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# Overseeing the Family of Whitefishes: The Priorities and Debates of Coregonid Management on America's Great Lakes, 1870–2000

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## ABSTRACT

Over the past 175 years, a number of coregonids – lake whitefish (*Coregonus clupeaformis*), lake herring (*Coregonus artedii*) and chub (two species flocks: *Coregonus hoyi-kiyi-nigripinnis* and *Coregonus zenithicus-johannae-reighardi*) – have been among the principal target species of America's Great Lakes commercial fishery. This essay historically examines the manner in which coregonids structured particular management priorities and debates among fisheries constituencies and fostered a management milieu that ranged from willing cooperation and optimism to strident division.

## KEYWORDS

Coregonids, whitefishes, fisheries management, commercial fisheries, fisheries science, Great Lakes

The management of coregonids, in either a customary or institutionally sanctioned fashion, has been present on the Great Lakes waters of the United States for centuries. Decisions concerning the use and observation of these fish species are central to understanding human habitation and environmental transformation in the Great Lakes Basin, and, beyond these considerations, shed insight on why certain natural resources gain strong, almost iconic regional affiliations.<sup>1</sup> For Native Americans living in this region, the lake whitefish (*Coregonus clupeaformis*) was a staple in their diet and such consistent use patterns and reliance made the species a cornerstone of Ottawa and Ojibwa culture. Early French explorers marvelled at waters teeming with whitefish and, in the 1820s, the well-known

American writer, explorer and Indian agent, Henry Rowe Schoolcraft, declared: 'Its beauty and flavour no person can doubt/If seen in the water, or tasted without'.<sup>2</sup> Not surprisingly, the rise of such sentiment among Euroamericans fostered increasing interest in the commercial value of whitefish. The advent of integrated rail and waterborne shipping in the Great Lakes region in the mid-nineteenth century placed the lake whitefish squarely in the mainstream of American commercial life. Volume harvests followed these developments, and, over the next century and a quarter, in addition to being commercially overexploited, the fortunes of the lake whitefish and other coregonids became inseparable from the industrial pollution, habitat alteration, biological invasions and allocation debates surrounding America's sections of the Great Lakes.

Since the late nineteenth century, coregonids – lake whitefish, lake herring (*Coregonus artedii*) and chub (two species flocks: *Coregonus hoyi-kiyi-nigripinnis* and *Coregonus zenithicus-johannae-reighardi*) – have constituted a key part of the commercial fisheries of America's Great Lakes. Once the mainstay of the world's largest freshwater commercial fishery, this family of whitefishes dominated the region's, and indeed the nation's, commercial fishery management debates and priorities. Within this context, the official (government regulation, scientific investigations) and customary (traditional ecological knowledge, commercial fishing values) management of these species embodied economic aspirations, political tensions and ecological quandaries endemic to modern America's use of natural resources. This essay will consider how these factors influenced the shifting priorities, temperament and discourse of American coregonid management since the 1870s. This legacy begins with optimism in artificial propagation and the belief that modern, progressive conservation measures could scientifically cultivate coregonid stocks back to their pre-industrial levels. Not willing to confront the wider problem of environmental degradation or increased commercial fishing effort, policymakers saw fish hatcheries as a politically expedient way of avoiding the more systemic problems plaguing the Great Lakes. Although artificial propagation was not devoid of scientific altruism, its political guise and lack of refinement brought it under increasing scrutiny from scientists and fishermen. By the turn of the twentieth century, coregonid management became more focused on fish morphology, habitat, and the role of human factors in fisheries; it was a time when ecological research began making its entry into Great Lakes fishery management.<sup>3</sup> This approach ushered in the management paradigm of the later twentieth century, one that paid increasing attention to coregonids within a highly transformed Great Lakes ecosystem afflicted by non-indigenous species (sea lamprey, alewife) and the competing claims of a powerful sport fishing industry. Identifying these trends assists in understanding the placement of coregonid management in the unfolding context of Great Lakes environmental politics from the late nineteenth century to the present.

## OPTIMISM IN ARTIFICIAL PROPAGATION: CULTIVATING THE INLAND SEAS

The lake whitefish's longtime economic and cultural role in the Great Lakes region was a leading factor in the rise of progressive fisheries management in late nineteenth century America. But more than centuries-old traditional use patterns accounted for this role. By the end of the 1860s, reports described increasing concern over depletions in local stocks due to intensive fishing pressure. Due to these conservation concerns, fish culturists placed whitefish management at the centre of their efforts to establish the US Fish Commission in 1871. Spencer F. Baird, the first commissioner of this newly authorised body, regarded whitefish as 'the most valuable food-fish of the lakes' and directed assistant commissioner James Milner to the Great Lakes in 1871 and 1872 to investigate the state of the species.<sup>4</sup> In fact, even though the Great Lakes teemed with a variety of important freshwater fishes, Milner's rapid dispatch to the Great Lakes carried specific instructions to make whitefish 'the principal object of attention and efficient action for their restoration'.<sup>5</sup> Baird, as secretary of the Smithsonian Institution, had a symbolic as well as practical stake in showing that applied fisheries science could help fulfil the egalitarian premise behind America's consumption of natural resources. But interest in ailing whitefish stocks was not his alone. Supplementing Baird's considerable aspirations for a comprehensive fisheries science program for the United States was the collective weight of the recently formed American Fish Culturists' Association. The high-profile membership of the American Fish Culturists' Association helped ensure that the group's principal interests in artificial propagation would take precedence in the federal government's new foray into fisheries management.<sup>6</sup>

These political factors affected the implementation of Baird's broader management vision for the US Fish Commission and the role it might play in the Great Lakes; in fact, these issues were amplified by the region's vast freshwater basins being more readily compatible with the experience of America's community of fish culturists. Given American society's strong attachment to an agrarian mythology, Baird's agenda – using experienced zoologists to conduct scientific investigations, prepare economic/ethnographic reports, and formulate regulatory legislation – was circumscribed by a cultural temperament that simply wanted to grow fish and was less interested in fish ecology. These management priorities converged with the lake whitefish's almost iconographic status around the shores of the Great Lakes and made the artificial propagation of the species a central component of the US Fish Commission's work in this region in the final quarter of the nineteenth century.<sup>7</sup>

Such sentiment was hardly concealed when Milner endorsed the stocking of whitefish, declaring it 'by far the more successful method, in restoring the number of food fishes'.<sup>8</sup> In Baird's view, 'Few fishes of North America will better repay efforts for their multiplication than the whitefish' and his prefatory

remarks to Milner's report emphasised these policy and management priorities stating that 'the whitefish is of great value ... excellent flavour ... is adapted to the larger and cooler lakes of the interior ... and is easily propagated artificially'.<sup>9</sup> Milner's report echoed popular opinion, government directives and astonishing optimism. Its boosteristic language extolled the benefits of artificial propagation and cited evidence to justify the direction of a management strategy designed to feed Americans of all social classes.<sup>10</sup> The US Fish Commission substantiated its case principally around the work of three of North America's most noteworthy fish culturists – Seth Green of New York, Nelson W. Clark of Michigan, and Samuel Wilmot of Ontario, Canada.<sup>11</sup> The advances they made in whitefish cultivation, along with whitefish being more regularly harvestable on a year-round basis – unlike anadromous species – made their artificial propagation even more attractive to efficiency-minded conservationists. These criteria prompted Milner to conclude that 'in the Great Lakes, if it were advisable, there is nothing apparent in the way of the propagation of unlimited millions'.<sup>12</sup> Politically, both Milner and his colleagues at the US Fish Commission were driven by the notion that nothing could be nobler than to rescue the whitefish from scarcity and prohibit it from becoming a dietary staple of the rich. In cultural terms, whitefish policy priorities were assuming the function of a modern scientific crusade.<sup>13</sup> Whitefish sustained local populations for centuries and preserving its abundance became a matter of jointly upholding the general idea of American economic opportunity and the more provincial Jeffersonian notion of regional empowerment.

