pervading the continent. The respect for nature that was intrinsic in the North American heritage was being directed toward fisheries. Unlimited exploitation had been benign on the frontier, but people recognized that the closure of the frontier necessitated a conservative attitude. Attempts to control exploitation were largely political and insufficient, but the scientific basis for more rational management was beginning to develop. The new century would harbor a new science and new approaches to the use and conservation of natural resources.

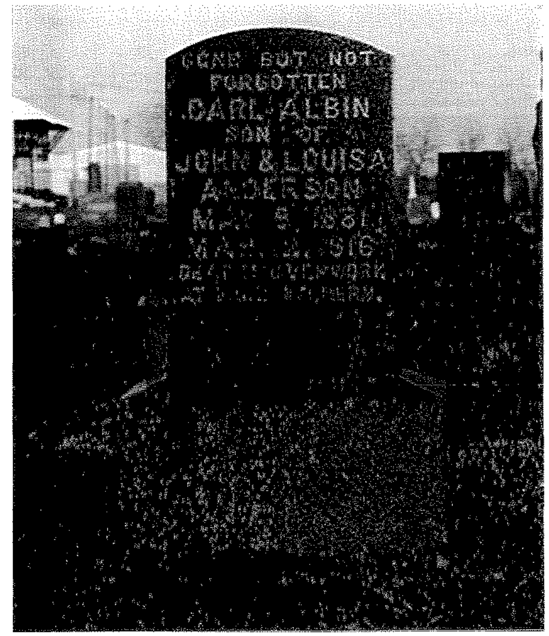

Figure 1.5 The dreadful truth about fisheries work is shown on this gravestone standing in Manchester, Iowa. The young man who died was not actually a hatchery worker but a member of one of the fish rescue crews that seined fishes along the Mississippi River.

1.5 THE SCIENTIFIC MANAGEMENT OF FISHERIES

Most historians mark the beginning of the North American conservation movement with the Governors' Conference of 1908. The U.S. president, Theodore Roosevelt, invited governors of all states and territories, federal legislators, the justices of the Supreme Court, cabinet officers, and selected authorities to the White House to discuss the conservation of natural resources. The conference serves well as a milestone marking the transition of the conservation movement from a collection of separate ideas and actions into a national priority.

Natural resource conservation received this attention partly because of the acknowledged need for better management, but mostly because it was swept along in a new national outlook. The twentieth century began with an obsession for efficiency in the conduct of human affairs—the progressive movement. Born of the waste and corruption of the concluding century, the progressive movement presumed that direct manipulation of human affairs, often aided by the best scientific expertise, could produce a better society—even a perfect one. The philosophy was the force behind the work of Gifford Pinchot, Chief of the U.S. Forest Service under President Roosevelt. Known in conservation as the founder of modern forestry, Pinchot was a zealous proponent of efficiency in all aspects of resource use and societal development—so zealous that his forceful rhetoric has been called "the gospel of efficiency." He popularized the notion that natural resources should be used for the long term, conserving their capacity to produce human value indefinitely. The other part of that philosophy, however, held that fully using the annual production of renewable resources was an obligation in the service of the present human population, as he observed for coal:

> The first principle of conservation is development, the use of the natural resources now existing on this continent for the benefit of the people who live here now. There may be just as much waste in neglecting the development and use of certain natural resources as there is in their destruction. We have a limited supply of coal, and only a limited supply. Whether it is to last for a hundred or a hundred and fifty or a thousand years, the coal is limited in amount, unless through geological changes which we shall not live to see, there will never be any more of it than there is now. But coal is in a sense the vital essence of our civilization. If it can be preserved, if the life of the mines can be extended, if by preventing waste there can be more coal left in this country after we of this generation have made every needed use of this source of power, then we shall have deserved well of our descendants. (Pinchot 1910)

Fish populations under the progressive philosophy served the primary purpose of providing food and the secondary purpose of providing economic value, much like agricultural crops (Bower 1910). For example, at Roosevelt's 1908 Governors' Conference, only two speakers mentioned fisheries, both extolling the virtues of commercial fisheries as thriving industries that provided a wholesome food supply (Smith 1971). The idea that natural resources were crops to be planted, managed, and harvested would later evolve into the founding principle of wildlife management (Leopold 1933) and would dominate the thinking of fisheries scientists for the first half of the twentieth century.

The efficient use of fish populations became known as maximum sustainable yield, or MSY. During the early twentieth century, the MSY concept was developed independently several times. E. S. Russell, a British scientist studying marine fisheries, presented it most effectively in his classic book, *The Overfishing Problem* (Russell 1942). He related the present abundance of a fish population to additions via growth, recruitment, and immigration and to losses via natural mortality, fishing mortality, and emigration. Russell's simple mathematics showed that the greatest long-term yield of fish was achieved by allowing small fish to grow before harvesting them. The "vital statistics" of a fish population—growth, recruitment, natural mortality, fishing mortality, immigration, and emigration rates—became the standard descriptors of fish population dynamics and remain so to this day (see Chapter 6).

