In the Wake of Politics

The Political and Economic Construction of Fisheries Biology, 1860–1970

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ABSTRACT

As an environmentally focused, applied field science, fisheries biology has recently been marked by its failed promise to enable sustainable exploitation. Fisheries biology's origin through state support raises many questions. How did fisheries biologists get this support? Did political considerations and economic ideals fundamentally shape the science? Why has it been perceived as fundamentally conservation oriented? New evidence indicates the political basis for Thomas Henry Huxley's contention that the deep-sea fisheries were inexhaustible; this essay shows how his influence extended to recent neoliberal resource management solutions. It also explores how fisheries biology acquired the ideal of maximum sustained yield (MSY) via Progressive Era efficiency conservation and German scientific forestry; how American Cold War foreign policy made this ideal paradigmatic of mid to late twentieth-century fisheries biology; and how emerging bioeconomics in the 1950s imposed a troublesome misunderstanding of fisheries biology's earlier mission.

IN THE NINETEENTH CENTURY, global and imperial interests championed the emerging physical ocean sciences and Humboldtian mapping of oceanic species. In contrast, fisheries biology, oceanography's younger sibling, was born out of local and particular political and economic interests. Fisheries biology emerged in the late nineteenth century when people living along the North Atlantic coastal margins protested that fishing was altering maritime environments. Governments adjudicating disputes over seemingly diminishing resources sought biologists' help; biologists eagerly offered expertise in return for government support. Unlike oceanography, fisheries biology remains stubbornly applied, despite its many contributions to a basic understanding of aquatic life. Its history, therefore, challenges scholars trained to value science that seeks universal insights into nature's workings. Furthermore, massive fish stock collapses of the late twentieth century marked fisheries biology's failure to effect its imperative: sustainable

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fisheries. What were the roots of this failure? Why did postwar fisheries biologists devise and use fish population models in spite of inadequate data and knowledge of fish life histories? Were such choices dictated by a desire to legitimate fisheries biology through using universal mathematical principles, or were other, political, factors at work?

In fact, its politically contingent genesis and growth has meant that fisheries biology has always harbored a central tension between two opposing goals: the primary goal was acquiring knowledge to enable new methods to conserve and restore the fisheries, while the ancillary goal was to increase fisheries' scope and intensity and, hence, the wealth yielded by fisheries for the state. As an applied science, fisheries biology furthermore straddled the distinction between "practical" science—such as state-sponsored coastal, hydrographic, and geological surveys—and science applied to develop new technologies. Beginning with the field's first leading scientist, the director of Norway's Fiskeridirektoratet, Johan Hjort, fisheries biologists developed new methods and tools for harvesting commercial species.[1] Perhaps because fisheries biology coalesced during the efficiency-oriented Progressive Era, its practitioners advocated for industrialized fishing and favored larger fishing corporations over independent fishermen. Yet in my experience, many people—even fisheries biologists themselves—believe that fisheries biology began and continued as a conservation-oriented science seeking to identify and remediate overfishing. This essay will highlight how fisheries biology, situated at the nexus of shifting environmental conditions, fluctuating populations, technological change, and uncertain government funding and support, has been vulnerable to changing political, economic, and environmental ideals at the local, national, and global scale.

APPLYING SCIENCE TO FISHERIES PROBLEMS, 1850–1900

At the root of most nineteenth-century fisheries conflicts lay three general developments: population growth, steam engines and railways, and proliferating trawlers and weirs. Before railways, few species not amenable to traditional processing methods were caught. Line fishing generated little waste, although baiting the hooks was time consuming and costly. Trawlers' huge nets, however, caught fish nonselectively; fishers jettisoned "as much as four-fifths of the catch" until railways created growing markets for fresh fish and a new fish-reduction industry to process "waste" fish into fertilizer or livestock feed.[2] Line fishermen complained that burgeoning steam trawlers and weirs depleted stocks.

Ironically, Thomas Henry Huxley (1825–1895), the Victorian champion of pure science, was the first scientist to investigate overfishing, perhaps because he had studied marine organisms during the HMS *Rattlesnake* Torres Strait expedition of 1846–1850. As Graeme Gooday recently highlighted, Huxley denied that any entity could be labeled "applied science," arguing that there was only pure science applied to different classes of problems. Yet Huxley's fisheries investigations could draw on no existing body of science. He involved himself in fisheries matters to supplement his meager income as a naturalist at the Geological Survey of London and the Royal School of Mines, chairing the 1863–1866 Sea Fisheries Commission. This commission investigated complaints by

[1] The two varieties of applied science are discussed in Paul Lucier, "The Origins of Pure and Applied Science in Gilded Age America," *Isis*, 2012, *103*:527–536. On the development of new harvesting methods and tools see Morten Karnøe Søndergaard and Vera Schwach, "The Nordic Shrimp Industry: State Entrepreneurship, Intellectual and Industrial Structures, c. 1895–1950," *Scandinavian Journal of History*, 2009, *34*:162–181.

[2] For the quotation see Robb Robinson, *Trawling: The Rise and Fall of the British Trawl Fishery* (Exeter: Univ. Exeter Press, 1996), p. 38.

traditional line fishermen that beam trawlers were depleting fish stocks. Huxley concluded that "the total supply of fish obtained upon the coasts of the United Kingdom has not diminished of late years," further asserting that restricting trawling would reduce people's food supply without any foreseeable benefits.[3]

Huxley's conclusions were unsupported by the majority of the testimony heard from fishers, fishery inspectors, shippers, and fish marketers, according to the environmental historian Robert Schwartz. Politicians, however, liked Huxley's message and chose him to chair the 1883 Royal Commission on Trawl Nets and Trawl Fishing to investigate line fishermen's claims that steam trawlers depleted fish and destroyed their spawning grounds. Schwartz's analysis of the commission's hearings reveals that the balance of testimony indicated falling catches. Nonetheless, Huxley concluded that trawling harmed neither fish populations nor the fisheries. Very likely he valorized evidence from shippers and marketers, who saw only growing markets, over fishers' testimony.[4] Furthermore, on the basis of the Norwegian oceanographer Georg O. Sars's finding that cod and other groundfish eggs floated, Huxley argued that bottom trawling was harmless.

