Can Nature Conservation Justify Sport Fishing?

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Anglers frequently justify their sport on the basis of nature conservation. According to this utilitarian equation, harming fish by angling is balanced by conservation of nature. To qualify as justification for angling, nature conservation must arise from and be connected to angling, a connection achieved by sport fisheries management. Management practices are, therefore, evaluated to determine if, on the whole, these practices are beneficial to nature and, if these benefits "outweigh" harms caused to nature by management and to fish by angling. Although not conclusive, according to this analysis, harms caused to nature by both sport fisheries management and to fish by angling "outweigh" angling related benefits to nature. Consequently, the justification of angling on the basis of nature conservation is dubious at best.

Also you should busy yourself to nourish the game in everything that you can, and to destroy all such things as are devourers of it.

—Dame Juliana Berners[1]

I. INTRODUCTION

Angling, like other forms of sport hunting, requires justification.[2] Angled fish have interests similar to hunted game.[3] Anglers frequently justify their sport because it supports conservation of nature which benefits themselves and also fish populations,

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[1] Dame Juliana Berners, *The Treatise of Fishing with an Angle* (1450), in John McDonald, *The Origins of Angling* (New York: Doubleday and Co., 1963), p. 66 (emphasis added).

[2] A. A. Luce, *Fishing and Thinking* (Camden: Ragged Mountain Press, 1993), p. 185; A. D. de Leeuw, "Contemplating the Interests of Fish: The Angler's Challenge," *Environmental Ethics* 18 (1996): 373–90.

[3] Harm to fish includes (a) killing them and (b) purposefully inflicting pain and suffering in them in order for anglers to have "sport" with them. An impressive body of evidence has been mounted strongly indicating pain, and the awareness of it in virtually all vertebrates, including fish. See de Leeuw, "Contemplating the Interests of Fish"; E. K. Balon, "Defending Fishes against Recreational Fishing: An Old Problem to be Solved in the New Millennium," *Environmental Biology of Fishes* 57 (2000): 1–8; Australian and New Zealand Federation of Animal Societies, *The Welfare of Fish and Aquatic Invertebrates* (Melbourne: ANZFAS, 1992); S. C. Kestin, *Pain and Stress in Fish* (Bristol: Royal Society for the Prevention of Cruelty to Animals, 1994), which lists fifty references on the topic; G. Peters, "Schmerz und Streb bei Fischen," *Deutsche Tieraerztliche Wochenschrift* 95 (1988): 60–63; B. Ollenschlager, "Schmerzausschaltung bei Fischen," *Berliner und Muenchener Tieraerzliche Wochenschrift* 88 (1975):

ecosystems, and nature generally.[4] A utilitarian perspective, it compares harming fish by angling on one side of the balance to benefits to nature through conservation on the other.[5] This argument is of considerable importance as much of the history and content of environmental conservation is firmly rooted in wildlife/fisheries management.[6] In this paper, I evaluate whether benefits conferred to nature through conservation, largely an empirical question, are sufficient to justify angling?

I begin by defining nature conservation as benefits to nature. These are then connected through sport fisheries management to angling. Management practices

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302–03; P. R. Laming and G. E. Savage, "Physiological Changes Observed in the Goldfish (*Carassius auratus*) during Behaviour Arousal and Fright," *Behavioural and Neural Biology* 29 (1980): 255–75; T. E. Finger, "Sensorimotor Mapping and Oropharyngeal Reflexes in Gold Fish, *Carassius auratus*," *Brain Behaviour and Evolution* 31(1988): 17–24; M. R. LaChat, in "An Argument in Defense of Fishing," *Fisheries* 21 (1996): 20–21, resorting to religion to suggest fish feel no pain is vacuous. There is no biblical evidence suggesting Christ was an angler. The publication by J. D. Rose, "The Neurobehavioral Nature of Fishes and the Question of Awareness and Pain," *Reviews in Fisheries Science* 10 (2002): 1–38, where he claims it is "untenable that they [fish] can experience pain" has been challenged by numerous researchers. L. U. Sneddon, V. A. Braithwaite and M. J. Gentle, "Do Fish have Nociceptors? Evidence for the Evolution of a Vertebrate Sensory System," *Proceedings of the Royal Society, London, Series B* 270 (2003): 1115–21; L. U. Sneddon, "The Evidence for Pain in Fish: The Use of Morphine as an Analgesic," *Applied Animal Behaviour Science* 83 (2003): 153–62; K. P. Chadroo, S. Yue and R. D. Moccia, "An Evaluation of Current Perspectives on Consciousness and Pain in Fishes," *Fish and Fisheries* 5 (2004): 281–95; K. P. Chandro, I. J. H. Duncan and R. D. Moccia, "Can Fish Suffer? Perspectives on Sentience, Pain, Fear and Stress," *Applied Animal Behaviour Science* 86 (2004): 225–50. Reducing pain and stress on angled fish in catch-and-release fisheries as suggested by J. C. Cooke, L. U. Sneddon in "Animal Welfare Perspectives on Recreational Angling," *Applied Animal Behavior Science* (2007): 176–98, does not address the issue of justifying angling. More recently, see also V. Braithwaite, *Do Fish Feel Pain?* (New York: Oxford University Press, 2010), and the review of this book by Gary Varner, *Environmental Ethics* 33 (2011): 219–22.

[4] B. Tufts, "Animal Rights vs. Catch and Release," *Atlantic Salmon Journal* 42, no. 4 (1993): 21; S. Quinn, "Effects of the Animal Rights Movement on the Future of Fishing." p. 151–56 in R. Barnhart, B. Slake and R. H. Hamre, eds., *Wild Trout V: Wild Trout in the 21st Century* (Yellowstone National Park: U.S. Department of the Interior, 1994), pp. 26–27 September 1994; LaChat, "An Argument in Defense of Fishing"; C. L. and S. L. Redmond, "Fifty Reasons to Fish," *Fisheries* 20 (1995): 32; "Special Session 5, Recruiting, Retaining and Training Consumptive Users of Fish and Wildlife," *Transactions of the Sixty-First North American Wildlife and Natural Resources Conference* (Washington, D.C.: Wildlife Institute, 1996), pp. 315–410; R. W. Loftin, "The Morality of Hunting" *Environmental Ethics* 6 (1984): 241–50; Ann S. Causey, "On the Morality of Hunting" *Environmental Ethics* 11 (1989): 330; T. R. Vitalli, "Sport Hunting: Moral or Immoral?" *Environmental Ethics* 12 (1990): 69–82.

[5] Loftin, in "The Morality of Hunting" on p. 242 accepts Peter Singer's "replaceability argument" *Practical Ethics* (Cambridge: Cambridge University Press, 1979). Vitali, "Sport Hunting," p. 29, views anti-hunting sentiments "as potentially tragic because such misconceptions may lead to the banning of hunting and thus a major shift in our hemisphere-wide attempt at managing wildlife and fish populations and their habitats." Both Loftus and Vitali fail to determine if benefits to nature actually occur from management and if these justify hunting.

[6] J. A. Tober, *Who Owns the Wildlife? The Political Economy of Conservation in Nineteenth-Century America* (Westport: Greenwood Press, 1981); W. R. Mangun, ed., *American Fish and Wildlife Policy: The Human Dimension* (Carbondale: Southern Illinois University Press, 1992); V. Geist and I. McTaggart-Cowan, eds. *Wildlife Conservation Policy* (Calgary: Detselig Enterprises, 1995). Undoubtedly the best treatment of conservation applicable to fishing and fish generally is G. S. Helfman, *Fish Conservation, A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources* (Island Press, Washington, 2007).

are then evaluated to establish if, on the whole, negative and/or positive impacts to nature have resulted from these practices. I conclude by discussing some implications of my analysis. My perspective is largely North American, and I don't address benefits to anglers here.