Logical arguments like Russell's and political philosophies like Pinchot's were powerful, but they also needed a strong scientific basis. The science of ecology answered that need. Ecology, which began in earnest in the late 1800s, developed rapidly during the 1920s and 1930s (McIntosh 1976). Much of the early work in ecology centered on aquatic environments, relating the lives of organisms to the physical and chemical characteristics of the habitat. Significant in that early work was Stephen A.

Forbes, Director of the Illinois State Laboratory of National History in the 1880s. His classic paper, "The Lake as a Microcosm," explains the attraction of aquatic ecosystems and the need for comprehensive information:

> It forms a little world within itself—a microcosm within which all the elemental forces are at work and the play of life goes in full, but on so small a scale as to bring it easily within the mental grasp. Nowhere can one see more clearly illustrated what may be called the *sensibility* of such an organic complex, expressed by the fact that whatever affects any species belonging to it, must have its influence of some sort upon the whole assemblage. He will thus be made to see the impossibility of studying completely any form out of relation to the other forms; the necessity for taking a comprehensive survey of the whole as a condition to a satisfactory understanding of any part. If one wishes to become acquainted with the black bass, for example, he will learn but little if he limits himself to that species. He must evidently study also the species upon which it depends for its existence, and the various conditions upon which *these* depend. He must likewise study the species with which it comes in competition, and the entire system of conditions affecting their prosperity; and by the time he has studied all these sufficiently he will find that he has run through the whole complicated mechanism of the aquatic life of the locality, both animal and vegetable, of which his species forms but a single element. (Forbes 1925)

1.5.1 The Scientific Basis for Fisheries Management

Ecology and fisheries science grew in mutualistic fashion, with ecology supplying hypotheses and principles and fisheries science supplying natural laboratories for testing them. Fisheries science grew exponentially in this exciting environment, with early scientists concentrating on gathering information in three areas critical to fisheries management.

First, scientists needed to describe and survey the fishes and invertebrates in important waters before the management of fisheries could even be considered. Building on classical studies by naturalists such as Louis Agassiz, many prominent ichthyologists, including Tarleton Bean, David Starr Jordan, Barton Evermann, and J. R. Dymond, conducted faunal surveys for state, provincial, and federal agencies in the early 1900s. Conservation agencies and universities carefully documented those surveys in elaborate reports complete with taxonomic keys and full-color drawings. The first volume of the *Roosevelt Wild Life Annals*, for example, published by the New York State College of Forestry, contains a 300-page report of the fishes and fishery of Oneida Lake (Figure 1.6; Adams and Hankinson 1928). This style of reporting was largely replaced by the next generation of zoologists, who prepared standardized taxonomic references for the continent or for large ecological regions. Works on the fishes of the Great Lakes by Carl Hubbs and Karl Lagler (1941) and on the freshwater invertebrates of North America by Ronald Pennak (1957), for example, became major references for biological surveyors.

The second type of information desired by fisheries scientists related to the physicochemical characteristics of important waters. Work in this area had developed a strong theoretical base through the work of European scientists like Francois Forel, who named the new field limnology in 1869 (Egerton 1976). Based on the ecological link between organisms and their environments and on the concern for the devastating pollution of the early 1900s, physical and chemical limnology became important components of

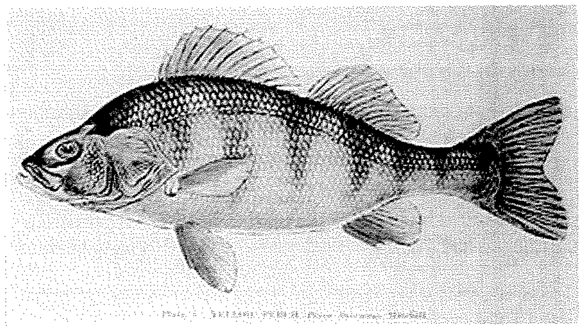

Figure 1.6 Agency reports were the first textbooks on fisheries science, ecology, and management. Drawings like this, from an intensive survey of Oneida Lake, New York, provided scientifically accurate records of fish species.

fisheries management (Osburn 1933). Realizing the need to survey the conditions of lakes and streams, researchers blanketed the continent with meters, water bottles, and nets. The most famous field-workers were Edward Birge and Chancey Juday, limnologists for the University of Wisconsin who surveyed waters throughout North America in the early 1900s (Beckel 1987). Their efforts were matched in Canada by Donald Rawson, who used his extensive field experience to create indices predicting fish production based on lake characteristics (Northcote and Larkin 1966). Large-scale physicochemical surveys are seldom conducted by fisheries managers today and are now handled by specialists in water management. Nevertheless, the idea remains firmly planted in fisheries management that water quality determines the type and productivity of a fishery.

