USES AND EFFECTS OF CULTURED FISHES IN AQUATIC ECOSYSTEMS

AMERICAN FISHERIES SOCIETY

Uses and Effects of Cultured Fishes in Aquatic Ecosystems

Edited by

Harold L. Schramm, Jr.
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American Fisheries Society Symposium 15

Proceedings of the International Symposium and Workshop on the Uses and Effects of Cultured Fishes in Aquatic Ecosystems

Held in Albuquerque, New Mexico
12–17 March 1994

American Fisheries Society
Bethesda, Maryland
1995

The American Fisheries Society Symposium series is a registered serial.
Suggested citation formats follow.

Entire book

Schramm, H. L., Jr., and R. G. Piper, editors. 1995. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15.

Article within the book

Campton, D. E. 1995. Genetic effects of hatchery fish on wild populations of Pacific salmon and steelhead: what do we really know? American Fisheries Society Symposium 15:000–000.

Library of Congress Catalog Card Number: 95-060393
ISBN 0-913235-91-1 ISSN 0892-2284

Printed in the United States of America on recycled, acid-free paper.

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Preface

As fisheries resource management has developed and expanded, the use of and need for cultured fishes has increased. Always a tool but never a panacea, stocking cultured fishes has been both supported and challenged. The use of cultured fishes in fisheries management was addressed at "The Role of Fish Culture in Fisheries Management" symposium in 1985. Increases in the scope of fisheries management responsibilities and declines in fisheries resources, coupled with advances in fisheries science and knowledge about fishes and fisheries systems, led to a clear need to examine again, scientifically, the uses and effects of cultured fishes.

The American Fisheries Society addressed this significant issue with a two-step process: (1) by making scientific information available to the diverse body of people that make fisheries resource management decisions, and (2) by asking representatives of resource management agencies to determine recommendations for the use of cultured fishes. To accomplish the first step, a symposium "Uses and Effects of Cultured Fishes in Aquatic Ecosystems" was convened in Albuquerque, New Mexico, 12–17 March 1994. The second step was accomplished by inviting all North American fisheries resource management agencies to send a representative to a facilitated workshop in Denver, Colorado, 29–30 July 1994, to develop comprehensive considerations for the use of cultured fishes.

This process could not have been accomplished without the dedicated support of many American Fisheries Society (AFS) subunits and individual members. The "Uses and Effects of Cultured Fishes in Aquatic Ecosystems" symposium was initiated by the Fish Culture Section and cosponsored by the Fisheries Management, Genetics, Fisheries Administrators, Introduced Fishes, Marine Fisheries, Bioengineering, Physiology, and Early Life History sections of AFS. The symposium Steering Committee generously provided their time, energy, and abilities to ensure a successful symposium and follow-up workshop.

This proceedings contains technical papers, abstracts of posters, and position statements of the sponsoring AFS Sections which were presented at the symposium, as well as results of the facilitated workshop. The poster and podium presentations are a blend of scientific research, case histories, and management programs. These presentations have all been peer reviewed and found to be acceptable for publication. The AFS Section position statements evolved during the symposium as new information was discussed. The "Considerations for the Use of Cultured Fishes" represents the collective thoughts of the participants at the July workshop and addresses biological, ecological, social, and economic issues associated with culturing and stocking fishes. The considerations have been reviewed by the symposium Steering Committee (who served as facilitators for the July workshop) to ensure that the final document accurately represents the message of the workshop participants.

The diligence of the Steering Committee and the workshop participants has resulted in a product that is technically informative and operationally useful. From the conception of this process, the Steering Committee's purpose has been to provide information that can be used to better manage fisheries resources. We believe this purpose has been accomplished; however, the utility of the material presented in this volume must be evaluated by researchers and managers who incorporate the information into fisheries management activities. We encourage all people responsible for fisheries resources to be responsive to future needs and opportunities to build on this information and continually improve our ability to wisely manage fisheries resources.