Faith in artificial propagation, so evident among prominent late nineteenth century fish culturists such as Spencer Baird and James Milner, became the prevailing method of whitefish management on the Great Lakes from the 1870s until the turn of the twentieth century. The US Fish Commission established a number of whitefish hatcheries spanning from one end of the Great Lakes basin to the other, and, in doing so, began the federal government's role in shaping Great Lakes coregonid management through informal channels with state fisheries officials. Not wanting to offend each state's jurisdictional prerogatives over its Great Lakes boundary waters, Baird established a strong federal presence knowing it could not help but influence coregonid management on the state level. His inclinations proved correct, creating a strong informal management relationship between Great Lakes states and the federal government that would last well into the middle of the twentieth century.<sup>14</sup>

The US Fish Commission worked intermittently on whitefish propagation in the 1870s and the first of its hatcheries dedicated principally to the species was established in Northville, Michigan in the 1880s. Once the US Fish Commission began to directly manage the artificial propagation of whitefish, it broadened its activities to maximise the collection and distribution of eggs and fry at some of the region's most important whitefish grounds. Federal whitefish hatcheries were built at Alpena, Michigan (on northern Lake Huron) in 1882 and at Duluth, Minnesota (at the western end of Lake Superior) in 1888. Moving eastward, the

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Commission assumed the use of the State of Ohio's hatchery at Sandusky on western Lake Erie in 1888 and substantially enlarged its whitefish propagation activities in this region when it commenced hatchery operations at Put-in-Bay, Ohio in the early 1890s (Figure 1). The period of whitefish hatchery expansion concluded in 1896 with the construction of whitefish hatchery facilities at Cape Vincent, New York (at the eastern end of Lake Ontario) in 1896.<sup>15</sup>



FIGURE 1. The US Fish Commission's Put-in-Bay, Ohio fish hatchery on Lake Erie, c. 1896. Although the commercial fishing community questioned the effectiveness of Put-in-Bay's whitefish propagation programme, it characterised the facility in *The Fishing Gazette* (January 25, 1894, vol. xi, no. 4) as 'the largest and best equipped fish hatchery in the world'. Such hyperbole, along with the size and architectural adornment of this facility, was emblematic of the optimism that accompanied early artificial propagation programmes. (US Commission of Fish and Fisheries)

Marked technological advances and architectural improvements accompanied the increase in the number of US Fish Commission whitefish hatcheries during the 1880s and 1890s. These whitefish stations reported significant increases in eggs collected and hatched, and fry reared. These numbers – ranging from 234,705,000 artificially propagated fry being deposited in the Great Lakes from 1875 to 1885 to a record 701,900,000 eggs being collected at western Lake Erie stations in 1902 – served as important scientific and management benchmarks in

promoting the Commission's on-going role in the region. Its fish rail cars linked widely separated federal and state whitefish hatcheries that rimmed the United States' side of the Great Lakes by supplying eggs and fry, and, in effect, created a concentrated network for the exchange of information between fish culturists and commercial fishing communities. To ensure its management position and its carefully orchestrated arbitrating role among Great Lakes states, the US Fish Commission consistently regarded its hatchery and stocking program as a success and in 1902 touted the benefits of twenty years of artificial propagation.<sup>16</sup> Ironically, the dissemination of information through these channels was one factor that revealed the shortcomings of over-reliance on artificial propagation and gradually instigated discussion for more complex, ecologically-based rehabilitation schemes.

By the turn of the twentieth century, the U.S. Fish Commission had the dominant voice in coregonid management largely due to the scale of its artificial propagation program. However, Great Lakes states did not surrender their managerial prerogatives. According to Great Lakes environmental historian Margaret Beattie Bogue: 'the states jealously guarded their rights to make rules for their Great Lakes waters and enforce them. Their desire for federal assistance in no way sanctioned federal control'.<sup>17</sup> However, in the course of preserving economic control over their waters, Great Lakes states were all too willing to accept voluminous donations of whitefish eggs from the US Fish Commission for their hatcheries, as well as the results of scientific investigations concerning the species. The federal government viewed this as the most acceptable course for maintaining some semblance of managerial participation in America's richest environment for coregonid species. Given the constitutional limitations on federal management of Great Lakes waters, this arrangement allowed the US Fish Commission to have a prominent role in whitefish management without threatening the territorial prerogatives of each state government.

State government shared, and in some cases anticipated, the federal government's strident concern over Great Lakes whitefish stocks. They followed the institutional course of the federal government and established state fish commissions that enthusiastically embraced artificial propagation. Not surprisingly, the states whose waters contained the most biologically prolific and economically developed whitefish grounds – Michigan, Wisconsin and Ohio – instituted extensive hatchery programs from the 1870s through the 1890s.<sup>18</sup> But these states, in addition to sustaining considerable commercial fishing operations, of which whitefish was the prized target species, also supported enough industrial activity to easily qualify them as centres of America's burgeoning industrial economy. Within this region's industrial economy, much activity was significantly linked to resource-extractive industries – such as mining, lumbering and, of course, fishing. Log drives and sawdust destroyed vital spawning areas, as did leaching metals from mine tailings.

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These dynamics fostered an economic juggernaut that made the 'inland seas' (as the Great Lakes are often called) into one of the world's most industrial corridors, rimmed with variously scaled urban/manufacturing sites whose trade wastes and effluent did not enjoy the rapid flushing action of America's oceanic ports. Commercial fishers expressed concern with habitat destruction and pollution in some of the earliest reports filed by the US Fish Commission, and their observations were noted in James Milner's initial investigations, Smith and Snell's exhaustive 1885 survey of Great Lakes fisheries, and in the work of one of America's first ecologists, Stephen A. Forbes. But fishers were not prepared to temper their harvesting habits or relent from exerting considerable pressure on their legislatures to adopt distinctly anti-regulatory stances toward commercial fishing. According to Margaret Beattie Bogue, a vanguard of Great Lakes fisheries authorities 'accepted the idea that the changing aquatic environment had serious consequences for fish life. Yet in official reports, thoughtless human greed, wastefulness and uncontrolled harvesting of the resource were cited as the primary cause of the deterioration of the fisheries'.<sup>19</sup> Even though George Perkins Marsh's assessments of habitat destruction by manufacturing and resource-extractive industries were fresh in policymakers' minds, the frenzied industrial temperament of the Great Lakes region paralysed the investigation or implementation of appropriate environmental remedies for whitefish and their habitat. Preferring to look past the conflicting sentiments of the wider fisheries community, policymakers contented themselves by focusing on equally urgent water quality issues that were showing a more immediate impact on human health. Outbreaks of typhoid, cholera and dysentery in Great Lakes venues quickly diverted political attention from fisheries and toward the construction of the Chicago Sanitary and Ship Canal and a host of sewage treatment facilities.<sup>20</sup>

Driven by the Gilded Age's optimistic ideas of economic development, none of these states were inclined to dramatically curb the whitefish fishery through stringent regulations, gear restrictions and closed seasons. Nor were policy makers prepared to dampen the economic crusade of the post-Civil War era by dealing with the systemic problems of habitat destruction or industrial pollution. While one writer ominously cast 'America feverishly devouring' its Great Lakes resources, most saw such rapid consumption as emblematic of America's liberating economic promise.<sup>21</sup> Under this set of assumptions, there was little political will in state legislatures to restrict whitefish harvests or rehabilitate their habitat.

These circumstances placed fisheries officials in each of the Great Lakes states in a paradoxical situation: what management plan could provide enough whitefish to preserve its centuries old dietary, cultural and ecological role, and, at the same time, make its voluminous harvest compatible with the frontier conquering spirit of *laissez-faire* capitalism? Confronted with these challenges, state fish commissions opted for whitefish hatcheries as their principal management tool; it was an approach that avoided the widespread political friction that



would be incurred by large scale ecological remedies and it played favourably to a society enamoured with new scientific solutions. In short, by cultivating and planting a large volume of whitefish eggs and fry, state fish commissions sought to scientifically engineer a solution to dwindling stocks in their adjacent Great Lakes waters. Empowered by scientific presumption, this management policy masked as many questions as it solved. Not yet aware of artificial propagation's limitations, each Great Lakes state employed it to circumvent political and biological problems that sprung deeply from a transformed fisheries ecology.