II. CONSERVATION, NATURE'S INTERESTS AND BENEFITS

Conservation, according to the *Oxford English Dictionary,* is the "preservation, esp. of the natural environment."[7] Now, in order to count as justification for angling, conservation must impart some benefit to nature and, for a benefit to be meaningful at all, it has to have a positive influence or prevent a negative influence on an interest. Alternatively, harm is a negative or detrimental influence on an interest, or the aggravation of a negative impact on an interest.[8] With nature, interests can be attributed to both individual and to classes of organisms. The attribution of interests only to individuals establishes survival requirements, among others, of individual organisms as the basic interest upon which all of nature's interests rest.[9] Interests of populations, ecosystems, and nature generally aggregate interests of individual organisms into groups.[10] Attributing interests to classes, on the other hand, recognizes populations, species, ecosystems and the like as having interests of their own, distinct from any interests belonging to individuals.[11] The functioning complexity of an intact biotic community is an interest of that community. The distinction between attributing interests to individuals or to classes, however, is not crucial to my analysis. What is crucial is the recognition of nature having interests that can be positively or negatively impacted and parallels Aldo Leopold where he concludes,

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[7] *The Oxford Dictionary of Current English* (New York: Oxford University Press, 1998).

[8] Meredith Williams, "Rights, Interests, and Moral Equality," *Environmental Ethics* 2 (1980):149–61; Steve F. Sapontzis, "The Moral Significance of Interests," *Environmental Ethics* 4 (1982): 345–58; Paul W. Taylor, *Respect For Nature* (Princeton: Princeton University Press, 1989), pp. 60–71.

[9] Taylor, *Respect for Nature*, p. 69, n. 5, concerning "species" and "classes," which "have no good of their own, only their members do." Harley Cahen, "Against the Moral Considerability of Ecosystems" *Environmental Ethics* 10 (1988):197.

[10] For the accumulation of interests, see Andrew Brennan, "The Moral Standing of Natural Objects," *Environmental Ethics* 6 (1984): 35–56; and is similar to Gary E. Varner, *In Nature's Interests? Interests, Animal Rights, and Environmental Ethics* (New York: Oxford University Press, 1998).

[11] Holism enlarges the scope of interest bearers to include groups or classes as done by Christopher D. Stone, *Should Trees have Standing? Toward Legal Rights for Natural Objects* (Palo Alto: Tiaga Publishing, 1988) and numerous other "deep," "holistic" ecologists, including Aldo Leopold and his "think like a mountain" logic recently resurrected in a number of essays in J. Baird Callicott, ed., *Companion to a Sand County Almanac* (Madison: The University of Wisconsin Press, 1987) and in several works also by Callicot in this journal. Such a holistic view would not exclude individual interests. See, for example, Don E. Marietta, Jr., "Environmental Holism and Individuals," *Environmental Ethics* 10 (1988): 251–58, but "must support the holistic functioning of an ongoing system." Bryan G. Norton, "Environmental Ethics and Nonhuman Rights," *Environmental Ethics* 4 (1982): 17–36; Holmes Rolston, III, *Philosophy Gone Wild* (Buffalo, N.Y.: Prometheus Books, 1989); and also his discussion on golden trout, in "Respect for Life: Counting what Singer Finds of No Account," in *Singer and His Critics,* ed. Dale Jamieson (Malden, Mass.: Blackwell, 1999), pp. 247–68.

> A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.[12]

Conservation then, as I interpret it here, becomes beneficial actions toward nature that maintain or further the preservation of intact functioning populations, ecosystems, or biotic communities with their full complement of indigenous species. Actions harmful to nature, on the other hand, negatively impact, limit, or aggravate nature. I accept many ecosystems have been negatively impacted and altered to varying degrees. Throughout this essay, I use terms such as *species, populations, ecosystems*, and *biotic communities* to denote nature.

III. NATURE CONSERVATION FROM ANGLING

Connecting angling to nature conservation is important, since if conservation does not arise from angling, then clearly it cannot justify angling.[13]

Angling can be connected to nature conservation through contributions anglers make, in the name of their sport, to management decisions affecting numerous aspects of nature. First, one of the principle ways in which anglers affect these decisions is financially. Anglers pay a license fee and in addition to regular taxes, frequently pay a surcharge on equipment or fuel purchased.[14] In North America these funds are allocated to federal, state, or provincial agencies for fisheries management. Second, anglers, as members of organizations, influence fish and wildlife management. They contribute to development of guidelines, standards, and mitigation measures for industrial, agricultural, commercial fishing, and other activities impacting sport fisheries and ecosystems.[15] Anglers also assist in collection

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[12] Aldo Leopold, "The Land Ethic," in *A Sand County Almanac* (New York: Oxford University Press, Press 1968), pp. 224–25.

[13] This is not a linkage in the strictly utilitarian sense of the act of catching fish "causing" or "resulting in" benefit/costs to nature, James Rachels, *The Elements of Moral Philosophy* (New York: McGraw-Hill, 1993), pp. 90–93; J. L. Mackie, *Ethics: Inventing Right and Wrong* (New York: Renquin Books, 1990), pp. 125–48; or of the "principle of double effect," R. M. Martin, *The Philosopher's Dictionary* (Peterborough: Broadview Press, 1994), p. 75, and Mackie, *Ethics*, pp. 160–68. Another way of describing "linkage," as I use it here, is as "arising from," or "affiliated with."

[14] In British Columbia the Habitat Conservation Fund provided approximately $24 million to fund more than 1,500 projects provincially, *Ministry of Environment, Lands and Parks News Release* (1 May 1995); *B.C. Ministry of Environment, Habitat Conservation Fund, Annual Review, 1988, 1988-89 to 1991–92*. In the U.S. this is the Federal Aid in Sport Fish Restoration Act, or the Dingell-Johnson Act, and the Wallop-Breaux amendments to the Pitman-Robertson Act. *Dingell-Johnson/Wallop-Breaux: The Federal Aid in Sport Fish Restoration Program Handbook* (Washington, D.C.: The Sport Fishing Institute, 2001). In 1995, of $327 billion, roughly $200 billion went to restoring sport fisheries. *Sport Fish and Wildlife Restoration* (Washington, D.C.: U.S. Fish and Wildlife Service, Division of Federal Aid, 1995).

[15] The B.C. Wildlife Federation has about 30,000 members in 144 clubs in ten regions of the province. *The British Columbia Environmental Directory,* 4th ed.(Vancouver: British Columbia Environmental Network, 1995), p. 18. See J. G. Terpenning, "The B.C. Wildlife Federation and Government: A Comparative Study of Pressure Groups and Government Interaction for Two Periods, 1947 to 1957, and 1958 to 1975*"* (M.A. thesis,Victoria: University of Victoria, 1982). Historically, fish and wildlife management

of information and execution of field projects including creel surveys, tagging and fish population studies, as well as stream enhancement projects and innumerable other volunteer and paid work. Invariably these activities require permits from, or supervision by, government management staff. Third, anglers often affect environmental decisions by lobbying politicians or becoming politicians themselves. Anglers, by virtue of their numbers and economic influence, exert considerable political "clout" through sport fishing clubs, popular/scientific publications, letter writing campaigns, and through the tackle, guiding, and tourist industry.[16] Fourth, angling is a recreational use of nature. Laws have been enacted to protect various components of sport fisheries such as fish and their habitats.[17] Trails, road access, and wilderness are also maintained.[18] Last, and perhaps most important, there is a very powerful connection of angling to nature conservation through provincial and state agency management staff who almost always also angle.[19] Indeed, many became sport fisheries management professionals because they angle. There is, therefore, a very close connection between angling and decisions that impact nature.