The third set of information desired by early fisheries scientists concerned the life history and ecology of fishes. Scientists recognized that management of fish populations required knowledge of the critical elements in a fish's life and of the factors that altered the vital statistics of the population. Therefore, management agencies began to sponsor directly research on fish ecology (Larkin 1979). In 1908, the Canadian government opened the Pacific Biological Station at Nanaimo, British Columbia, to advance both marine and freshwater research. Similar laboratories were founded throughout Canada and the United States, providing an institutional home for fisheries research. As knowledge grew, the study of changes in fish abundance based on reproduction, growth, and death rates (both natural and from fishing) became known as population dynamics. Understanding of fisheries ecology and population dynamics grew in this environment so massively that it defies a brief synopsis. The list of outstanding scientists working in these areas is a virtual who's who of fisheries (Box 1.2).

This growing wealth of facts and theories regularly confirmed the experiences of fishers and government officials that habitat destruction and unlimited fishing could have monumental impacts on fish populations. The corroboration of practical knowl-

BOX 1.2 A FISHERIES HALL OF FAME

Fisheries science developed so rapidly during the mid-1900s that a complete history would fill many volumes. A partial story, however, may be told in the accomplishments of those scientists honored to receive the American Fisheries Society's Award of Excellence. (Biographical information was compiled by Yanin Walker of the American Fisheries Society.)

1969	William E. Ricker	Population dynamics theory and quantitative fisheries computation methods
1970	Stanislas F. Snieszko	Fish diseases, especially bacteriological, and fish health management
1971	F. E. J. Fry	Dynamics of exploited fish populations and environmental effects on fishes
1972	Ralph O. Hile	Population dynamics of Great Lakes fishes and fisheries statistics
1973	Carl L. Hubbs	Taxonomy, distribution, ecology, life history, and evolution of fishes
1974	Clarence M. Tarzwell	Pollution biology, water quality requirements of fishes, and toxicty testing
1975	Robert R. Miller	Taxonomy and evolution of freshwater fishes and protection of endangered fishes
1976	Alfred W. H. Needler	Marine mollusk culture and management of marine fisheries
1977	Arthur D. Hasler	Fish ecology, fish behavior, and environmental effects on fishes
1978	Peter Doudoroff	Toxicity testing of fishes and fish physiology and energetics
1979	Kenneth D. Carlander	Life history of freshwater fishes and fish population management
1980	Reeve M. Bailey	Taxonomy, distribution, ecology, and nomenclature of freshwater fishes
1981	Gunnar Svardson	Genetics of northern European freshwater fishes, especially the whitefish group
1982	Douglas G. Chapman	Population dynamics of fishes and marine mammals
1983	Peter A. Larkin	Population dynamics of Pacific salmon and fish ecology
1984	James L. McHugh	Dynamics of exploited fish populations and management of North Atlantic fishes
1985	Lauren R. Donaldson	Culture of Pacific salmon, especially nutrition and genetics
1986	William B. Scott	Taxonomy, distribution, and ecology of freshwater and marine fishes
1987	David Cushing	Dynamics of exploited marine fishes and productivity of the sea
1988	Clark Hubbs	Fish ecology in relation to environmental conditions and endangered fish management
1989	John Cairns, Jr.	Environmental toxicology and biological monitoring
1990	John A. Gulland	Populations dynamics of marine fishes
1991	Kenneth Wolf	Fish virology, cell culture, and fish parasitology
1992	Henry A. Regier	Impacts of use and development on fishery resources and rehabilitation of damaged ecosystems
1993	Raymond Beverton	Fish population dynamics
1994	Shelby D. Gerking	Fish ecology and fish production dynamics
1995	William M. Lewis	Warmwater aquaculture
1996	Thomas Northcote	Fish ecology, especially salmonids
1997	William C. Leggett	Ecology of lake fishes
1998	Carl Bond	General ichthyology and fish biology

edge by the new sciences of ecology and limnology thus provoked the flowering of fisheries management to a form much as we see it today. Most of the techniques and approaches used today in fisheries management were developed during the first half of the twentieth century.

1.5.2 The Management of Fish Populations

The exploration of the principles of population dynamics of marine fishes by Russell (1942) and others was readily transferred to inland fisheries. Population dynamics became a fundamental concern to scientists and managers, and developments occurred rapidly throughout North America. In the Pacific Northwest, concern for Pacific salmon fisheries fueled the pioneering work of William Ricker and Earle Forester at Canada's Nanaimo laboratory. They demonstrated the individuality of salmon stocks in different rivers and the relationships between the abundance of spawning fish and the abundance of the subsequent generation (Ricker's stock–recruitment relationship; Ricker 1958). Ricker also invented and published computational techniques for measuring the vital statistics of fish populations; Chapter 6 in this book relies directly on Ricker's 6 decades of population dynamics research.