Huxley's conduct raises a number of questions. Were his conclusions formulated to impress politicians with the usefulness of science that he probably did not see as applied, so as to promote further state funding of science? Were his "commonsense" scientific conclusions shaped by his laissez-faire liberal inclinations? Or were they perhaps even based on class bias, which led him to ignore fishermen's testimonies? When Huxley was appointed one of England and Wales's two Inspectors of Sea Fisheries in 1879, he predicted that in dealing with fishermen he would be "jamming common-sense down the throat of fools," attempting to substitute scientific expertise for their ignorance. His predecessor, William Buckland's son Frank (1826–1880), had respected fishermen, was enthusiastic about solving fisheries problems, and tried to popularize science—in the shape of fish hatcheries—as an aid to fisheries. Huxley's contributions, as Schwartz has concluded, instead devalued fishermen's experience.[5] (See Figure 1.)

Huxley's most pernicious contribution came during an address to the 1883 London International Fisheries Exhibition. He stated: "in relation to our present modes of fishing, a number of the most important sea fisheries . . . are inexhaustible." Huxley exerted an excessive, and ultimately unfortunate, influence over fisheries biology and fisheries management for the next century: many fisheries biologists and economists accepted the dictum of this defender of pure science as gospel.[6] In later fisheries science disputes, rather

[3] Graeme Gooday, "'Vague and Artificial': The Historically Elusive Distinction between Pure and Applied Science," *Isis*, 2012, *103*:546–554, esp. pp. 549–550; and Great Britain, Parliament, House of Commons, "Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom, Vol. 1, Report and Appendix," in *Reports from Commissioners: 1866*, 22 vols., *Session: 1 February–10 August 1866*, Vol. 17 (pp. 571–755), "Report," p. ciii.

[4] Robert Schwartz, "How Many Fish in the Deep Blue Sea? Sea Fishing and Ecological Awareness in the British Isles, 1860–1910," paper presented at a conference of the European Society for Environmental History, Munich, 20–25 Aug. 2013. Schwartz used computer-assisted qualitative analysis. Some 3,537 witnesses saw declines, while 1,483 saw increasing catches.

[5] Leonard Huxley, *Life and Letters of Thomas Henry Huxley*, Vol. 2 (London: Macmillan, 1913), p. 292; Roger E. Jester, "Fisheries and the State: A Study of Some Aspects of Resource Conservation and Government Policy in England, 1860–1902" (Ph.D. diss., New York Univ., 1971), pp. 55–56 (Huxley's views), 85–112 (Buckland's approach); and Schwartz, "How Many Fish in the Deep Blue Sea?"

[6] T. H. Huxley, "Inaugural Address: Fisheries Exhibition, London, 1883," in *The Scientific Memoirs of Thomas Henry Huxley*, suppl. vol., ed. Michael Foster and E. Ray Lankester (London: Macmillan, 1903), pp. 80–89, on p. 88. On Huxley's lasting influence see Jennifer Hubbard, *A Science on the Scales: The Rise of Canadian Atlantic Fisheries Biology* (Toronto: Univ. Toronto Press, 2006), pp. 148–172.

Figure 1. *While Huxley recognized that overfishing threatened oysters and river species (such as salmon), he saw no reason to "ride carefully" in exploiting open-sea species. "*Punch*'s Fancy Portraits.—No. 23. Professor Huxley, LL.D., F.R.S., L.S.D.,"* Punch, *19 Mar. 1881,* 80*:130.*

than emphasizing the primary goal of fisheries biology—exploring overfishing's biological ramifications—fisheries biologists instead were motivated by its ancillary goal—modernizing the industry—unaware of their unstated political and economic preconceptions. Many endorsed hegemonic capitalist practices that privatized sea resources and diminished independent fishers' political power, ending traditional practices that had better served small coastal fishing communities and the marine environment.

Huxley's invisible ideals animated disputes in nineteenth-century American fisheries. Matthew McKenzie's environmental history of Cape Cod shows that interested scientists eagerly injected themselves into disputes arising when capital-intensive, net-lined weir fisheries proliferated in New England in response to new railways and markets. In 1871, Massachusetts Fish and Game Commissioner Theodore Lyman investigated line fishermen's complaints about too many weirs. Trained in natural history by Louis Agassiz at Harvard, Lyman believed in modernization and shared modernizers' views that traditional fisheries were backward, labor intensive, and poorly capitalized.[7] Profoundly influenced by Huxley, Lyman rejected outright the possibility of overfishing, but his weir experiments gave no conclusive answers. Spencer Fullerton Baird (1828–1887), the Assistant Secretary of the Smithsonian Institution, seized the chance to showcase the political and economic rewards from federally funding science. Baird's investigations led him to support line fishermen, finding "alarming" decreases, but by blaming the predatory bluefish he also gained support from Lyman and the weir owners. Baird's "success in quelling the dispute . . . firmly replaced fishermen with fisheries scientists in fisheries management." Thanks to his careful political, scientific, and economic calculus, Baird launched the U.S. Commission of Fish and Fisheries in 1871 as an ongoing federally funded body. This body threw its weight behind the ancillary goal of fisheries biology, avoiding measures to restrict fishing and instead supporting the establishment of politically favored, but ultimately ineffective, fish hatcheries.[8]