All of the above contributions, however, should not be construed as conservation per se, as these can more appropriately be interpreted as the various linkages connecting angling, via implementation of sport fisheries management objectives, to nature. Such objectives almost always constitute management practices implemented by government staff acting within the prevailing political milieu on behalf of anglers' interests. The only exceptions I can think of are privately owned fishing waters where the identical process occurs in microcosm. A discussion on how conservation flows from or is connected to angling, therefore, becomes a discussion entirely about sport fisheries management.

IV. ANGLING MANAGEMENT AND CONSERVATION

All sport fisheries management can be grouped into three broad activities: research, nature, and people management. Each activity is first described and then evaluated to determine its positive or negative impact on nature.

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throughout North America has largely been maintaining hunting, angling and some trapping interests. Tober, *Who Owns the Wildlife?*

[16] Ibid., pp. 179–48; R. S. Musgrave and M. A. Stein, *State Wildlife Laws Handbook* (Rockville: Government Institute, 1993), pp. 7–10. In some states, wildlife commissioners must be either a hunter, angler, or preferably both. Susan Hagood, *State Wildlife Management: The Pervasive Influence of Hunters, Hunting, Culture and Money* (Washington, D.C.: Humane Society of the United States, 1997).

[17] *Fisheries Act,* Canada, secs. 35 to 43, (R.S. Chapter F-14,S.1); B.C., *Fish Protection Act* (Bill 25, 1997).

[18] In British Columbia, forty-two rivers or their reaches have been classified "to protect their unique fishing opportunities." *Freshwater Fishing Regulations Synopsis* (Victoria: British Columbia Environment, 1996–97), p. 5. Rivers have been designated as "Heritage Rivers" for many reasons including angling. *British Columbia's Heritage Rivers System* (Victoria, B.C.: Heritage Rivers Program, 1997). The *Fish Protection Act* (1997) protects the mainstream of at least fifteen rivers from hydropower dams and other impacts.

[19] My own experience in British Columbia is that approximately 80 to 100 percent of all provincial fisheries management staff angle.

Research Management

Sport fisheries science aims to increase understanding of all aspects of the sport for the purpose of angling.[20] Included here is all research on fish biology, such as fish population abundance and survival studies, determining mortality rates relative to catch strategies, and redistributing this knowledge through dissemination of information. Studies include inventory and sampling programs, catching and tagging fish, detailed age analysis, size frequency and growth and yield calculations to achieve optimum harvests and implement management objectives.[21]

Additionally, a large body of research has documented fish habitat requirements,[22] information instrumental in developing standards, guidelines, and mitigation procedures for forest harvesting, agriculture, transportation, urban development, mining and hydropower projects.[23] Stream enhancement and ecosystem restoration procedures have also benefited from this knowledge. Considerable information has also been generated on fish diseases, fish health, anesthetics for fish, and the interactions between various species of fish. Technological advancements in fish sampling and data manipulation techniques can also be included here. Understanding anglers is another research activity and includes creel surveys, angler preference and demographic studies.[24] Besides formal studies by management organizations

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[20] *Fisheries Review* 39 (1994) and 40 (1995) lists 8,584 and 9,614 articles respectfully on aquatic plants and their control, culture and propagation, limnology and oceanography, physiology, genetics and behavior, natural history, parasite and diseases, pollution and toxicology, and research and management by roughly 4,500 authors in 1,600 journals throughout the world annually. See also *Transactions of the American Fisheries Society,* and *Canadian Journal of Fisheries and Aquatic Sciences.*

[21] W. E. Ricker, *Computation and Interpretation of Biological Statistics of Fish Populations,* Bulletin 191 (Ottawa: Department of the Environment Fisheries and Marine Service, 1975).

[22] G. F. Hartman, ed., *Proceedings of the Carnation Creek Workshop: A Ten-Year Review* (Nanaimo, B.C.: Pacific Biological Station, 1982); T. W. Chamberlin, ed., *Proceedings of the Workshop: Applying Fifteen Years of Carnation Creek Results* (Nanaimo: B.C. Biological Station, 1987); and G. F. Hartman and J. C. Scrivener, "Impacts of Forestry Practices on a Coastal Stream Ecosystem, Carnation Creek, British Columbia," *Canadian Bulletin of Fisheries and Aquatic Sciences* 223 (1990): 1–148; E. O. Salo and T. W. Cundy, eds., *Streamside Management: Forestry and Fishery Interactions* (Seattle: University of Washington, Institute of Forest Resources, 1987); *Instream Flow Needs* (Bethesda, Md.: American Fisheries Society, 1976), vols. 1 and 2; C. P. Newcombe and J. O. T. Jensen, "Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk Impact," *North American Journal of Fisheries Mangement* 16 (1996): 693–727, and many other papers.

[23] D. A. A. Toews and M. L. Brownlee, *A Handbook for Fish Habitat Protection on Forest Lands in British Columbia,* (Vancouver, B.C.: Department of Fisheries and Oceans, 1981); *British Columbia Coastal Fisheries Forestry Guidelines* (Victoria: B.C. Ministry of Environment and Parks, 1987); *Forest Practices Code of British Columbia Riparian Management Guidebook* and *Fish-Stream Identification Guidebook* (Victoria: Province of British Columbia, 1995).

[24] D. E. Olson and P. K. Cunningham, "Sport-Fisheries Trends Shown by an Annual Minnesota Fishing Contest Over a Fifty-Eight Year Period," *North American Journal of Fisheries Management* 9 (1989): 287–97; C. E. Adams, J. K. Thomas, and W. R. Knowles, Jr., "Explaining Differences in Angling Rates in the United States," *Fisheries* 18, no. 4 (1993):11–17; C. P. Dawson and B. T. Wilkins, "Social Considerations Associated with Marine Recreational Fishing Under FCMA," *Marine Fisheries Review,* 42, no. 12 (December 1980): 12–17; C. P. Dawson, N. A. Connelly, and T. L. Brown, "Salmon

and research institutions, anglers themselves take great interest in many aspects of their sport such as entomology, fish behavior, and general nature study.[25] Angling, therefore, not only generates an enormous amount of information on nature, it also creates an interest in nature.

Although sport fisheries research may guide conservation, it isn't until this understanding is applied in some way that biotic communities have been impacted. The entire research component of the conservation argument cannot be used to justify angling, as pure knowledge does not, in and of itself, directly impact nature. Indirectly, however, improved understanding greatly influences how nature is impacted.

Nature Management

In this section I evaluate direct manipulation of nature resulting from: (1) food enhancement, (2) habitat enhancement/restoration, (3) population control, (4) fish culture, and (5) mitigation.