In the southeastern United States, the field of population dynamics was developing from an empirical approach. In the 1930s Homer Swingle, an extension entomologist at Auburn University in Alabama, began work on the possibility of raising fish effectively in farm ponds (Figure 1.7). His work expanded quickly into a continuing series of pond experiments relating the species, sizes, and densities of fishes to the sustained quality of fishing. Swingle called his concept of sustainable quality fishing the "balance" of the fish population, monitored by a series of ratios comparing the relative abundance of predators and prey (Swingle 1950). Swingle's ideas have guided two generations of fisheries managers and, like Ricker's computational techniques, form the basis for the practical fisheries statistics described in Chapters 7 and 21.

The mideastern and midwestern areas of the continent have contributed many management innovations. Because of the abundance of natural waters and the high density of human populations, fisheries have always been important recreational and commercial resources in these regions. The dominant fishes of these waters, however, often have not been the species desired by anglers. Managers in these areas, therefore, pioneered techniques for the removal or control of undesired fishes. Commercial netting to reduce the abundance of unwanted fishes was used commonly in many states. In Minnesota, large-scale netting began in the 1920s and continued for several decades (Johnson 1948). Commercial fishing is still used successfully today to control undesirable fishes in several situations, but it has never produced the large increases in desired fishes that were expected. Fisheries managers, therefore, turned increasingly to chemical fish poisons. First used in 1913, chemical poisons became common tools after World War II as a larger variety and supply of chemicals became available (Cummings 1975). The use of fish poisons is now greatly restricted, but a few poisons still are important parts of specific management plans (see Chapter 15).

Fish stocking changed in important ways in the mid-1900s. Stocking remained a favorite tool for fisheries managers, but the promiscuous introductions of the late 1800s were supplanted by a more scientific, or at least conscientious, approach. Increasing knowledge of fish ecology and an increasing body of stocking experience allowed

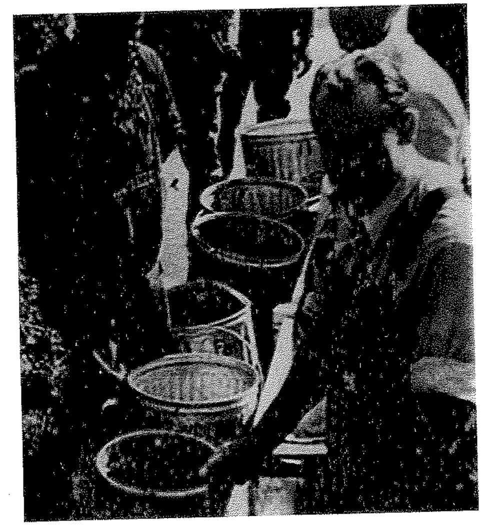

Figure 1.7 Homer Swingle pioneered the empirical approach to fisheries management. Working first with a few ponds and later with hundreds, Swingle and his colleagues at Auburn University discovered combinations of species, sizes, and densities of fishes that provided quality pond fishing.

fisheries managers to choose stocking locations where growth and survival were probable (Wood 1953). This knowledge was first employed systematically in 1927 by George Embody, a New York fisheries scientist, who published tables relating trout stocking densities to stream characteristics. Stocking eggs and larval fishes was largely abandoned in the 1920s; instead, fishes were raised in hatcheries for extended periods and were stocked when larger and more likely to survive. This idea was rapidly expanded to include stocking fishes at sizes desired by anglers, creating the put-and-take fisheries so common today (Chapter 14).

1.5.3 The Management of Habitats

Since earliest times, fisheries managers have modified aquatic habitats. Among the earliest laws governing fisheries in Europe and the United States were those that restricted dams. Dams that blocked entire rivers in order to catch fish, called fixed engines in England, were first prohibited in the Magna Carta (Nielsen 1976). Interest in habitat improvements in North America followed closely on the investigation of life history requirements of fishes and the development of the ecological concept of carrying capacity. Once these habitat-related limits on the abundance or size of fishes were outlined, managers began developing ways to remove them.

Initial attempts to increase carrying capacity focused on the living space available for fishes. In 1938 Carl Hubbs and Ralph Eschmeyer published their handbook, *The Improvement of Lakes for Fishing*, the first comprehensive description of lake habitat

Figure 1.8 Reservoir construction has provided millions of hectares of fishing water in North America. Most construction occurred between 1930 and 1960, when agencies like the Tennessee Valley Authority built hundreds of major impoundments. Photography is courtesy of the Tennessee Valley Authority.

management (Hubbs and Eschmeyer 1938). They emphasized the addition of artificial structures, especially brush piles, as a way to increase the standing crop of fishes. Managers had long been using analogous measures in coldwater streams, placing various low dams and shoreline obstructions where they would diversify the depth and velocity of water (Cooper 1970). Although the effectiveness of such structures has been evaluated only rarely, the manipulation of habitat diversity by adding structures is enormously popular, and, therefore, continuously employed (see Chapters 10 and 11).