Further south, the fecund Chesapeake oyster beds attracted heavily capitalized New England oyster companies in the 1850s, after their steam-powered dredges had wiped out northern oyster beds. When catches declined, according to Christine Keiner, scientists advocated leasing oyster bottoms for private enterprise, echoing the ethos of scientific agricultural modernization. William Keith Brooks (1848–1908), an embryology and developmental morphology expert at Johns Hopkins University, advocated for private oyster culture to stabilize catches. His engagement in applied science and active lobbying for government support of privatization show that these approaches were not merely imposed on later government-employed scientists. The politically numerous independent Maryland "watermen" opposed privatization and fought for a "regulated, state-defined commons regime." Brooks and his successor Reginald Van Trump Truitt (1890–1991), who founded the Chesapeake Biological Laboratory in 1925, saw watermen as regressive, greedy, and ignorant, while the Maryland watermen found scientists "arrogant and out of touch." In fact, Brooks's expertise in the oyster's developmental morphology was overshadowed by his ignorance of the environmental contexts of oyster life histories, which were well understood by the watermen. Privatizing sea resources became scientific experts' economic orthodoxy, but they ignored the extreme risks and prohibitive expenses involved for independent fishers.[9]

[7] Matthew McKenzie, *Clearing the Coastline: The Nineteenth-Century Ecological and Cultural Transformation of Cape Cod* (Hanover, N.H.: Univ. Press New England, 2010), pp. 96–101, 125; and Miriam Wright, *A Fishery for Modern Times: The State and the Industrialization of the Newfoundland Fishery, 1934–1968* (Oxford: Oxford Univ. Press, 2001), p. 7.

[8] McKenzie, *Clearing the Coastline*, pp. 126–128, 133, 136 (quotation).

[9] Christine Keiner, *The Oyster Question: Scientists, Watermen, and the Maryland Chesapeake Bay since 1880* (Athens: Univ. Georgia Press, 2009), pp. 38, 67, 82 ("regulated, state-defined commons regime"), 72–73, 101 ("arrogant and out of touch"), 132.

In promoting modernization, fisheries biologists won state support by promising to help governments devise sound fisheries policy and to find new exploitable resources for the industrializing fisheries. Political considerations intruded into several aspects of this new applied science. As we have already seen with Huxley and Brooks, scientists' personal economic and political convictions shaped their "scientific" policies. National political objectives were also imposed, as fisheries biology promised to help define territorial waters and protect and extend state interests. In industrially advanced countries, implementing rational scientific resource management would raise the state's political stature and promote national objectives for industrialized fishing in international waters.[10]

As biologists appropriated control over resource management from fishers, investing it in the state, they furthered a marine resource free-for-all that indirectly inspired Garrett Hardin's influential "The Tragedy of the Commons."[11] Hardin argued that the evolutionary principle of competition animates human use of a resource commons; greed and competition will therefore ruin that commons. Recent scholarship shows that preindustrial fisheries were neither a free-for-all nor a commons. To reduce competition, fishers' detailed knowledge of fish and fishing locations was selectively shared. Native American fishers used specific fishing gear for specific sites and adopted rules to conserve wild fish. In Norway, Lofoten fishermen grouped themselves according to the fishing gear they used and elected fishery inspectors and district committees to govern fishing times and gear use. American and Canadian fishermen restricted outsider access to local landing areas and the bait and salt supplies needed to catch and preserve fish.[12] With restrictions disappearing and industrial fishing intensifying, aquatic populations oscillated and declined. Oceanographers and biologists used economic uncertainties caused by these population fluctuations to gain state funding for fisheries-related science.

THE POLITICAL CONSEQUENCES OF STATE SUPPORT OF FISHERIES BIOLOGY POST 1900

Fisheries biology emerged as a distinct discipline around 1900, as North American and European scientists gained state-funded research stations and vessels in return for investigating fisheries problems. Nations straddling the North Atlantic sponsored several dozen fisheries research stations, including the Fiskeridirektoratet in Bergen, Norway (1903), and the Fisheries Laboratory in Lowestoft, England (1920). Canada, Great Britain, Germany, and the United States each supported several, indicating the science's localized nature. Each specialized in species and issues that were a priority in their geographic region. While, on one level, they helped build cosmopolitan knowledge, they did not partake of Humboldtian, global-scale projects of the sort that animated Rocky Mountain

[10] Eric L. Mills, *Biological Oceanography: An Early History, 1870–1960* (Ithaca, N.Y.: Cornell Univ. Press, 1989), p. 75.

[11] Garrett Hardin, "The Tragedy of the Commons," *Science*, 1968, *162*(3859):1243–1248.

[12] Regarding Native American practices and rules see Rosemary Ommer, "The Ethical Implications of Property Concepts in a Fishery," in *Just Fish: Ethics and Canadian Marine Fisheries*, ed. Harold Coward, Ommer, and Tony Pitcher (St. Johns: ISER, 2000), pp. 117–122. On Norway see Robert S. Pomeroy and Berkes Fikret, "Two to Tango: The Role of Government in Fisheries Co-management," *Marine Policy*, 1997, *21*:465–480, esp. p. 474; Svein Jentoft and I. Trond Kristoffersen, "Fisheries Co-management: The Case of the Lofoten Fishery," *Human Organization*, 1989, *48*:355–365; and Jentoft, *Dangling Lines: The Fisheries Crisis and the Future of Coastal Communities—The Norwegian Experience* (St. John's, Newfoundland: ISER, 1993), pp. 27–28. For American and Canadian fishermen's imposed restrictions see Brian J. Payne, *Fishing a Borderless Sea: Environmental Territorialism in the North Atlantic, 1818–1910* (East Lansing: Michigan State Univ. Press, 2010), p. 52.

field stations and laboratories or oceanographic programs and centers.[13] What fisheries biologists and their institutions did share, however, was a signature assemblage of techniques, goals, and ideals.