Each of the Great Lakes states worked with the federal government in pursuing this management course (receiving eggs, fry and scientific advice), but the actions of the State of Michigan exemplified the singular faith and focus of state fish commissions in whitefish hatchery programs in the late nineteenth century. Similar to the US Fish Commission's intentions, the enabling legislation that created the Michigan Fish Commission in 1873 specifically emphasised 'the artificial propagation and cultivation of White Fish and such other kinds of the better class of food-fishes'.<sup>22</sup> With whitefish grounds rimming most of Michigan's shoreline, the fish commission wasted little time establishing whitefish hatcheries throughout the state from the 1870s through the 1890s. In a move that mirrored the federal government's strategy, the Michigan Fish Commission integrated the functions of these stations by moving whitefish fry between them on its railroad fish car named 'Attikumaig' – the Ojibway name for whitefish. Michigan Fish Commissioner George Jerome consulted the renowned fish culturist Seth Green and hired his most promising student – Oren Chase – to oversee Michigan's whitefish operations. Chase's innovations dramatically increased the production of Michigan's whitefish hatcheries and annual plantings of whitefish fry rose to 70 million per year between 1880 and 1887.<sup>23</sup>

#### SCRUTINISING ARTIFICIAL PROPAGATION: SCIENTIFIC REFINEMENT, POLITICAL CHALLENGES

Though political factors stunted Baird's lofty goals for fisheries science, there were practical reasons for gaining a greater understanding of the broad ecology of whitefish. Both the US Fish Commission and the various state fish commissions relied on commercial fishers and their traditional ecological knowledge to identify whitefish grounds and breeding behaviour.<sup>24</sup> But when planting whitefish fry, the US Fish Commission, early on, wanted more accurate information on the species early feeding habits and food supply and employed Stephen A. Forbes to conduct this research.<sup>25</sup> The US Fish Commission also realised that its ability to evaluate its artificial propagation program required greater attentiveness to the effects of the whitefish fishery's human factors. In focusing on 'statistics of the fisheries (*Great Lakes*) with reference to the influence of artificial propagation of several species', the U.S. Fish Commission, starting

in 1885, began collecting economic and technological data that bore directly on the ecological dynamics of the whitefish fishery.<sup>26</sup> Fieldworkers collected copious information on fishing boats, harvesting technologies, fishing grounds, processing facilities, harvesting statistics, investment costs and the location and demographic profile of Great Lakes fishing communities. While hoping to statistically test the effectiveness of federal and state whitefish propagation programs, these reports also documented the adverse effects of overfishing, by-catch of undersized fish, pollution and urbanisation on whitefish stocks.<sup>27</sup> These reports tapped into a strong undercurrent of concern for the whitefish's larger ecology and, in short order, whitefish management – indeed, coregonid management at large – would start asking questions that received little or no priority during the preceding thirty years.

As fisheries researchers gradually identified ecological factors that endangered the health of whitefish stocks, they also fostered an awareness that the future of the species rested on an understanding of its relationship to its larger aquatic environment. The urgency of this problem grew as fisheries scientists faced an undeniable fact: by the last decade of the nineteenth century, artificial propagation was having no discernible effect in reversing the diminishment of commercial whitefish harvests. In the midst of these dilemmas, whitefish management in the Great Lakes region began its gradual shift toward an ecological orientation. At the time, Seymour Bower, of the US Fish Commission, saw few reasons why anyone should be surprised at the disappointing results of whitefish propagation on Lake Erie. Declaring that 'wasteful instead of rational methods of capturing the species have been practiced', he noted that the indiscriminate use of gill nets and pound nets was harvesting immature whitefish and impairing the spawning runs of adults.<sup>28</sup> He further mentioned, for Lake Erie, that these destructive practices were the outcome of each state's self-interest in maximising the economic profit of its respective whitefish grounds. Calling for an end to a fragmentary management tradition that ignored fish ecology, Bower stated: 'Rational and effective measures must be based on the fact that in its water life the lake is a unit'.<sup>29</sup>

Being forced to respond to the immediate concerns of its commercial fishers, and having the power to act legislatively, the State of Michigan readily accommodated the emerging ecological paradigm to the territorial priorities that traditionally governed the state's whitefish management policy. This new direction, initiated by the Michigan Fish Commission in 1893, linked past and present by recalling the explicit legislative language that, in 1873, put whitefish rehabilitation at the forefront of the agency's mission. Hoping to re-vitalise its mission through greater attention to whitefish ecology, the commission declared 'that one of the elements in this problem namely, the whitefish, we know but little ... What then, do we know of the other elements of the problem, the Great Lakes themselves'?'<sup>30</sup>

The Michigan Fish Commission acted on this research agenda by authorising Jacob Reighard, a zoologist from the University of Michigan, to direct inventories of the biota of Lake St. Clair and Grand Traverse Bay to determine the manner in which they supported whitefish populations. Grand Traverse Bay's inclusion in the traditionally rich whitefish grounds of northern Lake Michigan provided researchers with 'a locality which was the home of this species throughout the entire year, and which afforded hence an opportunity of studying it continuously in its natural environment'. The State of Michigan also passed legislation to strengthen whitefish stocks by closing commercial fishing during spawning season (generally November 1 to December 15) and the Milliken Act required 75% of the fry hatched from eggs from Michigan waters be returned to the state's whitefish grounds. Along with these legislative steps, Reighard's commitment to using aquatic ecology research as the basis of whitefish management continued through the 1890s. A number of Great Lakes-based colleagues joined him in this pioneering work and he was able to obtain funding from the US Fish Commission to continue, among other studies, a growing body of research on whitefish and other coregonids until 1902. Specifically, under this federally funded program, scientists based at Put-in-Bay, Ohio on Lake Erie continued research on the whitefish's wider biological context and began inventorying other coregonids (lake herring and chubs) and their locations. Reighard, who corresponded with Stephen Forbes, advanced the latter's aspirations for aquatic ecology, an enterprise that one ecologist claims Forbes saw 'of potential value to people of both pure scientific and practical interests ... to both research biologists and fish culturalists'. But in 1902, legislators who wanted what they saw as more direct, applied ways to improve the condition of whitefish stocks undervalued these advances. The future of biologically/ecologically-informed whitefish management became clouded by the US Fish Commission's continued emphasis on artificial propagation and the failure of the US House of Representatives to fund a Great Lakes biological research station at Put-in-Bay in 1902. The federal government's decision – rooted in its favour of immediate, applied measures and less scientific inquiry – undermined the biological/ecological study of whitefish and led to a virtual suspension of such work until the 1920s.<sup>31</sup>

The timing of this legislative decision, during the early twentieth century when some fisheries officials from both the states and the US Fish Commission were gradually moving towards ecologically-informed whitefish management, dealt a serious setback to growing interest in the systematic management of other coregonids. By the mid-1880s, as harvests of lake whitefish remained low, these so-called 'minor' coregonids – lake herring (*Coregonus artedii*) and three varieties of chubs (*Coregonus nigripinnis*, *alpenae* and *hoyi*) – quickly became dominant target species.<sup>32</sup> While lesser harvests of lake whitefish drove this shift, other factors figured in the commercial rise of these coregonids. This trend received some of its initial impetus from northern European immigrants who desired smoked herring and chub, but it was also accelerated by the rise of

greater off-shore fishing in deeper water using steam-powered fish tugs and gill nets.<sup>33</sup> By the early 1890s both state and federal researchers recognised that more fishing effort was being expended on these ‘minor whitefishes’ and anticipated the need for scientific data that would assist in managing these species.<sup>34</sup>

The Great Lakes fishing community’s three principal stakeholder groups – fishers, scientists and policymakers – entered the twentieth century equipped with new insights on how they might proceed with coregonid management. As management relations among these groups became more intertwined and contested, commercial fishers became noticeably vocal. From their earlier dealings with the US Fish Commission and the various state fish commissions, they proved that they were astute observers of the lake whitefish and its ecology. As Margaret Beattie Bogue notes from her review of the joint US/Canadian Great Lakes fisheries surveys of the early 1890s, many of these fishers ‘looked beyond the immediate practical questions of learning when and how to make the largest catch and tried to learn broadly about fish life cycles and habits’.<sup>35</sup> Not only were they emboldened by the role they played as informants in the major Great Lakes fisheries surveys of the day, but they were continuously relied upon by fisheries scientists in identifying whitefish grounds, spawning behaviour and the make-up of lake bottom. While federal and state fisheries officials relentlessly promoted artificial propagation, commercial fishers pointed out factors – such as unregulated entrapment methods and pollution – that readily negated the very efforts being touted. And, although Lake Erie’s fishers generally favoured artificial propagation, some found their enthusiasm shaken in 1891 when the excessive placement of pound and gill nets prohibited whitefish from getting to their spawning grounds in the western section of the lake.<sup>36</sup> This disaffection with the unidimensional application of artificial propagation led some commercial fishers, but by no means all, to comment increasingly on management strategies that did not account for the whitefish’s broader ecology.