(1) *Food Enhancement.* Many techniques have been developed to improve growth and survival of fish in angling waters by increasing their food supply. Fish can be fed directly with a variety of feeds such as dried pellets or frozen shrimp distributed into lakes and streams,[26] or indirectly by increasing nutrient levels.[27] Phosphorous,

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Snagging Controversy: New York's Salmon River," *Fisheries* 18, no. 4 (1993): 6–10; R. C. Bryan, *The Dimensions of a Salt-Water Sport Fishing Trip, or, What do People Look For in a Fishing Trip besides Fish* (Vancouver: Environment Canada, Fisheries and Marine Service, 1974); R. W. Stoffle, D. L. Rasch, and F. V. Jensen, "Urban Sport Anglers and Lake Michigan Fishery Policies" *Coastal Zone Management Journal* 10 (1983): 407–27; "New Times, Old Questions, Tough Answers," *SFI Bulletin* 433 (April 1992): 1–3; S. W. Adams, "Segmentation of a Recreational Fishing Market: A Canonical Analysis of Fishing Attributes and Party Composition," *Journal of Leisure Research* 11 (1977): 174–87; M. R. Carpenter and D. R. Bowlus, "Attitudes Towards Fishing and Fisheries Management of Users in Desolation Wilderness, California," *California Fish and Game* 62 (1976): 168–78; R. C. Knoph, B. L. Driver, and J. R. Bassett, "Motivations for Fishing," *Transactions of the North American Wildlife and Natural Resources Conference* 38 (1973): 191–204; W. Reid, *A Survey of 1987 Idaho Anglers, Opinions and Preferences,* Idaho Department of Fish and Game, 1989.

[25] Berners, *The Treatise of Fishing with an Angle*; Izaak Walton and Charles Cotton's *The Complete Angler or the Contemplative Man's Recreation* (Edinburgh: Riverside Press, 1925); W. P. McCafferty, *Aquatic Entomology* (Boston: Science Books International, 1981). R. A. Hand, *A Bookman's Guide to Hunting, Shooting, Angling and Related Subjects* (Metuchen: Scarecrow Press, 1991), lists thirty-four books dealing specifically with fly-fisher's entomology.

[26] J. C. Masson, "A Further Appraisal of the Response to Supplemental Feeding of Juvenile Coho (*O. kisutch*) in an Experimental Stream," *Canadian Fisheries and Marine Service Technical Report,* no. 470 (1974); J. C. Masson, "Response of Underyearling Coho Salmon to Supplemental Feeding in a Natural Stream," *Journal of Wildlife Management* 40 (1976): 775–88.

[27] J. G. Stockner, and K. R. S. Shortreed, "Enhancement of Autotrophic Production by Nutrient Addition in a Coastal Rainforest Stream on Vancouver Island," *Journal of the Fisheries Research Board of Canada 35* (1978): 28–34; K. D. Hyatt, and J. G. Stockner, "Responses of Sockeye Salmon (*O. nerka*) to Fertilization of British Columbia Coastal Lakes," *Canadian Journal of Fisheries and Aquatic Sciences* 42 (1985): 320–31; C. J. Perrin, L. Bothwell and P. A. Slaney, "Experimental Enrichment

nitrogen, and other limiting nutrients can be added to aquatic ecosystems to increase primary production resulting in greater food supplies. Prey species have also been introduced into aquatic ecosystems to benefit predatory game fish.[28] These methods intend to enhance sport fisheries, often with questionable results to anglers, and almost always at a cost to ecosystems.

Direct feeding and fertilization projects can be stopped and their impacts reversed. Doing so is virtually impossible when entire ecosystems have been altered by the introduction of non-indigenous prey. For instance, and much to the delight of anglers, opossum shrimp were introduced as food for trout and kokanee salmon into numerous lakes in the northern hemisphere.[29] The almost immediate impact of these introductions was increased growth of fish as shrimp population abundance escalated. Success after success prompted managers to introduce shrimp into other lakes despite a lack of long-term studies on effects of these introductions. However, success was short lived, as vastly enlarged shrimp populations competed with immature salmon for food with disastrous results to salmon. Irreversibly reduced salmon abundance had far reaching negative impacts on bears, eagles, and a host of other organisms dependant on annual salmon migrations.[30] Similar instances can be cited for fish introductions, rather than shrimp, as prey for game fish.[31] To consider food supply improvements for game fish a positive ecological impact is, therefore, doubtful at best.

(2) *Habitat Enhancement/Restoration.* Game fish abundance can also be improved by habitat enhancement and by restoration of negatively impacted aquatic

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of a Coastal Stream in British Columbia: Effects of Organic and Inorganic Addition on Autotrophic Periphyton Production," *Canadian Journal of Fisheries and Aquatic Sciences* 44 (1987): 1247–56; C. Walters, J. DiGisi, J. Post and J. Sawada, "Kootenay Lake Fertilization Response Model," *Fisheries Management Report,* no. 48 (Vancouver: Ministry of Environment, University of British Columbia, 1991); P. A. Slaney, W. O. Rublee, C. J. Perrin and H. Goldberg, "Debris Structure Placement and Whole-River Fertilization for Salmonids in a Large Regulated Stream in British Columbia," *Bulletin of Marine Science* 55 (1994): 1160–80.

[28] R. L. Welcomme, *International Introductions of Inland Aquatic Species,* FAO Fisheries Technical Paper 294 (Rome: FAO: 1980), p. 6, lists twenty-one international introductions of forage fish. E. J. Crossman, "Introduced Freshwater Fishes: A Review of the North American Perspective with Emphasis on Canada," in N. Billington and P. D. Hebert, eds., "International Symposium on 'The Ecological and Genetic Implications of Fish Introductions (FIN),'" *Canadian Journal of Fisheries and Aquatic Sciences* 48 (suppl. 1, 1991), describes negative impacts of stocking and lists 8 forage species introduced to support sport fisheries in British Columbia (table 3, p. 50).

[29] T. P. Nesler and E. P. Bergerson, *Mysids in Fisheries: Hard Lessons from Headlong Introductions,* Symposium 9 (Bethesda: American Fisheries Society, 1991).

[30] C. N. Spencer, B. R. McClelland and J. A. Stanford, "Shrimp Stocking, Salmon Collapse, and Eagle Displacement, Eascading Interaction in the Food Web of a Large Aquatic Ecosystem," *BioScience* 41 (1991): 14–21.

[31] In 1912, rainbow smelt was introduced into Crystal Lake, Michigan, as forage for Atlantic salmon, from where it spread throughout the Great Lakes. Crossman, "Introduced Fresh Water Fishes," p. 47. According to W. B. Scott and E. J. Crossman, *Freshwater Fishes of Canada,* Bulletin 184 (Ottawa: Fisheries Research Board of Canada, 1973), p. 316, introduction of rainbow smelt have negatively impacted lake trout. Other examples can be cited.

ecosystems. Aeration of lakes during critical low oxygen periods decreases the likelihood of fish kills, benefiting fish and anglers.[32] Lake shore spawning beds[33] and artificial reefs[34] have also been constructed with considerable success. Falls, rapids, and other stream barriers impeding upstream migration of salmon and trout can be removed using explosives or by installing fish ladders.[35] Frequently these upstream reaches are inhabited with non-migratory fish which are then replaced by invading species.[36] On the other hand, resident populations may benefit from additional adult carcasses.[37] Barrier removal projects of this kind also tend to homogenize fish populations rather than maintain discreet and separate subgroups.[38]

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[32] T. G. Halsey, "Autumnal and Over-Winter Limnology of Three Small Eutrophic Lakes with Particular Reference to Experimental Circulation and Trout Mortality," *Journal of the Fisheries Research Board of Canada* 25 (1968): 81–99; T. G. Halsey and D. M. Galbraith, "Evaluation of Two Artificial Circulation Systems Used to Prevent Trout Winter-Kill in Small Lakes," *British Columbia Fish and Wildlife Branch Fisheries Management Publication* 16 (Victoria, B.C.: Fish and Wildlife Branch, 1971), p. 13.