The earliest focus was determining whether overfishing was causing populations to fluctuate and fall (“the fishing question”). The era’s most important fisheries biologist, Norway’s Johan Hjort, investigated North Sea herring populations using methods drawn from statistical human demographic studies. He and his Fiskeridirektoratet assistants revealed that differential spawning success in successive years caused population fluctuations: the super year-class spawned in 1904—that is, all the fish spawned in that year that survived to become adults—formed a huge proportion of the commercial-aged herring for over a decade. Hjort’s classic *Fluctuations in the Great Fisheries of Northern Europe* (1914) was foundational to fisheries biology and seemingly lent credence to Huxley’s thesis that the great sea fisheries were inexhaustible.[14] Many fisheries biologists therefore turned to assisting efficient ocean resource use, which involved fisheries biology’s primary goal of discovering biological conservation measures but emphasized its ancillary goals of advancing more efficient fishing and fish-processing technologies and locating new populations and species to exploit.

Studying deep-sea fishes’ biology, migrations, and oceanography was beyond any single nation’s means. The economic importance of Northern European fisheries convinced governments around the North Sea to fund the International Council for the Exploration of the Sea (ICES). Founded in 1902, it coordinated oceanographic research by participating nations.[15] ICES supported Hjort’s studies and disseminated new techniques for analyzing commercial stock demographics: the Danish biologist C. G. Johannes Petersen’s fish tagging; the German zoologist C. Hoffbauer’s use of fish scale rings to determine age; and Friedrich Heinke’s anatomical measurements to identify species’ subpopulations.

International fisheries and oceanographic commissions became platforms for lobbying governments to fund costly science. Basic oceanographic research programs benefited and suffered alike from state preferences for funding fisheries-related oceanographic research, even through the early decades of the Cold War.[16] Industrialized states’ need for revenue, food supply, and marine products meant giving fishing enterprises unrestricted access to fish. Rather than focusing on fisheries biology’s primary goal—science for resource conservation—ICES and other organizations that accepted a strong role for applied science sought to serve political ends. With most fishing occurring in international waters, overfishing became a matter for international study, negotiation, and legislation. ICES and the later International Commission for the Northwest Atlantic Fisheries (ICNAF; 1959–1979), for example, became international instruments in which scientists served as

[13] On the development of fisheries research stations see Arthur J. Lee, *The Directorate of Fisheries Research: Its Origins and Development* (Guildford, Surrey: MAFF, 1992). Regarding Rocky Mountain field science see Jeremy Vetter, “Rocky Mountain High Science: Teaching, Research, and Nature at Field Stations,” in *Knowing Global Environments: New Historical Perspectives on the Field Sciences*, ed. Vetter (New Brunswick, N.J.: Rutgers Univ. Press, 2011), pp. 108–134.

[14] *ICES Journal of Marine Science* commemorates the centennial of *Fluctuations in the Great Fisheries of Northern Europe* with a special 2014 issue dedicated to Hjort.

[15] Helen J. Rozwadowski, *The Sea Knows No Boundaries: A Century of Marine Science under ICES* (Seattle: Univ. Washington Press; London: ICES, 2002), p. 42.

[16] Jacob Darwin Hamblin, *Oceanographers and the Cold War: Disciples of Marine Science* (Seattle: Univ. Washington Press, 2005), pp. 103–104, 219–229.

front-line negotiators alongside upper-level bureaucrats and politicians.[17] In 1920, the powerful British trawling industry (the Royal Navy's "nursery" for sailors) successfully lobbied British ICES delegates to block an international agreement to institute a minimum fish size limit that therefore required larger mesh sizes. The gentlemanly Henry Maurice (1847–1950)—a scientifically literate civil servant who was President of ICES from 1920 to 1938—avoided confrontation by urging that international scientific bodies remain independent of politics. Thenceforth, ICES became an advisory body; theoretically, European international fisheries negotiations occurred in separately organized diplomatic venues. However, many delegates at the London Overfishing Convention of 1937 were ICES scientists; later on, ICNAF was frankly political.[18]

Because industrialized states idealized modernization, the ancillary goal of fisheries biology was emphasized. In the United States, "gospel of efficiency" conservation—the Progressive Era's response to the closed and industrializing American frontier—guided official resource management policies. German scientific forestry, introduced by the German-trained forestry chiefs Bernhard Fernow and Gifford Pinchot, inspired gospel of efficiency conservation ideals for managing natural resources "rationally," "efficiently," and "sustainably."[19] These ideals had two consequences for fisheries biologists. First, with few exceptions, they supported industrialized fishing, developing close ties with large, centralized industrial fishing enterprises with good shipping connections to major markets. A centralized fishing industry helped them to train fishers and processors in improved techniques, reducing waste and thereby theoretically conserving fish.[20] Second, fisheries biologists' ideals for efficient management and conservation were entwined in gospel of efficiency ideals drawn from German scientific forestry. By the late 1930s, leading fisheries biologists' language, goals, and mathematical tools mirrored those of German forestry science. Maximum sustained yield (MSY), an economic ideal created by German forestry scientists in the mid-nineteenth century, became the central principle for fish conservation. The cornerstone of fisheries science became managing fisheries for a maximum yield using mathematical tools to model fish populations and the effects of fishing, so as to ensure a sustainable catch.[21]

[17] E.g., in Washington, D.C., during the 1970s, the ICNAF scallop expert John Caddy helped negotiate the Georges Bank U.S.–Canadian boundary for the 200-mile exclusive economic zone. See Jennifer Hubbard, "Introduction," in *A Century of Maritime Science: The St. Andrews Biological Station, 1908–2008*, ed. Hubbard, David Wildish, and Rob Stephenson (Toronto: Univ. Toronto Press, in press).