In the years immediately preceding World War One, commercial fishers steadily contributed to a growing public dialogue over the management of lake whitefish, lake herring and chubs. The lack of any type of holistic regulatory scheme for any of these species only fuelled the discourse’s intensity. Commercial fishers communicated their sentiment in daily talk and community meetings, but they also frequently submitted their management opinions to the pages of *The Fishing Gazette*, the occupation’s nationally circulated trade journal. David LeClaire, of Two Rivers, Wisconsin, one of the most active commercial fishing centres on the Great Lakes, harboured sentiments that circulated within the occupation’s ranks. Between 1915 and 1921, he editorialised, in *The Fishing Gazette*, opinions on coregonid management that only grew in importance in the years to follow. Most noteworthy among LeClaire’s management concerns were the aspersions he cast on the artificial propagation of whitefish and interference with the natural breeding process; specifically, in his view, the difficulty of handling whitefish eggs doomed any possible benefits from such measures.

He challenged the motivations of spawn permit fishers, and, whether gill netters or pound netters, saw them as privileged patrons in a politically tainted process driven less by conservation concerns and more by the prospect of easily catching whitefish in shoal waters and selling them in a less competitive market.<sup>37</sup>

The limited scope of early twentieth century coregonid management treated the fishery as a monolithic entity when, in practice, such measures needed to account for the occupation's political, class and sectional differences. Effective coregonid management thus suffered under the weight of each group's (individual, family and company-based fishing operations) divisive self-interest, a scenario that was compounded by the class differences that often separated highly-capitalised pound net operations from gill netting. Similar sentiments, such as LeClaire's description of the 'jealousy of the different classes of fishers', arose from those who favoured artificial propagation of whitefish, but could not financially bear the cost of coupling these measures to multiple closed seasons. Some fishers criticised small meshed nets that captured young whitefish before they could contribute their spawn to the natural breeding process.<sup>38</sup> These frayed relations – stemming from differing management positions among states and fishers – prompted LeClaire and other fishers to suggest federal control over Great Lakes fisheries management.<sup>39</sup> Other fishers' assessments were less critical than LeClaire's. One fisher noted the 'careless manner' of early whitefish planting, but saw these problems as largely remedied by the more recent, carefully handled studies of federal and state-sponsored scientists. He was quick to display his own in-depth, occupationally acquired ecological knowledge and suggested that such information from the commercial fishing community played no small part in helping researchers advance artificial propagation. In addition to these outcomes, he envisioned, along with a growing number of his colleagues, an emerging spirit of co-management between government fisheries managers and commercial fishers.<sup>40</sup>

These affairs exemplified the multi-faceted debate that, with ever-greater vigour, engulfed coregonid management options in the early twentieth century. But in spite of being freely circulated, these ideas led to no abatement in the increasingly heavy fishing pressure that was now being exerted on lake herring and chubs. Indeed, in 1915, David LeClaire's editorial in *The Fishing Gazette* asked why the State of Wisconsin was not doing more to rehabilitate its lake whitefish stocks rather than increase its dependence on lake herring and chubs (Figure 2).<sup>41</sup> The demand for lake herring and chub rose in commercial importance to offset the declining economic return of exhausted whitefish stocks; within this compensatory context, over-reliance on these species partially contributed to a regulatory culture ranging from managerial neglect to friction between fishers pursuing them for human consumption and fishers targeting them for bait.<sup>42</sup> As fishing pressure reduced chub numbers, fishers resorted to smaller mesh sizes to better insure their chances of acquiring the available stock. Starting in the 1880s, these mesh sizes went from 3 inches to as low as 2 1/2 inches in the 1910s



FIGURE 2. The Great Lakes fish tug *Earl Bess* with a large haul of lake herring from Lake Erie in November 1918. (US Bureau of Fisheries).

and 1920s. By the close of World War One, the problems of this managerial context led to stress on the chub population of Lake Michigan, and declines in the stocks of Lakes Huron and Ontario.<sup>43</sup>

The same dynamics that immobilised any progress in chub management were also at work in the lake herring fishery. By 1920, a thirty-year pattern emerged that showed unrelenting dependence on lake herring, particularly on the stocks that inhabited the shallow waters of Lake Erie, Saginaw Bay and Green Bay. On Lake Erie alone, the lake herring catch reached as much as 38,868,000 pounds a year, and an average of seven of the lake's yearly catches of lake herring, spread between 1890 and 1924, shows a median harvest of 23,139,000 pounds.<sup>44</sup> Lake herring fishers used both gill nets and pound nets, but it was the use of the highly efficient bull net – a gill net measuring 20 to 25 feet in height – that enabled the fishery to maintain such high annual harvest levels. Beyond a few regulations for the mesh size of pound nets and gill nets, this intensely targeted fishing effort did little to instigate more extensive plans for lake herring management.

In the years immediately following World War One, the strain of such fishing effort was leaving its mark. On Saginaw Bay, the commercial catch of lake herring consisted principally of younger fish (78% to 85% being three to four years old) that had just reached sexual maturity and eliminated on-coming classes' future contribution to propagation. The seemingly endless supply of

lake herring fostered managerial complacency. In spite of the species prevailing commercial role, there were no closed seasons or attempts at artificial propagation, only a few regulations for the mesh size of pound nets and gill nets. In fact, well after lake herring became the overwhelmingly dominant commercial fish in Green Bay and Saginaw Bay, the State of Michigan failed to keep any catch statistics for the species between 1909 and 1928.<sup>45</sup> In 1919, James Nevin, the influential superintendent of the Wisconsin Fish Commission, called for greater management attention of lake herring and chubs. Referring to the commercial importance of these 'family whitefish', he lamented that the 'State has not done as much as it should in propagating herring and chubs, due largely to lack of funds and equipment to carry on the business in a manner to assure success'.<sup>46</sup> He voiced growing concerns over pollution, supported uniform closed seasons on Lake Michigan, and attributed declining catches to small mesh gill nets. Nevins' views were both timely and fateful; they were shortly followed by the first Great Lakes coregonid management crisis of the twentieth century, the precipitous decline of Lake Erie's lake herring harvest from 32 million pounds in 1924 to 6 million in 1925.<sup>47</sup>

#### THE RISE OF ECOLOGICALLY-ORIENTED MANAGEMENT

In the midst of the lake herring crisis, the federal government shifted its management priorities away from artificial propagation and began focusing on the aquatic ecology of Great Lakes fish. The decline of commercially important coregonids placed them at the centre of this new initiative, and, not surprisingly, the US Bureau of Fisheries (formerly the US Fish Commission) went back to Jacob Reighard for advice on how to proceed. Not only had Reighard been instrumental in advancing ecologically-oriented approaches to coregonid research in the 1890s, but more recently served as chairman of the American Fisheries Society's Committee on Relations with National and State Governments. He was thus in a position to help facilitate a new era of federal-state cooperation that would address the complex environmental challenges facing coregonid management. At the request of the US Bureau of Fisheries research office, Reighard recruited two of his students – Walter Koelz and John Van Oosten – to begin the first sustained research on Great Lakes coregonids since his own work at the turn of the century. This re-invigorated agenda sought a more sophisticated understanding of various species' life histories, and the US Bureau of Fisheries planned on using this research to formulate new coregonid management procedures based on wider ecological criteria. Hoping to broaden these management perspectives even further, the Bureau planned to link this biological data to economic analyses and pollution studies.<sup>48</sup>

To act on these management plans, a better taxonomy for the region's coregonids was needed.<sup>49</sup> Koelz began this process by conducting, over the course

of the 1920s, the first comprehensive inventories of Great Lakes coregonids. Recognising the applied dimensions of his studies for both managers and fishers alike, Koelz contextualised the shortcomings of earlier coregonid taxonomies that 'were very vague and were simply general remarks about shape, size and colour'. In contrast, his work consisted of the examination of '10,000 specimens from many localities' and the evaluation of 'available data on spawning seasons, bathymetric and geographic distribution, seasonal movements, and other biological factors'.<sup>50</sup> Koelz's scientific method, along with his use of observations by fishers, showed the practical application of ecologically-oriented inquiry and set a new baseline for the management of Great Lakes coregonids. Van Oosten's work was no less emblematic of these new priorities. He contributed to this shifting management paradigm when he refined the study of the life histories of lake whitefish and lake herring through scale (age) analysis.<sup>51</sup>