[33] B .S. Harris, "Enhancement of Kokanee Shore Spawning Sites in Okanagen Lake, British Columbia," in J. H. Patterson, ed., "Proceedings of the Workshop on Habitat Improvements," Whistler, B.C., 8–10 May 1984, *Canadian Technical Reports of Fisheries and Aquatic Sciences,* no. 1483 (1986).

[34] For artificial reefs, see W. F. Sigler and J. W. Sigler, *Recreational Fisheries Management, Theory, and Application* (Reno: University of Nevada Press, 1990), pp. 66–67; for vegetation, D. G. Skeesick, "Terrestrial Vegetation in the Drawdown Zone of Flood Control Reservoirs in Oregon," in Patterson, "Proceedings of the Workshop on Habitat Improvements," pp. 49–59.

[35] E. A. Parkinson and P. A. Slaney, "A Review of Enhancement Techniques Applicable to Anadromous Game Fishes," *Fisheries Management Report,* no. 66 (Victoria: B.C. Fish and Wildlife Branch, 1975), pp. 20-22; *Stream Enhancement Guide* (Vancouver: Government of Canada and Province of British Columbia, Ministry of Environment, 1980), pp. 26-46; and Sigler and Sigler, *Recreational Fisheries Management,* p. 82.

[36] In coastal B.C. and Alaska, resident populations of Dolly Varden char, cutthroat trout, or rainbow trout in stream reaches and lakes upstream of barriers are frequently displaced by the introduction of other species such as coho salmon. R. A. Crone, *Potential for Production of Coho Salmon* (*Oncorhynchus kisutch*) *in Lakes with Outlet Barrier Falls, Southern Alaska* (Ph.D., diss., University of Michigan, 1981); J. Van Tine, "Coho Colonization of Inaccessible Headwater Habitats in the Quinsam River Watershed," in "Proceedings of the Workshop on Habitat Improvements," pp. 38–45; D. Tripp and P. McCart, "Effects of Different Coho Stocking Strategies on Coho and Cutthroat Trout Production in Isolated headwater streams," *Canadian Technical Reports of Fisheries and Aquatic Sciences,* no. 1212 (1983).

[37] C. J. Cederholm and N. P. Peterson, "The Retention of Coho Salmon (*O. kisutch*) Carcasses by Organic Debris in Small Streams," *Canadian Journal of Fisheries and Aquatic Sciences* 42 (1985): 1222–25; C. J. Cederholm, D. B. Houston, D. L. Cole, and W. J. Scarlett, "Fate of Coho Salmon (*O. kisutch*) Carcasses in Spawning Streams," *Canadian Journal of Fisheries and Aquatic Sciences* 46 (1989): 1347–55; R. E. Bilby, B. R. Fransen, and P. A. Bisson, "Incorporation of Nitrogen and Carbon from Spawning Coho Salmon into the Trophic System of Small Streams: Evidence from Stable Isotopes," *Canadian Journal of Fisheries and Aquatic Sciences* 53 (1996): 164–73; G. A. Larkin and P. A. Slaney, "Trends in Marine-Derived Nutrient Sources to South Coastal British Columbia Streams: Impending Implications to Salmonid Production," *Watershed Restoration Management Report,* no. 3 (Vancouver: British Columbia Ministry of Environment, Lands and Parks, 1996).

[38] J. N. Rinne and P. R. Turner, "Reclamation and Alteration as Management Techniques, and a Review of Methodology in Stream Renovation," in W. L. Minckley and J. E. Deacon, eds., *Battle against Extinction: Native Fish Management in the American West* (Tucson: University of Arizona Press, 1991), pp. 222–26; R. Behnke, "Native Trout of Western North America," *American Fisheries*

They also displace localized food sources for a variety of predators which key in on such sites during fish migrations.[39]

Another enhancement/restoration technique consists of constructing spawning channels, placement of gravels, log jams, and rock-filled gabions in impacted streams.[40] All are intended to improve the reproductive, nursery, and growing requirements of game fish.[41] Such manipulations have been popular with fisheries managers, engineers, and anglers. Projects are site specific, almost maintenance free, and can be installed with the help of anglers. Small impoundments have also been created to release water into streams during low flow periods.[42] In many cases these projects improve sport fisheries,[43] at times with questionable results to non-game fish species. Moreover, there are numerous restoration/enhancement projects which benefit many organisms, despite their primary objective being improvement of sport fisheries.[44] Overall, these procedures enhance, and more importantly restore, impacted ecosystems to their original state.[45] In this way, a very positive and beneficial influence to the environment occurs.

(3) *Population Control.* Game fish abundance can also be improved by removal of predatory or competing species. Mammals, birds, and fish that feed on

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Society Monograph, no. 6 (1992), p. 18. In some cases, barriers have been purposefully constructed to maintain genetic isolation between invading introduced and native resident populations. The importance of discreet populations is also discussed by M. F. Wilson, "Variations in Salmonid Life Histories: Patterns and Perspectives," Research Paper PNW-RP-498 (Portland: Department of Agriculture, Forest Service, Pacific Northwest Research Station, 1997), p. 50.

[39] When large numbers of migrating salmon congregate at barriers, fish ladders reduce fish availability for bears. Examples include fish ladders at Skutz Falls, on the Cowichan River, Vancouver Island, and the Meziadin River, a tributary of the Nass River. Numerous additional examples throughout British Columbia can be cited.

[40] J. Colt and R. J. White, eds., "Fisheries Bioengineering Symposium," *American Fisheries Society Symposium,* no. 10 (Bethesda: American Fisheries Society, 1991); Patterson, "Proceedings of the Workshop on Habitat Improvements."

[41] D. Soltess, "A Mitigated Disaster: The Ethic of Intensive Stream Enhancement," *Trout Canada,* Spring/Summer 1993, pp. 15, 16, 35.

[42] *Stream Enhancement Guide* (Province of British Columbia, Ministry of Environment, 1980), pp. 69–73.

[43] "The only report of a structure built to assist a non-game fish was from Wyoming, for the Endangered Kendall Warm Spring speckled dace." Rinne and Turner, "Reclamation and Alteration as Management Techniques," p. 222. See also Minckley and Deacon, *Battle against Extinction,* pp. 171–89, where preserves and refugia are discussed.

[44] S. A. Burgess, "Some Effects of Stream Habitat Improvements on the Aquatic and Riparian Community of a Small Mountain Stream," in J. A. Gore, ed., *The Restoration of Rivers and Streams* (Boston, Butterworth Publishers, 1985), pp. 223–46.