[18] For Maurice's role see Rozwadowski, *Sea Knows No Boundaries* (cit. n. 15), pp. 66–67. On the 1937 convention see Jennifer Hubbard, "Changing Regimes: Governments, Scientists, and Fishermen in the Construction of Fisheries Policies in the North Atlantic, 1850–2010," in *A History of the North Atlantic Fisheries*, Vol. 2, ed. David J. Starkey and Ingo Heidbrink (Bremerhaven: North Atlantic Fisheries History Association and the German Maritime Museum, 2012), pp. 129–176, esp. p. 142.

[19] This scientific management was in fact neither rational, nor efficient, nor sustainable. For a synopsis of problems arising from German scientific forestry management see James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Agrarian Mission Have Failed* (New Haven, Conn.: Yale Univ. Press, 1998), pp. 11–22; and Jennifer Hubbard, "The Gospel of Efficiency and the Origins of Maximum Sustained Yield: Scientific and Social Influences on Johan Hjort and A. G. Huntsman's Contributions to Fisheries Science," in *Century of Maritime Science*, ed. Hubbard *et al.* (cit. n. 17).

[20] See Vera Schwach, "An Eye into the Sea: The Early Development of Fisheries Acoustics in Norway, 1935–1960," in *The Machine in Neptune's Garden: Historical Perspectives on Technology and the Marine Environment*, ed. Helen M. Rozwadowski and David K. van Keuren (Sagamore Beach, Mass.: Science History Publications, 2004), pp. 211–242; and Hubbard, *Science on the Scales* (cit. n. 6), pp. 80–81, 85, 120–148.

[21] See Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890–1920* (Pittsburgh: Univ. Pittsburgh Press, 1999), Chs. 3, 4, and 7; and Hubbard, "Gospel of Efficiency and the Origins of Maximum Sustained Yield" (cit. n. 19).

MAXIMUM SUSTAINED YIELD, POPULATION MODELS, AND AMERICAN COLD WAR POLICY OBJECTIVES

Enormous confusion surrounds maximum sustained yield, an economic concept that has little to do with protecting fish stocks and much to do with maximizing human benefits at the expense of wild populations. MSY also had a political dimension, being associated with state objectives of promoting economic and, therefore, social stability.[22] Although MSY itself was an ideal—to set exploitation at rates that preserve some chosen population level—its practice required scientifically based mathematical tools. Fisheries biologists formulated statistical equations to model the recruitment (number of fish joining the adult population each year), individual growth, population growth, natural death rates, and fishing mortality rates of exploited wild fish populations.

Despite the economic purpose of MSY in fisheries biology, it has often been presented as having a biological intent: discovering the state of fish populations. How did this confusion arise? The earliest intimations of MSY fisheries management ideals appeared during the Great Depression as concern grew that North Sea stocks and Pacific halibut were overfished. These ideals appeared in tandem—but I would argue coincidentally—with logistic models devised by Hjort, E. S. Russell, and Michael Graham during the late 1920s and 1930s to calculate the effects of fishing on fished populations. These new mathematical approaches were derived from population ecology, an emerging science that used population equations and models *that need have no economic purpose*. William F. Thompson (1888–1965), the American director of the International Fisheries (later Pacific Halibut) Commission, also developed fishing equations to gain Canadian and U.S. government support for restricting the halibut fishing season. His influence was a 1918 graphical model by the Canadian fisheries biologist Archibald G. Huntsman (1883–1973), who had developed a biological—not economic—analysis showing how fishing affects a stock's age structure.[23] Later fisheries biologists may have confused the economic purpose of MSY calculations with population ecology, since both use similar mathematical tools. I must emphasize, however, that this approach's pioneers unequivocally understood the objective as an economic one that required some basic understanding of fish population biology. MSY united the primary and ancillary goals of fisheries biology, often serving, as will be seen, to justify intensified fisheries through determining the upper limits for fish catches while ostensibly assisting in their conservation.

Many historians and even scientists have also confused MSY with the fishing equations themselves, perhaps because both debuted in fisheries biology in the 1930s. The influential fisheries historian Arthur McEvoy even identified 1957 as the year in which the MSY theory was worked out in its entirety. That was the year *On the Dynamics of Exploited Fish Populations* was published—but it never once mentions MSY. Its authors, Raymond Beverton (1922–1995) and Sidney Holt (1926–), were hired by Michael Graham, the director of the Fisheries Laboratory, to devise improved fishing equations. The Beverton-Holt equations became benchmarks for future fisheries biology. McEvoy clearly confused

[22] Robert G. Lee, "Sustained Yield and Social Order," in *History of Sustained Yield Forestry: A Symposium*, ed. Harold K. Steen (Portland, Maine: Forestry History Society, 1984), pp. 90–100, esp. p. 93.

[23] Tim D. Smith, *Scaling Fisheries: The Science of Measuring the Effects of Fishing, 1855–1955* (Cambridge: Cambridge Univ. Press, 1994), pp. 194–235.

the Beverton-Holt equations with MSY; Holt remains perplexed by claims that he and Beverton invented the concept.[24]

The postwar shift to a mathematical focus had its critics. Older or mathematically disinclined scientists predicted presciently that office-bound fisheries scientists would now conduct science using catch statistics and field data they had not collected and lose touch with fisheries and fish biology. They would engage in what Huntsman castigated as "the mathematical treatment of ignorance."[25] Basic fish science and old-fashioned, scientifically unpopular but critically important data series would be neglected. As with the dynamic oceanographers of this period—discussed by Jacob Hamblin elsewhere in this Focus section—the goal for a growing cohort of fish population modelers was to "plug" the latest data into equations to predict population sizes and maximum sustainable yields possible under different fishing intensities.