Koelz and Van Oosten, both as students at the University of Michigan and staff members of the US Bureau of Fisheries, received other assignments that typified the federal government's growing interest in assisting Great Lakes states with coregonid management problems that could only be solved through wider ecological inquiry. Such studies included Van Oosten's work on Saginaw Bay where he concluded that discharge from Dow Chemical stunted the growth of lake herring. His work on northern Lake Huron revealed fish managers using faulty maturation schedules for whitefish, negating their efforts to protect spawning stock. Koelz engaged in the first systematic attempt to delineate the contours of the region's fisheries ecology and to situate the predicaments of coregonid management within the dynamic interplay of biological, economic and cultural factors. Along with other scientists, he raised concerns over the effects of overfishing, the early and on-going destruction of coregonid habitat by pollution, and the amount and type of technology used to increase fishing effort. As lake herring and lake whitefish stocks suffered under the weight of commercial exploitation, Koelz's scientific research brought a note of caution to the unprecedented fishing pressure now being placed on declining chub stocks; it was an assessment which substantiated Nevin's earlier concern over the capacity of chub populations to endure such a shift in fishing effort. Conceding the blatant effects of overfishing, he further contended that lack of information on the life histories of coregonids impaired the sound evaluation of fishing practices and their effect on fish stocks.<sup>52</sup>

In spite of these advances, Koelz contended that broad-based fishery investigations still faced impediments. In his view, attempts to advance ecologically-informed whitefish management were, as late as the mid-1920s, suffering under the lingering influence of 'rank and file conservationists' who clung to artificial propagation and 'rosy visions of the possibilities of the new-found art'. His comments echoed earlier criticism of fish culture and reminded whitefish management and fishers that artificial propagation was an enhancement, not the solution, to rehabilitating whitefish stocks. His challenging remarks declared



that 'no one may safely affirm that the relatively few eggs that are artificially hatched – few in comparison with the numbers destroyed to collect them – can compensate for the benefits that might be derived if all the fish were allowed to spawn naturally'. Koelz's integrated analysis lent credence not only to the practical problem of limiting catches and closing seasons, but, as a methodological starting point, allowed the US Bureau of Fisheries to better envision the priorities and limitations that confronted any broadly-conceived examinations of Great Lakes fisheries ecology.<sup>53</sup> By the mid-1920s, Koelz and Van Oosten's work had made coregonids the most comprehensively studied species in the Great Lakes basin and convincingly displayed the relevance of scientific inquiry in prioritising modern management schemes.

These advances, along with the staggering decline of Lake Erie's herring harvests, encouraged the federal government to finally authorise the US Bureau of Fisheries to create a Great Lakes fisheries laboratory in 1927.<sup>54</sup> The US Bureau of Fisheries placed this initiative, known officially as the Great Lakes Fishery Investigations (hereafter referred to as GLFI), under the direction of John Van Oosten. Having been 'born in the crisis arising from the disappearance of the Lake Erie cisco (*the lake herring*)', the founding of GLFI exemplified the continuing capacity of coregonids to dictate management priorities for the Great Lakes basin.<sup>55</sup> Dramatic shifts in coregonid values (economic and cultural) and coregonid consumption defined Van Oosten's earliest work. But the need to balance political and economic pressures (the Great Depression, fish stock collapses) with scientific research was evident when Van Oosten shifted from studying the life histories of coregonids (whitefish, chubs and lake herring) to the 'more practical and controversial problems that confronted commercial fishermen'.<sup>56</sup> Upon taking control of the GLFI, Van Oosten worked cooperatively with a variety of federal, state, local and private agencies to determine the causes of the lake herring's decline. Beginning in 1927, Van Oosten and his GLFI staff spent three years analysing the distribution of fishing pressure around Lake Erie, and, to account for the role of pollution, conducted limnological studies of the basin's well-known water quality problems. Van Oosten determined that overfishing was the principal cause of the lake herring's decline, a finding that influenced the organisation of a number of management conferences and the adoption of a uniform law that eliminated the use of bull nets on Lake Erie in 1933.<sup>57</sup>

From 1930 to 1932, Van Oosten's team worked with the States of Michigan and Wisconsin and four net manufacturers to devise a gill net for chubs that would reduce the by-catch of small lake trout. This study revealed the selectivity of chub net meshes but did not lead to any discernible changes in chub regulations. However, this study did accumulate substantial data on the distribution of chub species, their growth patterns, their food, and other relevant information on the deep-water habitats and hydrology of Lake Michigan.<sup>58</sup>

In its final cooperative project before World War Two, the GLFI and the State of Michigan also collaborated in assessing the devastating effects of deep trap

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nets on whitefish stocks in Lakes Michigan and Huron during the late 1920s/early 1930s. Van Oosten and his colleagues discovered that deep trap nets, typically used at depths of 50 feet and below – some placed as deep as 100 to 160 feet – harvested whitefish in unprecedented numbers in areas that naturally served as sanctuaries from the fishing pressure of pound nets and gill nets (Figure 3).<sup>59</sup> The deep trap net's unparalleled efficiency and versatility in a variety of lake bottom conditions even caused the Great Lakes-based commercial trade journal *The Fisherman* to declare that the apparatus had 'invaded the sanctuary of the whitefish and, with the present size of mesh fished in unlimited depths, are depleting the mature fish and destroying the juveniles'.<sup>60</sup> Van Oosten's research and warning led to what was, arguably, his most important contribution to coregonid management. In 1934 and 1935, the State of Michigan acted on his recommendations and passed laws prohibiting the use of deep trap nets for whitefish in its Lake Michigan and Lake Superior waters. Although Michigan still allowed their use in a minimum of 80 feet of water in Lake Huron, its passage of the aforementioned law, along with Wisconsin's earlier laws prohibiting deep trap nets, eliminated them from the Great Lakes whitefish fishery. Through each of these efforts, Van Oosten and the GLFI served the development of coregonid management by simply linking stakeholders and instituting unprecedented cooperation through research projects, conferences and daily deliberations.<sup>61</sup>

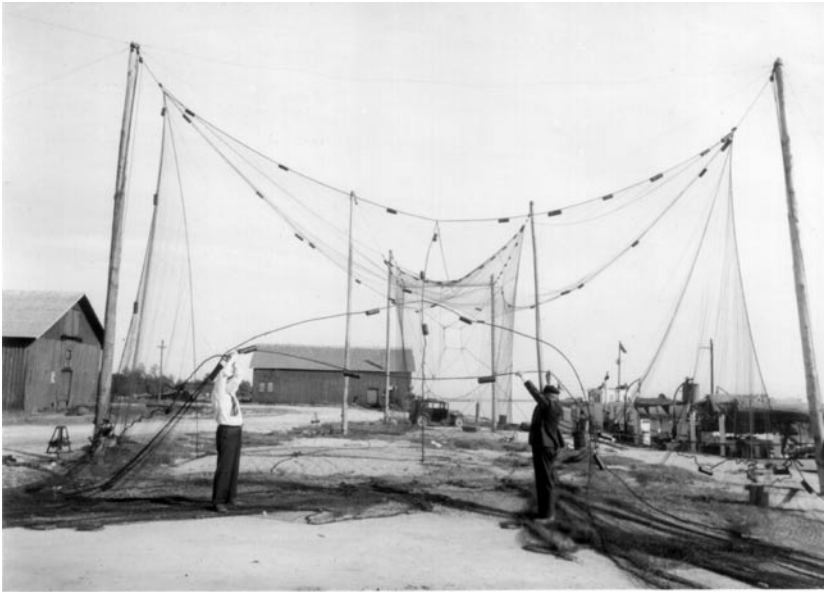


FIGURE 3. John Van Oosten (left) inspects a deep-water trap net in Manistique, Michigan, June 1932. The trap net has been hung to display its arrangement in the water when used in the whitefish fishery. (Great Lakes Science Center, US Geological Survey, 32-C-5)

The force of integrated management, which made its mark in the changing orientation of the federal government and the establishment of the GLFI, also affected each of the Great Lakes states' management approaches. During the 1920s, Great Lakes states began instituting changes in their fisheries management strategies, most notably, the elimination of fish commissions and the creation of fisheries divisions within state conservation departments. By the close of the decade, many of these states had passed their most comprehensive fishing regulations to date. But, in spite of these advances, most of which were directly driven by coregonid management concerns, Great Lakes states lacked the resources and expertise, as shown by their cooperative projects with the GLFI, to evaluate fishing conditions and define appropriate regulatory frameworks. Today, it is widely conceded that the Great Lakes states increasingly relinquished these duties to the federal government from the 1920s through 1950s. Specifically, it is widely acknowledged that Michigan's fisheries division informally consigned these duties to John Van Oosten's GLFI from the late 1920s through the 1950s so it could devote its limited resources to managing small inland lakes and streams.<sup>62</sup>