Where natural lakes were scarce, the preferred method for expanding fisheries habitat was to build artificial lakes. Farm ponds and other small impoundments have always graced the human landscape, but the environmental problems of the early twentieth century greatly stimulated their construction. When the extended droughts of the 1920s settled in on the Great Plains, farming practices had already produced a land stripped of its natural protection from erosion and with little water available for irrigation. In 1934, the U.S. Soil Erosion Service (now part of the Natural Resource Conservation Service) was created to rectify the causes of the dust bowl. It developed a cost-sharing program for building farm ponds. The purpose was to raise the water table, but the ponds also provided fisheries habitat. As an incentive to build ponds, the U.S. Fish and Wildlife Service supplied farmers with free fishes for stocking. Thus began nationwide programs of farm pond construction and fish stocking that have produced over 5 million small fishing ponds in the United States. Agency-sponsored fish stocking is greatly reduced today, but small impoundments are still primary opportunities for fishing (see Chapter 21).

Reservoir construction had similar beginnings. Fewer than 100 reservoirs (larger than 200 ha) existed in North America in 1900. Under the impetus of burgeoning human development, the U.S. government accelerated the construction of large reservoirs in the 1930s (Figure 1.8). The development of the Tennessee River valley, for example, began in 1933 as part of a federal program to revitalize the region's economic and social well-being through natural resource conservation. By 1941, the Tennessee Valley Authority had built seven major impoundments, providing navigation, flood control, hydroelectric energy—and fishing (TVA 1983). More than 1,300 large reservoirs had been built in the United States by 1970, mostly in the southeast and upper midwest (Jenkins 1970). Because the most desirable sites for reservoir construction have been used, the rate of construction has slowed markedly, and few new reser-

voirs are being built today. Although fishing was generally a secondary objective for most reservoir construction, the nearly 4 million hectares in major impoundments are intensively managed for fisheries today (Chapter 22).

1.5.4 The Management of Fisheries Users

Early in the twentieth century, the importance of recreational fisheries began to grow. This expansion caused demands for regulations on the competing harvests of commercial fishers. Exhortations for governmental restrictions on environmental degradation and on overfishing became common after World War I. In response to massive depletion of inland fish stocks for food during the war, the U.S. government passed the Black Bass Act of 1926. This act, which prohibited interstate movement of bass taken in violation of state laws, effectively eliminated most large commercial markets for freshwater predatory fishes in the United States. Since that time, commercial fishing in freshwaters has been regularly reduced and is now a minor part of most inland fisheries management programs.

Regulation of recreational fishing, in contrast, has fluctuated widely. The earlier regulatory emphasis on closed seasons and areas was supplemented with new techniques based on studies of fish population dynamics. Once managers began to understand the value of higher growth rates and lower mortality rates, they tried to improve those rates through regulations. Highly restrictive fishing regulations, including minimum size limits, fishing equipment restrictions, and daily catch (creel) limits, were implemented broadly and uniformly by state agencies (Redmond 1986). In the early 1940s, however, the regulatory pendulum swung in the other direction, because several new studies showed the inappropriateness of restrictive regulations in many waters. State agencies responded by liberalizing regulations, again in a largely uniform manner. The pendulum has reversed direction again, and stricter fishing regulations have returned. Because regulations represent one of the few sure methods of decisively manipulating fisheries, they are popular among managers (see Chapter 17).

The decades from 1900 to 1950 might well be called the golden age of fisheries management. The continent had discovered the value of recreational fisheries and had backed the research and management to improve them. Scientific information grew rapidly and, when combined with the experience of previous years, provided fertile ground for the proliferation of management techniques. Maximum sustainable yield was firmly established as the goal for fisheries management, whether for commercial or recreational fisheries. Managers stocked and poisoned fish, they built and modified water bodies, and they regulated fish harvest with the single aim of providing the greatest sustained quantity of fish. Fisheries management now had a well-developed kit of tools, and the significant changes after 1950 would come in its purposes rather than its techniques.

1.6 MODERN FISHERIES MANAGEMENT

The modern era of fisheries management began after the end of World War II. State and provincial agencies grew rapidly by enlarging management, fish culture, and law enforcement staffs. Spurred on by the trend for higher education and by the increasing use of fisheries resources for recreation, governments invested generously in education, research, and management. Along with this investment came an outpouring of data that has allowed fisheries management to develop as the multifaceted profession it is today.