Why did this shift occur? Did it mirror the sort of emerging mathematical elitism that Hamblin fingers in the oceanographic community, or were external political forces also a factor? It appears that political pressure played a significant role. The Canadian government demanded this style of science, according to the fisheries biologist R. E. Foerster in 1947.[26] Perhaps it was seen as being cost effective? Postwar fish stocks had rebounded because the war had suppressed fishing. This so-called Second Great Fishing Experiment dampened enthusiasm for conservation measures and basic fish research; scientists now saw fish as a robust resource that recovered quickly from overfishing, easily manageable for MSY. At the 1946 London Overfishing Conference, delegates from nations that lost many of their fishing vessels during the war rejected a British proposal to restrict fishing vessel tonnage to existing levels. Delegates finally agreed to politically palatable mesh size restrictions, to be scientifically monitored by ICES.

The United States declined to send representatives to this conference. American scientific fisheries policy, however, dominated during the Cold War, as revealed by Carmel Finley's recent groundbreaking work *All the Fish in the Sea*. During World War II the U.S. government's involvement in fisheries grew substantially, as it initiated policies and subsidies to industrialize U.S. fisheries and increase fish supplies. American fisheries biologists, led by Wilbert McLeod Chapman (1910–1970) as fisheries advisor to the Undersecretary of State for Fish and Wildlife, tailored fisheries policies to assist the new superpower's geopolitical objectives. Government subsidies converted excess U.S. warships into large industrial fishing vessels and rebuilt Japan's fishing fleet and economy as a bulkhead against Communism. During the war Chapman had discovered that South Pacific waters held quantities of tuna sufficient for commercial exploitation; he now wanted American fisheries science to develop close ties to the fishing industry to stake out new fishing grounds. He and his colleagues framed American fisheries biology to align with U.S. Cold War policies intended to show the superiority of freedom, democracy, capitalism, and free-market systems in generating abundance.[27] Accordingly, they ele-

[24] Arthur McEvoy, *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850–1980* (Cambridge: Cambridge Univ. Press, 1986), p. 158; and Sidney Holt, personal communication.

[25] A. G. Huntsman, "Are the Biological Stations Doing Scientific Research," memo, ca. 1950, Huntsman Collection, University of Toronto Archives, Accession no. B1979-0048/011.

[26] R. E. Foerster, "Prospects for Managing Our Fisheries," in *A Symposium on Fish Populations Held at the Royal Ontario Museum of Zoology, Toronto, Canada, Jan. 10 and 11, 1947*, ed. Daniel Merriman (Bulletin of the Bingham Oceanographic Collection, 11) (New Haven, Conn.: Peabody Museum of Natural History, Yale Univ., 1948).

[27] Carmel Finley, "The Cold War and *Sebastes atutus*," paper presented at a conference of the European Society for Environmental History, Munich, 20–25 Aug. 2013 (government subsidies); Finley, *All the Fish in*

vated MSY as the goal of fisheries management, invented the abstention principle, and exported both ideals to the rest of the world.

The abstention principle was devised by William C. Herrington (1903–1991), Chapman's successor as fisheries advisor at the State Department, to promote American interests in distant-water fishing. The abstention principle argued that when a country scientifically managed a fishery, other states should agree not to compete for that resource. This would encourage other countries to begin scientifically managing their own fisheries as well. The political aspirations of Herrington's abstention principle were to preserve existing 3-mile limits—thus allowing American and Japanese industrial fishing fleets free access to the world's oceans—and to assist America's foreign policy defense of the principle of the freedom of the seas. Herrington argued that the abstention principle would save fish stocks from an international free-for-all. Unfortunately, his own fisheries conservation recommendations had so far been "backed by absolutely no comprehensive effort to discover what [a safe] level of fishing actually was."[28]

The postwar deep-sea fisheries could, in fact, be characterized as a frenzied free-for-all. Industrialized fishing intensified as American allies and their Soviet bloc opponents subsidized a modernized fishing industry. Factory trawlers invaded Grand Banks, Icelandic, and other fishing grounds, with fast-freezing facilities to process catches immediately. Huge Soviet factory trawlers deployed "as if in a military campaign" whenever Soviet "experimental" exploratory fishing located rich fishing grounds on the Grand Banks, often under the aegis of the ICNAF science program.[29] Moreover, the United Nations Food and Agriculture Organization (FAO), created in 1945, commenced its war on world hunger by avidly promoting new fishing technologies, including sonar. By the early 1950s, the international assault on local fish stocks led Iceland, Peru, Chile, and Ecuador to demand that the International Law Commission create 200-mile exclusive economic zones.

Against this international backdrop, American fisheries biologists needed to find scientific forums to construct an international consensus for MSY and the abstention principle. How did they achieve this? Chapman worked through the State Department in 1949 to help create the International Commission for the Northwest Atlantic Fisheries (ICNAF) and the Inter-American Tropical Tuna Commission (IATTC), appointing his colleague Milner B. Schaefer (1912–1970) director of the latter. ICNAF was created because the State Department rejected the 1946 International Convention—the international agreement forged by European participants at the 1946 London Overfishing Conference—fearing European control of American fisheries.[30] Chapman shifted American interests away from what had been a protectionist stance, assisted by British support for the principle of the freedom of the seas. Under Chapman's influence, both ICNAF and IATTC were designed to investigate and manage fisheries for MSY scientifically, using minimum fishing net mesh size as the sole measure to conserve fished populations and catch and sampling data to estimate population demographics using mathematical models.

the Sea: Maximum Sustainable Yield and the Failure of Fisheries Management (Chicago: Univ. Chicago Press, 2011), pp. 24, 57–59 (new fishing grounds); and Paul W. Hirt, *A Conspiracy of Optimism: Management of Forests since World War Two* (Lincoln: Univ. Nebraska Press, 1994), pp. xxi–xxii (alignment with Cold War policies).

[28] Finley, *All the Fish in the Sea*, pp. 79, 129, 133. The "3-mile limit" refers to the distance of ocean waters from a nation's coastline over which it had legal and economic jurisdiction, including exclusive fishing rights.