#### BIOLOGICAL INVASIONS AND SPORT FISHERIES: COMPETING INTERESTS AND ALLOCATION DEBATES

On the eve of the Second World War, after fourteen years of interstate and international conferences, the rise and fall of artificial propagation schemes, and the formation of the International Board of Inquiry for the Great Lakes Fisheries in 1940, the coregonid fisheries of America's sections of the Great Lakes showed continued decline or stagnation with no indication of returning to the health of their pre-1890 years.<sup>63</sup> The management plans that were in effect offered no changes that would reverse these conditions and were simply intended to keep fishers operating on a profitable basis. As with the First World War, the production demands of the Second World War diverted attention from these pressing issues. By the war's end, the predatory sea lamprey had fully invaded the Great Lakes and inflicted heavy losses on whitefish. The predatory effects of the sea lamprey were exacerbated by the on-going biological invasion of the alewife. At the end of the 1950s, the biological dominion of both species resulted in the almost total re-configuration of the Great Lakes' ecosystem. Fishers who targeted coregonid species were economically crippled by these circumstances and remained solvent by focusing on the harvest of chubs. The overwhelming magnitude of the sea lamprey problem left little time for state and federal authorities to address new coregonid management plans, and the marginal economic standing of the commercial fishing community reduced its leverage in shaping policy directions. Ultimately, fishers found themselves not

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only having to adapt to bewildering ecological changes, but to a political and cultural climate that favoured a new emphasis on recreational fishing.<sup>64</sup>

Starting in the 1950s, these ecological and cultural changes provided the context for a new set of coregonid management priorities. Commercial fishers throughout the upper Great Lakes were now relying heavily on chubs as their principal target species. With the drastic reduction of its main predator – the lake trout – certain chub stocks (particularly the smallest chub species known as ‘bloater’) remained high. Starting in the late 1950s, the Michigan Department of Conservation reported record catches of chub, and between 1960 and 1966 the state’s commercial fishers produced an annual average chub harvest of five million pounds.<sup>65</sup> In the early 1960s, in an effort to control rising chub numbers in its Lake Michigan waters, the State of Wisconsin encouraged its commercial fishers to begin trawling to reduce the ecological imbalance caused by the overabundance of the species.<sup>66</sup>

Concessions for commercial fishers who targeted coregonids, such as the trawl fishery for chub, came to an abrupt end in the mid-1960s. To answer post-World War Two America’s unprecedented enthusiasm for outdoor recreation, Michigan and Wisconsin began to aggressively promote sport fishing on the open waters of the Great Lakes. Michigan’s new fisheries chief, Howard Tanner, declared his state’s view that Great Lakes ‘management goals must be shifted toward recreational fishing opportunities rather than commercial fishing, with commercial fishing playing a useful and productive secondary role’.<sup>67</sup> Tanner was not content only to manage native stocks to achieve these objectives, but, instead, moved boldly and successfully created a new sport fishery based on the introduction of Pacific salmon – a decision that was shortly followed by Wisconsin and other Great Lakes states.<sup>68</sup> Hatchery-reared Pacific salmon thrived in the Great Lakes, and the region’s recreational economy flourished from the increased construction of marinas, the sale of fishing tackle and boats, and patronage of tourist-oriented amenities. Tanner, along with his professional cohort in other Great Lakes states, seized this momentum and deftly linked their management crusade to America’s emerging Green Movement. Drawing on the nation’s powerful ‘back to nature’ ethos and frontier mythology, state governments worked with sport fishing constituencies to transform the environmental politics of the Great Lakes region and make recreational use of natural resources paramount over traditional industrial uses (Figure 4). Commercial fishers, economically crippled by the decline of their most valuable target species and relying principally on chub, had little support in countering this new management direction. A growing environmental movement and a burgeoning recreational fishery created new allocation priorities for the Great Lakes and complicated the claims of those who wished to harvest coregonids commercially.<sup>69</sup>

Under these circumstances, coregonid management was re-configured to accommodate its placement among a far greater number of user groups and ecological concerns. To further the goal of rehabilitating devastated stocks of



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lake trout and whitefish, Michigan drastically reduced commercial fishing areas, limited entry to the commercial fishery, designated specific commercial fishing zones and placed unprecedented conditions on types of gear used. Under this plan, commercial fishing for coregonids was geographically and technologically restricted to balance two simultaneous management goals: 1) lessen any negative impact it might have on the sport fishery through incidental by-catch of sport species; and 2) ensure commercially sustainable yields in the future. Great Lakes commercial fishing policy and management was long overdue for reform, but fisheries scientists now had to balance not only the effect of coregonid harvests, but also a new, complex ecology of predator-prey relationships caused by the arrival of the sea lamprey and alewife, and the recent introduction of Pacific salmon.<sup>70</sup>

Michigan's elaborate zone management plan became the blueprint for the Great Lakes states, and, beyond its role in furthering the rehabilitation of endangered lake trout and whitefish stocks, served to advance the long-term prioritisation of sport fishing. Frequently amended since its adoption in 1969, this management framework continues to dictate the procedures by which Michigan's state-licensed fishers harvest coregonids. Gill netting for lake whitefish and chubs was restricted to areas, depths and seasons that minimised its by-catch of lake trout. In the 1960s, Michigan re-authorised the use of deep trap nets and ultimately required their use in the state's limited whitefish fishery. As a form of live entrapment gear, trap nets allowed commercial fishers to return their by-catch of officially designated sport species such as salmon and lake trout. But as late as 1987, lake trout by-catch by coregonid fishers – particularly those pursuing whitefish – continued to pose problems in lake trout allocation debates and restoration efforts, leading Randy Eshenroder of the Great Lakes Fishery Commission to declare: 'Conflicts involving commercial fishing and lake trout restoration remain unresolved in many areas of the Great Lakes'.<sup>71</sup>

The on-going fishing pressure exerted on chubs in the 1960s and early 1970s, and the need to closely monitor rehabilitation of whitefish stocks, led Michigan's fisheries scientists to refine the state's zone management plan. Mapping its Great Lakes waters into a series of grids, Michigan's Department of Natural Resources was better able to gauge whitefish fishery effort and identify areas of chub concentration and provide justification for the establishment of refuges, limiting entry to the fishery, quotas and gear restrictions. Stress on chub stocks led Michigan, Wisconsin, Illinois and Indiana to close their Lake Michigan fisheries almost totally in 1975, although some harvesting was permitted through a highly monitored stock-assessment fishery. Following its emergency closure of the chub fishery – imposed from July 1975 through January 1976 – Michigan instituted increasingly strict regulations on the use of gill nets and areas that could be fished. These measures coincided with Michigan's interest in compensating large mesh gill net fishers (who pursued whitefish) to convert to trap nets. These policies thinned the state's commercial fishing ranks and,

according to Michigan's scientists, helped in the restoration of whitefish and chub stocks in the 1970s and 1980s.<sup>72</sup>

The intent of Michigan's actions, which were adopted in varying degrees in other Great Lakes states, was to prioritise the management of the waters and resources of the Great Lakes for their recreational value, not for their capacity to produce food for human consumption. This was a significant departure from earlier coregonid management, which, from the earliest measures taken by federal and state authorities in the late-nineteenth century, sought to maintain and enhance the commercial fishery's sound economic standing in the Great Lakes region. Commercial fishers faced an official policy premised on drastic reductions in the number of fishers and vast restrictions in the areas fished and type of gear used. Starting in the 1970s, in order to further reduce commercial fishing activity, the State of Michigan began offering compensation to chub fishers in exchange for the non-renewal of their gill net licenses and for the investment they had in their netting. Similar provisions were offered to gill netters who pursued whitefish; in addition, they were offered financial compensation to convert to trap nets.<sup>73</sup>

The 'secondary' priority that Michigan and other states allotted to commercial fishing became suspect among fishers because it was not accompanied by specific benchmarks or what they viewed as manageable economic outcomes for coregonid use. From the commercial fisher's perspective, new coregonid management schemes were less active in creating linkages between improved stock levels and economic return and more focused on removing any commercial fishing activity that might unintentionally infringe on sport fishing stocks or the actual act of sport fishing. Under these circumstances, commercial fishers often viewed restrictions as veiling state government's lack of commitment to the occupation, and, by extension, to active coregonid management. The expense of acquiring, using and maintaining trap nets precluded many longtime fishers from participating in the whitefish fishery. Gill net restrictions, unfavourable economic circumstances and the closure of the chub fishery from 1975 to 1976 forced other chub fishers to abandon the occupation.<sup>74</sup> Michigan's imposition of minimum income requirements had the unintended result of angering the state's Native American population – a group that relied on the supplemental income of part-time fishing, and, from a cultural perspective, valued their centuries old practice of ritually pursuing whitefish at certain times of the year.<sup>75</sup>