Perhaps the greatest stimulus to inland fisheries management in the United States was the passage in 1950 of the Federal Aid in Sport Fish Restoration Act, popularly known as the Dingell–Johnson Act. Patterned after the earlier Pittman–Robertson Act for wildlife, the Dingell–Johnson Act created a 10% excise tax on specified fishing equipment. The tax was dispersed to state fisheries agencies to support the creation and improvement of recreational fisheries. From its inception through 1985, the Dingell–Johnson program had dispersed over US$480 million for fisheries development and research. In 1985, the Dingell–Johnson program was expanded significantly, increasing the range of items taxed, adding marine fuel taxes to the program, and authorizing development of marine, as well as freshwater, recreational fisheries. This important legislation, known as the Wallop–Breaux Act, has more than doubled the annual funds available, with $332 million dispersed in 1992 alone.

The initial decades of the twentieth century had been dominated by the concept of fisheries as crops, with the single objective of achieving the highest physical yield, or MSY. Since 1950, focus on MSY has been challenged repeatedly, and possible objectives for management have been continually expanded. This expansion has not been a sequential process, with each new idea following neatly behind the previous. For most modern viewpoints, the antecedents extend well back into the last century. Their rise to widespread acceptance, however, has followed a somewhat identifiable path.

The initial challenge to MSY was the idea that producing physical yields was really secondary to the more universal objective of producing economic value. Biologists had learned that physical yield could be maximized (theoretically) by regulating the total fish catch via a quota or similar means. Economists now reasoned that if the effort used to catch those fish was so great that the cost equaled the revenue, no economic value (profit) would exist. This idea was expressed eloquently by Michael Graham, a leading British fisheries scientist, in his classic essay *The Fish Gate*: "Fisheries that are unlimited become unprofitable" (Graham 1943). The result of such economic inefficiency was a different type of common property dilemma: although the natural resource was preserved, the dominant human benefit—economic gain—would be lost if fishing effort was unrestricted.

In the 1950s, fisheries economists began to point out that MSY should be replaced by the concept of maximizing profit, alias maximizing net economic revenue (MNER). Management for MNER required a different approach. Scientists such as Milner Schaefer, who analyzed the Pacific tuna fisheries, and Anthony Scott, working in British Columbia, stated that not only must the fish harvest be regulated but also the effort used to acquire that harvest must be limited. The fundamental economic premise was that the fish harvest must be allocated to particular fishing units—individual fishers, corporations, or nations—in order to keep the fishing effort low. The concept, which is usually called limited entry, grants some persons the right to fish while excluding everyone else. This economic principle is not universally accepted, but it is being increasingly used for important commercial fisheries and is the basis for the 200-mi limit that most coastal nations now claim over their marine fisheries.

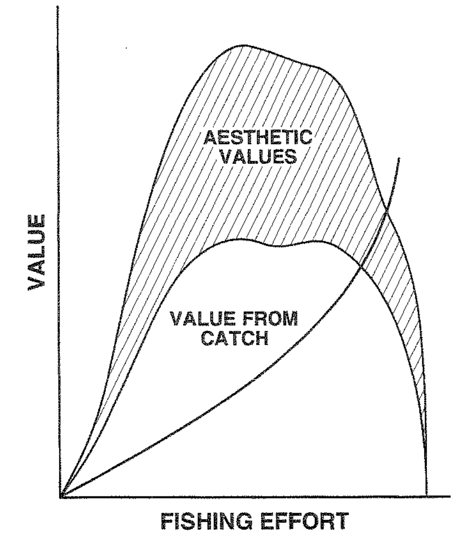

Figure 1.9 The addition of nonbiological concerns to the objectives of fisheries management is shown in this figure from James McFadden's keynote address to the American Fisheries Society in 1968.

While economic concerns were challenging MSY in commercial fisheries, MSY was also being challenged as a sufficient objective for recreational fisheries. The quality of recreational fishing had been measured traditionally as the number and size of harvested fishes. Nevertheless, anglers had always admitted that other parts of the fishing experience were at least as important as the catch itself. People value companionship and pleasant surroundings in their fishing experiences, and their preference for catch might vary from one large fish to many small fish. The idea that such sociological concerns should be part of fisheries management gained popularity in the 1960s as public opinion became more important in directing government decisions. The addition of aesthetic values to the relationship between fishing effort and fish harvest was formalized by James McFadden (1969) in a modern classic of fisheries literature (Figure 1.9). Since then, the development of socioeconomic principles for fisheries management has been a high priority for management agencies (see Chapter 8).