[45] Special issue on watershed restoration, *Fisheries* 22, no. 5 (1997); special issue on ecosystem management, *Fisheries* 21, no. 12 (1996); special issue on freshwater biodiversity, *Fisheries* 21, no. 9 (1996); position on biodiversity, *Fisheries* 20, no. 4 (1995); also on biodiversity, *Fisheries* 17, no. 3 (1992); *The New Watershed Imperative: A New Approach to Restore America's River Ecosystems and Biodiversity* (Eugene: Pacific Rivers Council, 1993); P. A. Slaney and D. Zaldokas, eds., "Fish Habitat Rehabilitation Procedures," *Watershed Restoration Technical Circular,* no. 9 (1997).

game fish can be selectively removed through shooting, trapping, chemical, and other means.[46] Entire lakes and streams can be "poisoned" to eradicate existing and potentially competing fish so more valuable game fish can be re-introduced with excellent results for anglers.[47] The unfortunate consequence has often been complete alteration of lake/stream ecosystems. In some instances extirpation of isolated populations of non-game fish species has resulted.[48] On the other hand, natural populations can be rehabilitated by selectively eradicating alien species.[49] Most often, this type of restoration takes place when competing fish negatively affect sport fisheries.[50] "Therapeutic" removal of overabundant game fish, as in hunting,[51] has, to the best of my knowledge, not been implemented. On the whole, to consider population control as ecologically benign is doubtful at best.

(4) *Fish Culture.* Hatcheries are an important component of sport fisheries management.[52] All spawning, fertilization, egg incubation, hatching, fish growth, and health are artificially controlled. Cultured fish are released in angling waters

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[46] For historic evidence, see Berners in *Treatise of Fishing with an Angle* and Walton and Cotton, *The Complete Angler or the Contemplative Man's Recreation*. Control of predators is less well documented for fish. My experience in British Columbia is that both bears and mergansers were, at least historically, frequently shot to protect spawning salmon, fry, and smolts. On the Skeena River, I have also encountered several dead seals riddled with bullet holes, all killed illegally, presumably to protect sport fisheries.

[47] "Fish toxicants represent one of the most effective tools available to the fishery management biologist for the enhancement of fish populations and improvement of angling quality." Foreword of P. H. Eschmeyer, ed., *Rehabilitation of Fish Populations with Toxicants: A Symposium, North Central Division, American Fishery Society, Special Publications,* no. 4 (1975); J. N. Bone, "A Method of Dispensing Rotenone Emulsion," *Fisheries Management Report,* no. 62 (Victoria: British Columbia Fish and Wildlife Branch, 1970); C. D. Tredger, R. P. Griffith, and J. C. Wightman, "Detoxification and Decontamination of Water following Chemical Rehabilitation with Noxfish," *Fisheries Technical Circular,* no. 84 (Victoria: British Columbia Ministry of the Environmenbt, 1989); Sigler and Sigler, *Recreational Fisheries Management,* pp. 86 and 171–88.

[48] In British Columbia, at least one rare species of white fish was extirpated by such a "rehabilitation" project. J. D. McPhail and R. Carveth, *A Foundation for Conservation: The Nature and Origin of the Freshwater Fish Fauna of British Columbia* (Victoria: Queens Printer for British Columbia, 1993), p. 29; Rinne and Turner, *Battle against Extinction,* pp. 219–44.

[49] Ibid.

[50] Sigler and Sigler, *Recreational Fisheries Management,* pp. 171–88.

[51] J. L. Schmidt and D. L. Gilbert, eds., *Big Game of North America: Ecology and Management* (Harrisburg: Stackpole Books/Wildlife Management Institute, 1980); S. D. Schemnitz, ed., *Wildlife Management Techniques Manual* (Washington, D.C.: Wildlife Society, 1980).

[52] R. L. Welcomme, *International Introductions of Inland Aquatic Species,* lists 1,354 introductions of 237 species into 140 countries. Of these, "sport fishing has provided the second major motive for introduction with a relatively constant number of introductions per decade," pp. 8–9. From 1985 to 1991, well over a billion fish were stocked in the U.S. through Federal Aid in Sport Fish Restoration Programs, and accounted for 14.5 percent of all expenditures from this program. From 1989 to 1993, $27 million (two percent) were expended on salmonid hatchery related projects, only one percent on habitat related projects, J. McGurrin, C. Ubert, and D. Duff, "Use of Cultured Salmonids in the Federal aid in Sport Fish Restoration Program," in *Uses and Effects of Cultured Fishes in Aquatic Ecosystems American Fisheries Society Symposium* 15 (1995), pp. 12–15.

as catchables in put-and-take fisheries or as juveniles to grow naturally into larger fish. Anglers benefit by establishment of new fisheries where natural fish production is low, has been reduced, or is not possible. Overfished wild stocks can be augmented to provide more bountiful sport fisheries.[53] Although benefits to anglers may be substantial, a number of questionable ecological consequences result from this practice.

First, parking areas for staff, visitors, and equipment, as well as space requirements for buildings and raceways, replace ecosystems. Water diversions and energy requirements to run the operation also affect nature negatively.[54] Second, the interests of fish are negatively affected in hatcheries.[55] Third, there are potentially long-term negative genetic impacts to wild fish populations.[56] Hatchery fish are not subjected to natural selection. In the wild, natural selection "weeds out" debilitating traits. In hatcheries, these are incorporated into the population by artificially reducing deaths in fish. When cultured fish mate with wild counterparts, hatchery maintained traits become part of the wild (hybrid) population. Such hybrids no longer have the naturally selected-for genetic attributes to adequately survive in the wild. Continuing to take hybrids as a brood source (these are indistinguishable from wild fish) compounds the problem. Fourth, in hatcheries, where fish are kept at high densities, disease is a continuous threat. Epidemics are controlled by frequent and constant treatment. Once released into the wild, however, pathogens can spread to wild fish.[57] Fifth, hatchery fish, when released into natural ecosystems, compete

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[53] For historic reviews, see Sigler and Sigler, *Recreational Fisheries Management,* pp. 129–40; and H. L. Schramm, Jr., and R. G. Piper, eds., *Uses and Effects of Cultured Fishes in Aquatic Ecosystems, American Fisheries Society Symposium* 15 (1995).

[54] R. J. White, J. R. Karr, and W. Nehlsen, "Better Roles for Fish Stocking in Aquatic Resource Management," in Schramm and Piper, *Uses and Effects of Cultured Fishes in Aquatic Ecosystems,* p. 533, list both flow reductions and habitat destruction of stream channels and riparian zones.

[55] G. A. Wedemeyer, "Physiological Response of Juvenile Coho Salmon (*O. kisutch*) and Rainbow Trout (*Salmo gairdneri*) to Handling and Crowding Stress in Intensive Fish Culture," *Journal of the Fisheries Research Board of Canada* 33 (1976): 2677–2702.

[56] F. M. Utter, "Detrimental Aspects of Put-and-Take Trout Stocking," *Fisheries* 19, no. 8 (1994): 8–9. Although some that argue genetic implications are not so severe, for example, D. E. Campton, "Genetic Effects of Hatchery Fish on Wild Populations of Pacific Salmon and Steelhead: What do We Really Know?" in Schramm and Piper, *Uses and Effects of Cultured Fishes in Aquatic Ecosystems,* pp. 337–53, it is generally accepted that fish culture negatively affects the genetics of natural populations. See also K. Hindai, N. Ryman, and F. Utter, "Genetic Effects of Cultured Fish on Natural Fish Populations," *Canadian Journal of Fisheries and Aquatic Sciences* 48 (1991): 945–57; W. Goodman, "Keeping Anglers Happy has a Price: Ecological and Genetic Effects of Stocking Fish," *Bioscience* 41(1991): 294–99; M. M. Ferguson, "The Genetic Impact of Introduced Fishes on Native Species," *Canadian Journal of Zoology* 68 (1990): 1053–57.