By the late 1970s/early 1980s, complex challenges continued to confront the new orientation of coregonid management. Enthusiasm over the salmon sport fishery spread to lake trout, walleye and perch, causing state authorities to be even more vigilant about incidental catch of these species by commercial fishers. But new regulations significantly curtailed fishing effort and commercial fisher and state officials took some satisfaction in watching new measures begin to stabilise whitefish and chub populations. But these successes were tempered by consumer warnings concerning DDT (dichloro-diphenyl-trichloro-ethane),

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PCBs (polychlorinated biphenyls) and various metals in Great Lakes fish; in the late 1970s, high levels of dieldrin led to a closure of the chub fishery in southern Lake Michigan.<sup>76</sup> While much needed regulatory reform of coregonid fisheries produced discernible results in terms of stock levels, the restrictions that were designed to accommodate these fisheries – particularly gill netting for chub – to the presence of sport fishing made it increasingly difficult to conduct profitable operations and many fishers left the occupation. Native Americans responded, in part, to their earlier disgruntlement with minimum income requirements by having their treaty fishing rights re-affirmed by the US Federal Court in 1979, giving them the right to conduct their own self-regulated commercial fishery.<sup>77</sup>

With Native Americans free to conduct their own self-regulated commercial fishery, Michigan more aggressively monitored Euroamerican commercial fishing activity and its potential effect on sport fishing. Michigan responded to its loss of control in matters relating to Native American fishing by placing greater restrictions on state-licensed fishers and continuing buy-out programs to retire from use a fisher's license and equipment. The State of Michigan also supported, along with the federal government, an experiment to explore the feasible use of purse seines in the whitefish fishery. Federal and state fisheries officials supported this effort, claiming that it would be an effective way of reducing by-catch of lake trout and salmon.<sup>78</sup>

Since the 1970s, in contrast to Michigan, Wisconsin has attempted to balance the interests of sport fishers and commercial fishers more equitably, and retains a far greater semblance of its longstanding coregonid fisheries through the allocation of quotas based on each fisher's past harvest record for chubs and whitefish. Unlike Michigan, Wisconsin fisheries officials have allowed the use of both gill nets and trap nets for whitefish, although there are restrictions on the placement of this gear to avoid infringing on areas that are heavily used by sport fishers. Wisconsin, far more than any other Great Lakes state, instituted co-management schemes and permitted commercial fishers to participate in the allocation of whitefish and chub quotas by serving on the Lake Michigan and Lake Superior Commercial Fishing Boards.<sup>79</sup>

Competing priorities, both within and among US Great Lakes states, the federal government and tribal authorities, afflicted coregonid management for the better part of the 1970s and 1980s as a more crowded field of stakeholders laid claim to limited resources and geographic areas. These circumstances underscored the need for a mediating institution, and increasingly the Great Lakes Fishery Commission (hereafter GLFC) assumed this role. A binational entity, the GLFC was established in 1955 and owes its existence largely to the panic that ensued from the sea lamprey's excessively predacious impact on lake trout and whitefish. While given the task of controlling sea lamprey proliferation, the GLFC was also mandated to conduct research on lake trout restoration and the health of other Great Lakes fish communities. GLFC research identified the predicaments of reconciling coregonid management with the competing claims



of sport and commercial fishers, the desire of state and federal government to restore lake trout, the on-going effects of longtime and recently arrived non-indigenous species, concern over bioaccumulation of toxins in valued target species, and a rejuvenated, self-regulating tribal fishery. The GLFC's research and advisory capacity, coupled with its non-binding management authority, was less threatening to the territorial prerogatives of US states and during the 1980s its role as a management mediator became more conspicuous. Although this role was charted for the GLFC as early as the mid-1960s, the implementation of the Joint Strategic Plan for Management of Great Lakes Fisheries by US and Canadian agencies in 1981 provided the GLFC with a more efficient framework for addressing contemporary coregonid management problems. Given the biological conditions of the Great Lakes and their multiple stakeholder groups, this plan placed renewed emphasis on an ecosystem management approach for fisheries. To implement this approach, the GLFC placed more management oversight in its specific lake committees – each consisting of membership from all major fishery groups. The oversight of coregonid fisheries became a central concern of the diversely-constituted lake committees and by the 1990s management protocols evolved to insure these species as a 'wholesome food' source and an enduring component of the region's 'cultural heritage, employment and income, and healthy aquatic ecosystem'. The effectiveness of the GLFC's initiatives awaits future judgement, but in the short-term, it began instituting a more balanced hearing for broad coregonid management concerns among US Great Lakes states.<sup>80</sup>

Since the late nineteenth century, coregonid management in the United States' Great Lakes region has been governed by a complex blend of human and biological factors. The optimism of early artificial propagation schemes reflected the aspirations of modern progressive science. Unfortunately, its priority as a management method often masked the inability, or unwillingness, of policy makers to address the broader problems that ecologically afflicted the family of whitefishes. When artificial propagation did not lead to the rehabilitation of whitefish stocks, commercial fishers turned their efforts to lake herring and chubs. The commencement of an intensive commercial fishery for lake herring and chub led to the depletion of the former and extreme fluctuations in the stock conditions of the latter. By the 1920s, the burden that had been placed on all these species, along with the overall environmental transformation of the Great Lakes ecosystem, led to the rise of ecologically-informed coregonid management and the establishment of the Great Lakes Fishery Investigations.

Although two world wars and the Great Depression hampered the development of ecologically-informed approaches to coregonid management, a minimal framework did exist to confront unprecedented changes caused by the invasion of the sea lamprey and alewife. Since the 1960s, the state governments of America's Great Lakes basin have managed coregonid fisheries with the goal of rejuvenating stocks and minimising any possible negative impact

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they might have on the recreational use of the Great Lakes. Not surprisingly, this process became increasingly contentious following World War II as more groups laid claim to the resources of the Great Lakes. The very limited number of Euroamericans who hold state-issued commercial fishing licenses direct their catch of whitefish and chub to small-scale local/regional markets. At present, self-regulated Native Americans are exercising more latitude in the management of coregonids and are partially linking their economic/cultural revitalisation to the harvest of these species. At the beginning of the twenty-first century, the cultural, environmental and economic efficacy of coregonid management within U.S. waters rests on interstate cooperation within the United States, international cooperation between the United States and Canada in the form of the bi-national Great Lakes Fishery Commission, the plans of autonomously regulated Native American fishers, and the ability of all interested groups to actively investigate the unfolding ecological dynamics of the Great Lakes basin.

## NOTES

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<sup>1</sup> William Ashworth, *The Late, Great Lakes: An Environmental History* (Detroit: Wayne State University Press, 1986), 14, 116.

<sup>2</sup> Margaret Beattie Bogue, *Fishing the Great Lakes: An Environmental History, 1783–1933* (Madison: The University of Wisconsin Press, 2000), 5–9; Charles E. Cleland, *Rites of Conquest: The History and Culture of Michigan's Native Americans* (Ann Arbor: The University of Michigan Press, 1992), 45–7; Philip P. Mason, ed., *Schoolcraft's Ojibwa Lodge Stories: Life on the Lake Superior Frontier* (East Lansing, MI: Michigan State University Press, 1997), 43.

<sup>3</sup> Stephen Bocking, 'Stephen Forbes, Jacob Reighard, and the Emergence of Aquatic Ecology in the Great Lakes Region', *Journal of the History of Biology* 23 (Fall 1990), 461–98.

<sup>4</sup> 'Investigations in 1871 and 1872 on the Great Lakes', in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1872 and 1873* (Washington, D.C., Government Printing Office 1874), xiv–xv.

<sup>5</sup> *Ibid.*, xv.