[29] North Atlantic Fisheries Organization, "Changes in Fishing Technology," http://www.nafo.int/about/history/canada-fishery/Chapter2.html (accessed 6 May 2010); a shortened version of this material is available at http://www.thefreelibrary.com/Changes+in+fishing+technology.-a017711444.

[30] Hubbard, "Changing Regimes" (cit. n. 18), p. 143.

The MSY ideal was augmented by a further concept from German scientific forestry: the notion that populations would benefit from the removal of surplus aged stock, enabling younger individuals to grow faster. Huntsman injected this theory into fisheries management ideals at the 1947 Symposium on Fish Populations in Toronto. Soon after the 1947 symposium, the idea of surplus production of fish populations was taken up by O. E. Sette of the U.S. Fish and Wildlife Service and became central to Schaefer's 1954 mathematical treatment of fished populations, his "surplus production model."[31]

The two commissions Chapman helped found could not ensure international acceptance of MSY and the abstention principle to safeguard American access to international waters. Herrington therefore initiated the innocuously named United Nations International Technical Conference on the Conservation of the Living Resources of the Sea. Held at the FAO headquarters in Rome in 1955, this conference was designed to stop the International Law Commission from adopting 200-mile national exclusive economic zones to conserve marine resources. At this conference American "political and economic objectives had already been inextricably interwoven with the science. Politics and economics were embedded in fisheries theory, especially surplus production theory. Scientists helped run the meeting, but science did not." MSY was presented as a tool for conservation, "which even the most unsophisticated delegate thought he understood and was in favor of." However, Chapman's and Herrington's policies entailed that there would be no fishing restrictions until scientific proof showed that overfishing had occurred. British scientists opposed MSY. Graham wanted fishing restricted before fish stocks showed much decline and fish stocks protected prior to spawning. Holt argued that MSY would lead to large, government-subsidized fishing fleets that would exert political pressure to ignore overfishing.[32]

In the end, despite opposition from Iceland and some South American countries, the Rome technical conference endorsed the American proposals. Soviet and British support (in the latter case diplomatic, not scientific) owed much to those nations' own geopolitical agendas. MSY would enable "rational exploitation of the living resources of the sea" by conducting fisheries work "so as to increase, or at least maintain, the average sustainable yield of products," using "scientifically sound positive measures . . . to improve the resource."[33] Accepted as the international standard, MSY became the research and management basis for all international fisheries commissions.

Fisheries biology's focus on efficient resource exploitation made it a handy tool for the U.S. government; since nobody could actually see the resource, geopolitical ambitions were successfully projected onto the fish. However, rapacious international, government-subsidized, industrialized fishing fleets proved fatal to ICNAF's attempts to manage the Northwest Atlantic fisheries. Perhaps surprisingly, scientists failed to see the writing on the wall. The director of Newfoundland's St. John's Research Station, Wilfrid Templeman, stated blandly, "For a considerable time it will be unwise to allow other conservation measures to interfere with the assessment of the mesh [size] experiment."[34] Cold War

[31] A. G. Huntsman, "Fishing and Assessing Populations," in *Symposium on Fish Populations*, ed. Merriman (cit. n. 26), pp. 5–31, esp. p. 17; and O. E. Sette, "Studies on the Pacific Pilchard or Sardine (*Sardinops caerula*)," in *Structure of a Research Program to Determine How Fishing Determines the Resource* (Report no. 19) (Washington, D.C.: United States Fish and Wildlife Service, 1943).

[32] Finley, *All the Fish in the Sea* (cit. n. 27), pp. 147 (quotations), 88, 146.

[33] *Ibid.*, p. 148.

[34] Wilfrid Templeman, "Groundfish Stocks of the Western North Atlantic," ICNAF Annual Meeting—June 1955, document no. 15, Bedford Institute of Oceanography, Darthmouth, Nova Scotia, CNAF Meeting Documents, 1955.

resource policy extirpated formerly sturdy fish populations, but fisheries biologists were blinkered by the politically constructed delimitation of fisheries biology as a support for modernization.

The situation was exacerbated by the Cold War agenda of exporting applied science to modernize Third World nations using scientist-ambassadors to promote science and scientific practices in agriculture, oceanography, and fisheries biology. Western experts helped developing countries build large-scale, mechanized fisheries. Thailand, for example, developed industrial trawl fisheries, managed for MSY, with the assistance of German experts. By the mid 1960s commercial species were disappearing, as bottom trawling decimated the Gulf of Thailand's delicate coral reefs. When German experts tried to intervene in the 1970s, their efforts were dismissed by Thai experts as "neo-imperialist environmentalist" attempts to rein in Thailand's trawling industry and thwart its economic development.[35]

The view of the oceans as an infinite resource was reinforced by economists' incursions into the theory of fishing. Their meteoric rise in political influence in the 1960s exerted an unforeseen influence on late twentieth-century fisheries biology because the Canadian cofounder of bioeconomics, H. Scott Gordon, and his successors layered further interpretations on MSY. Scott Gordon was profoundly influenced by Huxley; he and other economists had no concerns about the health of fish stocks. They saw overfishing merely as a state of reduced profitability, which could arise when the catches were so diminished that few fish were brought to market or, more probably, when fishers expended too much effort catching fish, driving up their costs and reducing or even eliminating profits. Their interpretation of MSY ended up changing its meaning. At the first FAO conference on fishery economics in 1956, one economist observed that "the demand for a 'sustained maximum yield' from a given fish stock has been repeated ad absurdum. The term puts too much emphasis on the *naturalistic romantic approach* to the fisheries and it puts man and his needs too much in the background." As time passed, economists insisted that fisheries biologists, by managing fisheries to the level of "maximum sustainable physical yields[,] ignore the wants, needs and welfare of [people]—only the fish benefit."[36] This view soon dominated in government circles.