[57] Wild Norwegian Atlantic salmon have been decimated by parasites introduced through resistant Baltic stocks. Utter, "Detrimental Aspects of Put-and-Take Trout Stocking," pp. 8–9. Similarly, Sigler and Sigler, *Recreational Fisheries Management,* p. 44, discuss impacts of pathogens introduced through fish culture to threatened or endangered non-game fishes. See also White, Karr, and Nehlsen, "Better Roles for Fish Stocking in Aquatic Resource Management," p. 533, table 2.

with wild fish populations, many of which have declined substantially as a direct consequence of competition with hatchery introductions.[58]

A fish culture protagonist could argue hatcheries are good, recruiting more anglers, resulting in increased conservation. This logic fails on several accounts. (1) Although it may be possible to demonstrate increased angler use in hatchery augmented waters, demonstrating this increase for the entire angling population is difficult. Angling is now less popular than it used to be despite fish culture.[59] Hatcheries tend to improve success rates of anglers and to concentrate their distribution. Total angler abundance is not affected, at least not positively. (2) The very assumption of angling resulting in conservation is what is being examined in this essay. Accepting this assumption without substantiation for the specific case of hatcheries is to make a claim based on ignorance. (3) Artificial enhancement of game fish populations may create a false expectation in anglers of aquatic ecosystems. Rather than accepting some waters to be naturally fish poor, rivers and lakes are expected to provide fish in abundance. Anglers are drawn to stocked waters with their focus on catching their limit. The relationship of respect for nature that angling as a sport is meant to foster is diminished.[60] Erosion of this relationship is exacerbated because fish, the very core of the angling experience, have been artificialized. Fish culture, therefore, drives a wedge between anglers and the wildness of nature, ultimately to the detriment of all angling and nature.

Despite some use of hatcheries in restoration projects,[61] fish culture on the whole cannot be considered a positive biological influence. On the contrary, there are substantial negative impacts to both aquatic and terrestrial ecosystems.

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[58] The evidence supporting this claim is exhaustive. See, for instance, D. W. Narver, "Are Hatcheries and Spawning Channels Alternatives to Stream Protection?" *Fisheries Research Board of Canada Circular,* no. 93 (1973); B. Brown, "Salmon Hatchery Flop," *Seattle Times* (1978): A–1; R. J. White, "Why Wild Fish Matter: Balancing Ecological and Aquacultural Fishery Management," *Trout,* Autumn 1992, pp. 17–33, 44–48; W. McMillan, "The Hatchery Steelhead Hoax," *Salmon Trout Steelheader* (April/ May 1989): 3, 30–33; G. K. Meffe, "Techno-Arrogance and Halfway Technologies: Salmon Hatcheries on the Pacific Coast of North America," *Conservation Biology* 6, no. 3 (1992): 350–54; Minckley and Deacon, *Battle against Extinction*; Welcomme, *International Introductions of Inland Aquatic Species*; Behnke, "Native Trout of Western North America"; and numerous other publications.

[59] "Special Session 5, Recruiting, Retaining and Training Consumptive Users of Fish and Wildlife," *Transactions of the Sixty-First North American Wildlife and Natural Resources Conference* (1996): 315–410. Angler numbers increased from 1955 to 1975, remained constant for a decade, and declined from 1985 to 1991. J. C. Mangun, D. A. Hall, and J. T. O'Leary, "Desertion in the Ranks: Recruiting and Retention of Sportsmen," *Transactions of the Sixty-First North American Wildlife and Natural Resources Conference* (1996): 338–44.

[60] White, "Why Wild Fish Matter"; McMillan, "Hatchery Steelhead Hoax"; R. Barnhart, W. Shake, and R. H. Hamer, eds., *Wild Trout V: Wild Trout in the 21st Century* (Yellowstone National Park: U.S. Department of the Interior, 1994), esp. J. H. Hair, "A Sense of Place: Keeping the Wild in Trout Fishing," pp. 15–20.

[61] J. E. Johnson and B. L. Jensen, "Hatcheries for Endangered Freshwater Species," in Minckley and Deacon, *Battle against Extinction,* pp. 99–217.

(5) *Mitigation.* Included here are all management actions that reduce the severity of, or cause to become less harsh or hostile, potential impacts from industry, resource extraction projects, urban and agricultural developments, and similar activities. Mitigation measures include statutory protection of fish and their habitats, and maintaining "aesthetic" qualities of angling. I exclude compensation here as this invariably consists of an enhancement/restoration practice already described.

Numerous laws protect fish and their habitats.[62] In British Columbia, Canada, for instance, both federal and provincial legislation protect habitat requirements for various fish species supporting food, commercial and sport fisheries.[63] Guidelines have been developed to maintain water quality, aquatic habitats,[64] riparian areas, and entire drainages.

Aesthetic values of sport fishing, guiding, and associated tackle and recreational industries also play a significant role in supporting conservation. Increasingly, wilderness areas, heritage rivers, and classified waters have reduced development, limited access, and restricted resource exploitation, which are beneficial to numerous organisms in addition to game fish.[65]

Streams, lakes, ponds, and wetlands, core ecosystems on which innumerable animals and plants depend, are, furthermore, enjoyed by anglers while pursuing their sport. A very beneficial impact to both aquatic and terrestrial ecosystems is, therefore, realized by this management practice.

People Management

In this section I discuss laws regulating (1) angling and (2) competing fisheries. Excluded are laws, already discussed, protecting habitats for fish and anglers.

(1) *Regulating Angling.* Rules affecting angling can be either "soft" or "hard." Soft rules anglers impose on themselves as a code of ethics for their sport.[66] Anglers

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[62] C. Deacon Williams and J. E. Deacon, "Ethics, Federal legislation, and Litigation in the Battle against Extinction," in Minckley and Deacon, *Battle against Extinction*, pp. 109–21; R. S. Musgrave and M. A. Stein, *State Wildlife Laws Handbook* (Rockville, Md.: Government Institutes,1993); W. R. Mangun and J. C. Mangun, "An Intergovernmental Dilemma in Policy Implementation," in W. R. Mangun, ed., *Public Policy Issues in Wildlife Management* (New York: Greenwood Press: 1991), pp. 3–16.

[63] The *Fisheries Act* (Canada) and *Fish Protection Act* (British Columbia, 1997).

[64] D. A. A Toews, *Handbook for Fish Habitat Protection on Forest Lands in British Columbia* (Vancouver: Department of Fisheries and Oceans Canada, 1981); *British Columbia Coastal Fisheries Forestry Guidebook* (1987); *Forest Practices Code of British Columbia, Riparian Management Guidebook* and *Fish-Stream Identification Guidebook* (1995).

[65] *British Columbia Heritage Rivers System* (1997).

[66] R. L. Haig-Brown, "Ethics and Aesthetics," in *A Primer of Fly Fishing* (Toronto: William Collins Sons and Co., 1974), pp. 177–83, and "Limits and Ethics," in *The Western Angler* (Don Mills, Ont.: William Collins Sons and Co., 1968), pp. 299–303; *Proceedings of the International Conference on Outdoor Ethics* (Lake of the Ozarks, Mo.: Izaak Walton League of America, 1987); D. L. Hawley, "Ethics," *Conservation and Outdoor Recreation Education* (British Columbia: Ministry of Environment, Lands, and Parks, 1989), pp. 199–207; A. A. Luce "The Ethics of Angling," *Fishing and Thinking* (Camden: Ragged Mountain Press, 1990), pp. 170–91; Jeremy Paxman, ed., "The Ethics of Fishing," *Fish, Fishing and the Meaning of Life* (London: Michael Joseph, 1994), pp. 473–540.

may release their catch while taking fish is permitted; they can restrict their sport to fly fishing while bait fishing is allowed and more productive; and they can report poachers and habitat violators to enforcement officers.[67] Although important, I do not further discuss soft rules here. They are often personal and difficult to define, and when they are definable, "soft" rules ultimately rest on "hard" rules.