<sup>6</sup> *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1872 and 1873* (Washington, D.C.: Government Printing Office 1874), xvi–xvii, xxxiv–xxxv; 'Operations of the U.S. Fish Commission', in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1878* (Washington, D.C.: Government Printing Office, 1880), liv; John

F. Reiger, *American Sportsmen and the Origins of Conservation* (New York: Winchester Press, 1975), 11–72; E.F. Rivinus and E. M. Youssef, *Spencer Baird of the Smithsonian Institution* (Washington, D.C.: Smithsonian Institution Press, 1992), 141–51.

<sup>7</sup> Bogue, *Fishing the Great Lakes*, 195–203; Stephen Bocking, ‘Stocking the Great Lakes: Fish Culture in the 19th Century’, *Inland Seas* 57 (Spring 2001), 64–74. For a comparative perspective on the cultural and societal factors that drove the U.S. Fish Commission’s commitment to hatcheries, see Joseph E. Taylor III, *Making Salmon: An Environmental History of the Northwest Fisheries Crisis* (Seattle: University of Washington Press, 1999), 68–98.

<sup>8</sup> James W. Milner, ‘Report on the Fisheries of the Great Lakes; The Result of Inquiries Prosecuted in 1871 and 1872’, in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1872 and 1873* (Washington, D.C.: Government Printing Office 1874), 24.

<sup>9</sup> ‘Fishes Especially Worthy of Cultivation’, in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1872 and 1873* (Washington, D.C.: Government Printing Office, 1874), lxxv; ‘Propagation of Whitefish in 1872’, in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1872 and 1873* (Washington, D.C.: Government Printing Office, 1874), xxvi.

<sup>10</sup> Fredrick Wallem, a Norwegian delegate to the U.S. Centennial Exhibition in 1876, was taken not only by America’s optimism in fish culture, but also in the movement’s political implications stating that its goal was to ‘make fish diet *cheaper for the people*’. See Wallem, ‘Report on the American Fisheries’, in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1878* (Washington, D.C.: Government Printing Office, 1880), 102.

<sup>11</sup> ‘Investigations in 1871 and 1872 on the Great Lakes’, xv–xvi; ‘Propagation of Whitefish in 1872’, xxvi; Milner, ‘Report on the Fisheries of the Great Lakes’, 25–34.

<sup>12</sup> Milner, ‘Report on the Fisheries of the Great Lakes’, 44.

<sup>13</sup> See Philip J. Pauly, *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton: Princeton University Press, 2000), 44–60 and Charles E. Rosenberg, *No Other Gods: On Science and American Social Thought* (Baltimore: The Johns Hopkins University Press, 1976), 153–99, for more on the cultural and political context of applied American science.

<sup>14</sup> Bogue, *Fishing the Great Lakes*, 196–8; Dean C. Allard, *Spencer Fullerton Baird and the U.S. Fish Commission* (New York: Arno Press, 1978), 151–2.

<sup>15</sup> ‘The Propagation of Food Fishes – Work Accomplished in 1878’, in U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1878 (Washington, D.C.: Government Printing Office, 1880), xxxv; U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1881 (Washington, D.C.: Government Printing Office, 1884), xvi, xlv–xlv; Frank N. Clark, ‘Report of Operations at the Northville and Alpena Station during the Season of 1884–1885’, in U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1884 (Washington, D.C.: Government Printing Office, 1886), 151–5; U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1884 (Washington, D.C.: Government Printing Office, 1886), xvi, xli–xlii, xlix–l; Tarleton H. Bean, ‘Report on the Propagation and Distribution of Food-Fishes’, in U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1894: (Washington, D.C.: Government Printing Office, 1896), 42–4, 57; W. de C. Ravenel, ‘Report on the Propagation and

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<sup>25</sup> Stephen A. Forbes, 'The First Food of the Common Whitefish', in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for 1881* (Washington, D.C.: Government Printing Office, 1884), 771–82; Coker, *Stephen Forbes and the Rise of American Ecology*, 87–9.

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<sup>32</sup> Hugh M. Smith, 'Report on the Division of Methods and Statistics of the Fisheries: Investigations of the Statistics and Methods of the Fisheries-The Great Lakes', in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for the Year Ending June 30, 1892* (Washington, D.C.: Government Printing Office, 1894), cxxxvi–cxxxvii; 'Division of Statistics and Methods of the Fisheries', in *U.S. Commission of Fish and Fisheries, Report of the Commissioner for the Year Ending June 30, 1892* (Washington, D.C.: Government Printing Office, 1894), x–xii

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- <sup>61</sup> Arthur J. Blume, 'Deep Trap Net Banned', *Atlantic Fisherman* 15 (April 1934), 12; 'New Changes in Michigan Laws', *The Fisherman* 3 (March-April 1934), 7; 'Deep Trap Nets Abolished in Lake Michigan', *The Fisherman* 4 (June 1935), 1; 'Deep Trap Net Fishing On Lake Superior To Be Illegal After June 30', *The Fisherman* 5 (June 1936), 1; John Van Oosten, 'The Value of Questionnaires in Commercial Fisheries Regulations and Surveys', *Transactions of the American Fisheries Society*. 64 (1934), 107–117; Dean A. Brege and Niles R. Kevern, 1978: *Michigan Commercial Fishing Regulations: A Summary of Public Acts and Conservation Commission Orders, 1865–1975* (Ann Arbor, MI: Michigan Sea Grant Program, 1978), 46.
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<sup>66</sup> Trawling in U.S. Great Lakes waters was initially driven by interest in reducing so-called 'rough' fish numbers – species targeted for use in pet food and mink feed. Trawling for chub followed shortly thereafter. Working with federal and state fisheries personnel, a small number of U.S. Great Lakes commercial fishers made extensive adjustments to their technology and traditional knowledge of local fish habitat to accommodate this shift in harvesting procedures. See, 'May Allow Sheepshead Trawling in Winnebago', *NF* 37 (September 1956), 32; 'Markets for Lake Erie Rough Fish Expanding', *NF* 38 (June 1957), 17; 'Would Use Trawl Nets in Lake Michigan Waters', *NF* 40 (October 1959), 20; Ron Poff, *From Milk Can to Ecosystem Management: A Historical Perspective on Wisconsin's Fisheries Management Program, 1830s-1990s* (Madison, WI: Wisconsin Department of Natural Resources, 1996), 11; Smith, 'Species Succession and Fishery Exploitation in the Great Lakes', 679; W.F. Carbine, 'One Answer for a Fishery', *Michigan Conservation* 29 (July-August 1960), 25–27; William G. Gordon and Keith D. Brouillard, *Great Lakes Trawler Conversion*, U.S. Department of the Interior, U. S. Fish and Wildlife Service/ U.S. Bureau of Commercial Fisheries, Fishery Leaflet 510 (Washington, D.C.: 1961); William G. Gordon, 'A Great Lakes Stern-Ramp Trawler', *Commercial Fisheries Review* 24 (April 1962), 33–36.

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<sup>68</sup> Wayne H. Tody and Howard A. Tanner, *Coho Salmon for the Great Lakes: Fish Management Report No. 1*. (Lansing, MI: Michigan Department of Conservation, 1966); Poff, *From Milk Can to Ecosystem Management*, 11.

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<sup>70</sup> Wayne H. Tody, 'Zones for the Big Lakes', *Michigan Natural Resources* 39 (March-April 1970), 3–9; Smith, 'Species Succession and Fishery Exploitation in the Great Lakes', 667–93.

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<sup>73</sup> Tody, 'Zones for the Big Lakes', 3–9; Crowe, 'Profile of an Industry', 18–22; Edward H. Brown, Jr., Thomas R. Busiahn, Michael L. Jones and Ray L. Argyle, 'Allocating Great Lakes Forage Bases in Response to Multiple Demand', in *Great Lakes Fisheries Policy and Management: A Binational Perspective*, eds. William W. Taylor and C. Paola Ferreri (East Lansing, MI: Michigan State University Press, 1999), 361, 386; 'Governor Milliken Favors Payments or Modified Rules for Fisherman', *The Fisherman* 27 (April 1975), 5; 'More Fishermen Paid Off in Michigan', 28 (September 1976), 5; 'Michigan Continues to Pay Off Gill Netters', *The Fisherman* 29 (March 1977), 9.

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<sup>76</sup> 'Chub Fishery Hampered by Presence of Dieldren', *The Fisherman* 31 (August 1979), 18; 'Lake Michigan Chub Fishermen Further Plagued by Increases in Pesticide Levels', *The Fisherman* 27 (April 1975), 10; Lawrence M. Sommers, et al., *Fish in Lake Michigan: Distribution of Selected Species* (Michigan Sea Grant: 1981), 12–14.

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