The third major addition to the objectives of fisheries management that challenged MSY was the result of continuing advances in ecological science. Because fisheries are components of the productivity of aquatic ecosystems, ecological research has continuously improved the theoretical foundation of fisheries management. In the 1970s, for example, ecologists supplied the notion that the management of single fish species must be replaced by multiple-species management. The yield of predatory fish (e.g., largemouth bass) depends on the condition of the food base; when the food base is also

BOX 1.3 R.I.P. FOR MSY

Maximum sustainable yield (MSY) served the fisheries profession well for many decades. In the 1970s, however, the concept of optimum sustainable yield supplanted MSY as the dominant fisheries objective. In the keynote address at the 1976 American Fisheries Society meeting, Peter Larkin (1977) laid MSY to a gentle rest:

> Whatever lies ahead in the development of new concepts for harvesting the resources of the world's fresh waters and oceans, it is certain that the concept of maximum sustained yield will alone not be sufficient. The concept has served an important service. It arrived just in time to curb many fisheries problems. To appreciate what MSY has done, we need only ask what the world's fisheries would have looked like today if the concept had not been developed and advocated with such fervor. The fish, I'm sure, would shudder to think of it. Like the hero of a western movie, MSY rode in off the range, caught the villains at their work, and established order of a sort. But it's now time for MSY to ride off into the sunset. The world today is too complex for the rough justice of a guy on a horse with a six-shooter. We urgently need the same kind of morality, but we also need much more sophistication.
>
> Accordingly, I tender the following epitaph:
>
> MSY
> 1930s–1970s
> Here lies the concept, MSY.
> It advocated yields too high,
> And didn't spell out how to slice the pie.
> We bury it with the best of wishes,
> Especially on behalf of fishes.
> We don't know yet what will take its place,
> But hope it's as good for the human race.
>
> R.I.P.

exploited (e.g., bluegill), the pair of species must be managed together, not separately. The idea that fisheries must be thought of as communities, or at least as interacting groups of populations, has become firmly rooted through a series of symposia focusing on multispecies fisheries (e.g., Clepper 1979). Since the days of Forbes, ecology has been and will continue to be the basic science that contributes most to the understanding of fisheries management.

The accretion of additional concerns—economic, sociological, and ecological—into the management of fisheries forced MSY off its throne in the 1970s (see Box 1.3). It has been replaced by a new guiding principle: management for optimum sustainable yield, or OSY. Optimum sustainable yield was formalized in a 1975 symposium (Roedel 1975) that assessed management from a variety of viewpoints. The basic tenets of OSY are that the appropriate goal for fisheries management includes a broad range of considerations (not just maximizing physical yield) and that a unique management goal exists for each fishery. Optimum sustainable yield thus greatly complicates fisheries management. Defining the OSY for a fishery is much more difficult than defining

the MSY because fishery-specific information is needed about biological, ecological, economic, and sociological aspects of fishery use. Optimum sustainable yield, however, is also much more realistic in that it recognizes the diversity of aquatic ecosystems and the diversity of human needs in relation to them.

The job of the fisheries manager has evolved rapidly. What the manager does today has been conditioned as much by the events of the past 2 decades as by the accumulated history of fisheries. The remainder of this chapter describes some of the substantive areas of fisheries work today, specifically as they relate to later chapters in the book.

1.6.1 The Management of Habitats

The growth of the environmental movement in the 1960s changed the world of the fisheries manager. United States law had required fisheries managers to assess the impacts of federal development projects since the 1930s (the Fish and Wildlife Coordination Act), but recent decades have greatly expanded and defined that general charge (see Chapter 4). Of greatest significance were the U.S. National Environmental Policy Act of 1969, which created the process of developing environmental impact statements, and the 1970 amendments to the Canadian Fisheries Act, which broadly prohibits harm to aquatic habitats (Pearse et al. 1985). Fisheries managers are now required to review thousands of government-sponsored developments each year, and many states have passed legislation requiring impact analysis for state-regulated projects.

The need to predict the relationship between habitat modification and the effects on fisheries has given rise to entirely new specialties concerned with habitat analysis (see Chapter 10). Habitat analysis has been concentrated in the western half of the continent, where water supplies are low and where fisheries compete directly with consumptive uses of water. The most significant efforts have helped define the water flow conditions needed to sustain fish life (usually called instream flow). Scientists have created methods for expressing the relationships between instream flow and habitat conditions and have determined the specific habitat conditions needed by dozens of fish species.

Environmental laws have also allowed fisheries managers to address the ecological principle that land uses throughout a watershed affect the well-being of fish (see Chapter 9). Fisheries managers have advanced well past the point of merely predicting changes. They now prescribe remedies for the anticipated problems in the design, construction, and operation of development projects (Swanson 1979). Mitigation, as this process is called, allows the manager to participate in the planning process for land and water projects. The manager can then help developers make good choices—eliminating avoidable damages by redesign or improved operation and gaining suitable restitution for the damages that are unavoidable.