Scott Gordon (1924–), a student of John Maynard Keynes, published "The Economic Theory of a Common-Property Resource: The Fishery" in 1954; it was seminal for the field of resource economics that inspired Garrett Hardin's "The Tragedy of the Commons." Anthony Scott, a University of British Columbia economics professor, responded that economic models needed to include managing fish stocks for future generations.[37] To

[35] See Scott, *Seeing Like a State* (cit. n. 19), pp. 262–306 (agriculture); Hamblin, *Oceanographers and the Cold War* (cit. n. 16), pp. 100–110 (oceanography); and Franziska Torma, "Environment and Development: West-German Fisheries Experts in Thailand," paper presented at a conference of the European Society for Environmental History, Munich, 20–25 Aug. 2013.

[36] H. Zoeteweij, "Fishermen's Remuneration," in *The Economics of Fisheries*, ed. Ralph Turvey and Jack Wiseman (Rome: FAO, 1957), pp. 18–34, on p. 20 (emphasis added); and C. L. Mitchell, "Canada's Fisheries at the Crossroads: Some Policy Issues," 1974, Library and Archives Canada, Ottawa, RG 23, Vol. 1847, pp. 5–6. Regarding Huxley's influence on Scott Gordon see Jennifer Hubbard, "Fisheries Biology and the Dismal Science," paper presented at a meeting of the North Atlantic Fisheries History Association, Hull, England, 9–11 Nov. 2011.

[37] H. Scott Gordon, "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy*, 1954, *62*:124–142 (his admiration for Huxley is apparent); and Gordon Munro, "Tribute to Anthony Scott on the Fiftieth Anniversary of the Publication of His *JPE* Article: 'The Fishery: The Objectives of Sole Ownership,'" http://oregonstate.edu/dept/IIFET/NAAFE/Tribute%20to%20Tony.pdf (accessed 20 Oct. 2012).

make the fisheries more profitable for industry stakeholders, Scott Gordon and Scott called for privatized access to fisheries to reduce effort costs. Both also criticized Schaefer's and others' fishing equations for treating fishers and the economy as extraneous. By including economic context and treating fishers as investors, they introduced neoliberal, privatizing solutions to the deep-sea fisheries—solutions later reflected in state impositions of total allowable catches and licensed catch quotas. Economists promised governments that their science would turn the fisheries into wealth generators. Governments bought the promise; by the 1970s fisheries economists' expert status eclipsed that of fisheries biologists.[38]

The rise of economists, and governments' embrace of public policy analysis for science in the 1960s, was accompanied by a demotion in fisheries biologists' status as experts that they were slow to recognize.[39] Why did this change come about? Was it driven by the influential economic and social policy objectives prescribed by the Organization of Economic Cooperation and Development? Or was it linked to an emerging cultural shift toward postmodern sensibilities, which Paul Forman has linked with science losing its primacy over technology?[40] I have no answer for these questions, but the consequences were profound. By 1970 governments seeking to modernize every sector of Western economies ordered fisheries biologists to develop management tools for "optimum sustained yield." This economic goal encompassed not merely sustainable fisheries but optimum social outcomes for fishers and their communities. As fisheries economists reshaped government policies, fisheries biology—continually reconfigured in the crucible of political contingency—was again diverted from conservation. This occurred just when 200-mile exclusive economic zones were being established.

The economists, having misconstrued the integral economic meaning of MSY, constructed the story that fisheries biologists were too focused on safeguarding fish stocks, when in fact, as we have seen, much of fisheries biology throughout its history had emphasized the ancillary goal of expanding the fisheries. Fisheries biologists accepted economists' interpretation of the goals of MSY and their science because, as the historian and fisheries biologist Tim Smith astutely observed, they did not fundamentally understand their discipline's origins or history.[41] Why is this important? The twofold answer lies in the problem of conservation itself. First, fisheries biologists are unaware of the cultural and political context of the "commonsense" and "rational" elucidation of environmental problems and, therefore, of the proposed solutions. From Huxley onward, political and economic ideals of efficiency, conservation, and modernization have shaped fisheries biology and its goals, especially when American Cold War geopolitics led fisheries biologists to second MSY in the service of American political goals. Second, historians of fisheries biology share a concern that, in the post–*Silent Spring* era, and in the wake of so many catastrophic stock collapses, it is seen as a failed science and is consequently experiencing diminished government support. In fact, the fisheries crises of the 1990s ended the gospel of efficiency and MSY scientific paradigms for many (not all) fisheries

[38] Wright, *Fishery for Modern Times* (cit. n. 7), p. 43.

[39] See, e.g., *A Science Policy for Canada: Report of the Senate Special Committee on Science Policy* (Ottawa: Queen's Printer, 1970). John Caddy, a scallop expert for ICNAF, the Fisheries Research Board of Canada, and, later, the FAO, told me that in the 1960s fisheries biologists "felt like cowboys in the frontiers of science," a sentiment vanquished by later budget cuts.

[40] Egil Kallerud, *Goals Conflict and Goal Alignment in Science, Technology, and Innovation Policy Discourse* (Oslo: Nordic Institute for Studies in Innovation, Research, and Education, 2010), pp. 6–9 (available at http://www.csiic.ca/PDF/Kallerud.pdf); and Paul Forman, "The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology," *History and Technology*, 2007, *23*:1–152.

[41] Smith, *Scaling Fisheries* (cit. n. 23), p. 2.

biologists and resulted in a return to many strands of basic research, including evolutionary ecology and fisheries oceanography.[42] In addition, fisheries scientists have learned to appreciate the contributions of fishers and in some cases have sought to develop collaborative work with them. In many respects, fisheries biology's quest to conserve fish has just begun; it will require enough will on the part of governments to continue funding this science and its institutions and to valorize the conservation of commercial populations as a public good.

[42] Rob Stephenson (former director, St. Andrews Biological Station), personal communication.