Hard rules are government enforced, clearly defined, sport fishing regulations anglers must abide by and are a major component of sport fisheries management. There are, roughly, two types: (a) rules protecting sporting aspects of angling, and (b) those that protect fish.

(a) Regulations that maintain sporting qualities of angling prohibit snagging, trapping, netting, chumming, using certain baits, spearing, etc., to catch fish.[68] They do not affect what, where, when, or how many fish can be taken. Since the method itself, rather than the number of fish taken, has largely no impact on aquatic ecosystems or species assemblages per se, no benefit or cost to nature can be associated with regulations pertaining strictly to the method of angling.

(b) Regulations that protect fish, on the other hand, establish bag limits, seasonal and area closures as well as species and size restrictions.[69] Game fish frequently play a significant role in establishing and structuring predator-prey and other relationships in aquatic and terrestrial ecosystems.[70] An unregulated fishery could, over time, decimate game fish populations with negative impacts to these ecosystems. Maintaining natural abundance of game fish by regulating the catch could be regarded as a positive affect on nature and as justification for the sport. Unfortunately,

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[67] "The unethical angler is a threat to our fisheries resources and outdoor recreation." "Observe, Record, Report," *Freshwater Fishing Regulations Synopsis 1998–1999* (Victoria: Ministry of Fisheries, 1999), p. 72.

[68] *1989* and *1990 Alaska Sport Fishing Regulations Summary* (Juneau: Alaska Department of Fish and Game, 1990), p. 4; *1989 Michigan Fishing Guide* (Lansing, Mich.: Department of Natural Resources, 19899, p. 5; *1989–1990 Main Regulations, Sport Fishing in Quebec* (Quebec: Ministrere du Loisir, de la Chase et de la Peche, 1990), p. 4, and also *1998 Quebec Salmon Fishing, Summary of* Regulations, p. 3–4; *1987–1988, 1988–1989, 1989–1990, Sport Fishing Regulations Synopsis* (Whitehorse: Yukon Renewable Resources, 1990); *1989 Ontario Sport Fishing Regulations Summary* (Toronto: Ministry of Natural Resources, 1989), pp. 5–6; *1989 Guide to Sport Fishing* (Edmonton: Alberta Forestry, Lands and Wildlife, Fish and Wildlife, 1989), p. 5; *1989 Angler's Guide, Newfoundland and Labrador* (St. John's: Fisheries and Oceans Canada, 1989); *1989 Saskatchewan Angler's Guide* (Regina: Saskatchewan Parks, 1989), p. 4; *1988 Sport Fishing Guide, Northwest Territories* (Yellowknife: Renewable Resources, 1988), pp. 4–6; *1977* to *1989 Sport Fishing, Summary of Regulations, Nova Scotia* (Pictou: Nova Scotia Department of Fish., 1989), p. 8; *1985* to *1989 Manitoba Sport Fishing Guide* (Winnipeg: Manatoba Natural Resources, 1989), p. 6; *1980–1981* to *2000–2001 Freshwater Fishing Regulations Synopsis* (Victoria: Ministry of Fish and Fisheries Management, 2001).

[69] Ibid.

[70] For lake trout, see N. V. Martin and C. H. Olver, "The Lake Charr, *Salvelinus namaycush,*" in E. K. Balon, ed., *Charrs, Salmonid Fishes of the Genus Salvelinus* (The Hague: W. Junk Publishers, 1980). For interaction of salmon and terrestrial ecosystems, see J. G. Stockner, eds., *Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity,* American Fisheries Society Symposium 34 (Bethusda: American Fisheries Society, 2003); C. E. Wilkinson, M. D. Hocking, and T. E. Reimchen, "Uptake of Salmon-Derived Nitrogen by Mosses and Liverworts in Coastal British Columbia," *Oikos* 108 (2005): 85–98.

regulation of the sport fishery cannot be claimed as justification for angling. By imposing limitations on themselves, anglers in effect, reduce the negative impact of themselves on their own sport, an entirely circular and self-referential argument at best.

(2) *Regulating Competing Fisheries.* With many stocks nearing depletion, competition for fish is inevitable. Anglers could justify their sport by lobbying for greater protection of stocks threatened by commercial, food, and other fisheries. This argument is plausible when game fish populations require protection, and/or incidental species are also protected.

If a competing fishery threatens a sports fish population, and anglers intervene effectively to reduce this threat, then a species has clearly been afforded increased protection. When anglers restrict large-scale net fisheries that catch (or more properly, mine) not only squid or tuna, but also game fish, turtles, sharks, porpoises, and a host of other incidentally caught species,[71] significant protection of a variety of species occurs. Anglers, in collaboration with many environmentalists, can legitimately claim such restrictions as beneficial to marine species and ecosystems. This justification becomes increasingly obscure when some portion of the threatened population continues to be fished by anglers.

V. CONCLUSIONS

If, despite the perhaps limited and arbitrary nature of my analysis, this review has merit, then the combined effects of angling management overall, do not clearly indicate a positive impact on nature. Research does not directly impact nature, regulating angling is a circular argument, while food enhancements, population control, and fish culture generally impact nature negatively. However, there are considerable beneficial impacts on nature resulting from habitat protection/restoration, regulation of other fisheries, and mitigation. When harm to fish by angling is included, sport fishing becomes increasingly unjustifiable on the basis of nature conservation. To justify angling, sport fisheries management must increase its positive, as well as decrease its negative, impacts on nature. These must outweigh harms caused to fish as a result of angling, a project not without its challenges.

First, all fish culture activities, food enhancement projects, and many population control programs could be severely restricted with the immediate result of reducing game fish abundance, thereby conflicting directly with sport fishing interests.

Second, many fish and wildlife programs are funded by revenues generated from the sale of angling and hunting licenses and from surcharges on equipment

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[71] T. Williams, "Incidentally on Purpose, Salmon and Steelhead Piracy in the North Pacific," *Rod and Reel,* May/June 1989, pp. 19, 21–22; Seacops, *High Seas Pirates are Stealing our Salmon and Steelhead* (available from Seacops, 700 Water Street, Upper Ketchikan, Alaska 99901); I. Brown, "High Seas Driftnet Fishery Investigation," *The Western Conservation Officer*, Winter 1997/98, pp. 8–10, and especially G. Roberts, *The Unnatural History of the Sea* (Washington, D.C.: Island Press/Shearwater Books, 2007).

purchased to pursue these sports. Reduced fish abundance would inevitably recruit even fewer anglers to fund management programs. Fisheries management professionals, many of whom also angle, may find their programs, employment, and recreation at risk. There is, therefore, a strong incentive for them to continue making decisions favoring anglers rather than nature.

Third, the complex problem of significantly reducing sport fisheries management actions that impact nature negatively could be side-stepped by increasing efforts to reduce society's harm to nature. This maneuver shifts sports fisheries managements' conflict with itself and anglers to one with society generally. Escalation of protective and restoration actions beneficial to species and ecosystems increases conflict with many of society's projects that negatively affect nature.

The obstacle confronting all of sport fishing then is primarily to sacrifice the interests of anglers for the interests of nature. Unless steps are taken to meet this challenge, it will be difficult to justify angling on the basis of nature conservation.