The legal framework for maintaining fisheries, along with their increasing economic and social value, has also allowed for the small- and large-scale rehabilitation of habitats. Stream reconstruction in the West and wetland reconstruction in the East are widely practiced by public agencies and private companies. Earlier techniques of stream improvement have been augmented so that now entirely new stream channels can be constructed, kilometers of stream bottoms can be removed, washed, and replaced, and existing dams and other structures can be removed (see Chapter 10). Although lake habitat is not as easily remodeled as stream habitat, the methods available far exceed those of previous decades. New reservoirs are constructed with outlets designed to enhance fisheries, and a seemingly endless supply of devices is available for improving water quality and fisheries habitat (see Chapter 11).

1.6.2 The Management of Aquatic Organisms

As ecological knowledge has increased, the breadth of interest in management of fishes and other aquatic organisms has similarly increased. The concentration on a limited number of predatory fishes has been replaced by the recognition that the entire aquatic community is valuable and needs management attention.

Endangered and rare species are now managed primarily by fisheries and wildlife professionals. Although the addition of this responsibility to their more traditional roles has been resisted by some managers, fisheries agencies are the natural homes for endangered species concerns. Fisheries managers have the skills and experience to manipulate ecosystems to enhance endangered species, just as they manipulate other fisheries organisms. Today the management of endangered species is recapitulating the entire course of fisheries management, rapidly moving through the stages of life history descriptions, distribution studies, and habitat assessments to the stage of prescribing how to remove species from the danger of extinction (see Chapter 16).

Management interest has also broadened to incorporate the nonharvested species of a typical aquatic environment. Attention is now being directed toward smaller fishes that provide the food for predators and toward competing fishes that reduce the reproduction, growth, and survival of desired predators (see Chapters 12 and 13). Concern has also developed for other species that may not enter in any way into a fishery. Conservation biology, as this interest is called, concentrates on preserving and enhancing the diversity of all species. Although initially stronger in Europe than in North America (Maitland 1974), the conservation of aquatic biodiversity is now a standard part of agency management, from the U.S. Forest Service to state fish and game departments.

Aquaculture remains one of the most valuable management techniques in fisheries today (Stroud 1986)—as well as one of the most controversial. It still serves traditional purposes of stocking fish for angling, but it also serves faunal restoration efforts and endangered species management. As the use of natural waters for commercial fishing has declined, aquaculture has developed rapidly as the source for food fish. At the same time, serious questions have arisen about the wisdom of relying on fish culture as a long-term solution to fisheries problems. Scientists and managers, therefore, will be forced to confront many significant issues related to aquaculture, including genetic engineering, the effects of hatchery-reared fish on wild stocks, and the use of public waters for commercial fish farming.

1.6.3 The Management of Fisheries Users

The human component in fisheries management, so long de-emphasized, is now a major element in all management activities. Optimum sustainable yield demands that the needs and desires of fisheries users be discovered and incorporated into management plans. Consequently, creel surveys and attitude assessments are now continuing

activities of state and federal agencies. Methods for assessing user demands and for comparing the relative value of various fisheries are evolving rapidly in the face of both professional and legal demands for information (see Chapter 7).

Now that fisheries agencies know more about the demand for fisheries, they have changed their notions about how to serve society. Fisheries programs now typically include urban fisheries and fisheries accessible to physically impaired anglers. Aquatic education, which opens fishing to people without a family tradition of angling, is increasingly important in fisheries agencies. A more representative balance also is being achieved in the allocation of fishes between commercial and recreational fisheries. Comanagement of fisheries, by which traditional regulatory agencies relinquish some authority to local governments, Native American groups, and conservation organizations, is beginning and seems highly likely to increase in the future. The utility of socioeconomic information to guide management will continue to expand as techniques improve and as the success of incorporating such information is established.

As fisheries management has become more complex—more quantitative, more political, more scientifically sophisticated, and more diverse—the need for effective planning of fisheries programs has become apparent. Beginning in the 1970s, the concept of comprehensive planning has become increasingly popular as a way to anticipate the future. An increasing number of state, provincial, and federal agencies are functioning under strategic plans (which describe what could be done) and operational plans (which describe how to do it). The emphasis is now placed on setting specific objectives for fisheries management and monitoring the achievement of those objectives (see Chapter 2).

1.7 CONCLUSION

And just what is this profession we call fisheries management? Viewpoints about management are as diverse as the collection of human activities that fall under the rubric of what we call fisheries. As the profession has evolved and radiated in recent decades, the precepts that fisheries management was applied biology, applied ecology, or even applied economics have all proven too restrictive. A dictionary definition is not really important; a principle for guiding the management of fisheries, however, is necessary. Most fisheries professionals would agree that the principle objective of fisheries management is to provide people with a sustained, high, and ever increasing benefit from their use of living aquatic resources. In the pursuit of that principle, fisheries managers manipulate all aspects of the natural and human ecosystem. Where people and water meet, fisheries exist; where people and water could meet, potential fisheries exist; and wherever fisheries, real or potential, exist, fisheries management can make them better.

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