HAROLD L. SCHRAMM, JR.
ROBERT G. PIPER
Coeditors

Acknowledgments

The dedicated efforts of many people are required to plan and stage a major symposium, to conduct a facilitated workshop, and to prepare a proceedings of this size and scope. The symposium, "Uses and Effects of Cultured Fishes in Aquatic Ecosystems," sponsored by the American Fisheries Society, was a success due to the hard work and commitment of the Steering Committee and many individual volunteers. Gary J. Carmichael and Vincent A. Mudrak (U.S. Fish and Wildlife Service) compiled an excellent program that spanned 5 days, 68 podium papers, and 23 poster presentations. The eight technical sessions were moderated by Steering Committee members Vincent A. Mudrak, J. Holt Williamson (U.S. Fish and Wildlife Service), Wayne J. Daley (Kramer, Chin & Mayor, Inc.), Thomas W. Gengerke (Iowa Department of Natural Resources), Harold L. Kincaid (National Biological Service), Mark Konikoff (University of Southwest Louisiana), Donald D. MacKinlay (Canada Department of Fisheries and Oceans), and Franklin T. McBride (North Carolina Wildlife Resources Commission). Churchill B. Grimes (National Marine Fisheries Service) moderated a ninth program session during which AFS Section position statements were presented. He also organized a poster session and several lively point–counterpoint discussion sessions that followed each day of podium presentations. Fred P. Binkowski (University of Wisconsin) and Martin T. Marcinko (Pennsylvania Fish and Boat Commission) handled conference registration superbly. Wayne J. Daley was responsible for the overall budget and Dennis C. Ricker (Pennsylvania Fish and Boat Commission) provided scrupulous financial management. Several people at the Pennsylvania Fish and Boat Commission deserve recognition. Jule Weaver served as the on-site computer expert and assisted authors, attendees, and staff with various functions; Mary Ellen McMahon provided registration and clerical support for the symposium; Ted Walke designed and produced the printed symposium program on a very tight schedule; and the Commission Bureau of Education and Information Executive Director Peter Colangelo contributed the program book. The Steering Committee is grateful to Kim Marggraf of Marggraf Meetings who provided registration expertise. Gary J. Carmichael did an outstanding job coordinating the local arrangements for the symposium. Special thanks are also extended to the many regional office and field station personnel of the U. S. Fish and Wildlife Service Southwest Regional Office who worked hard to ensure that the symposium ran smoothly.

A follow-up workshop was convened four months after the symposium in Denver, Colorado. Local arrangements were skillfully negotiated and managed by Thomas G. Powell, Donald D. Horak (Colorado Division of Wildlife), and J. Michael Stempel (U.S. Fish and Wildlife Service). The three-day meeting was facilitated by Terry Radcliff who also provided training to the Steering Committee and who made it possible for a large group of people to work diligently to develop a consensus document that outlines considerations for the use of cultured fishes in aquatic ecosystems.

Harold L. Schramm, Jr. (Mississippi Cooperative Fish and Wildlife Research Unit) and Robert G. Piper (Piper Technologies) contributed enormous amounts of time, technical expertise, and editorial skill to evaluating and editing manuscripts from the symposium for this volume. Harold Schramm also prepared the workshop results for final publication. Many people provided peer reviews that strengthened the quality of this proceedings; their names are listed on the following page. Robert L. Kendall guided the editorial process for the American Fisheries Society and Beth D. Staehle coordinated the editing and production of this volume. Eva M. Silverfine, Amy E. Moore, and Janet E. Harry all made important contributions to the quality and production of this proceedings.

Financial support for the symposium and this publication was coordinated by AFS Executive Director Paul Brouha and was provided by the Federal Aid in Sport Fish Restoration Fund.

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Considerations For The Use of Cultured Fishes in Fisheries Resource management

American Fisheries Society Symposium 15:1–4, 1995

KEYNOTE ADDRESS

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The central theme of this symposium is fish husbandry: the culture of fishes. Usually such a symposium would focus on husbandry techniques and the near-miraculous advances in technology would be chronicled. But instead we are gathered here to discuss the uses and effects of cultured fishes in aquatic ecosystems, that is, the ethical use of the products of fish husbandry. Fishery managers and biologists have debated this subject among themselves for decades. Now the discussion has moved to the broader societal forum, the environmental community.

As we are all well aware, the controversy over the role of cultured fishes in natural environments has increased in intensity during recent years. All aspects of fish husbandry, in the broader term, aquaculture, are in question, including facility siting, effluents, genetics, animal rights, and a host of social and economic impacts. It is a quantum leap from the early days of fish culture in the United States, described by Bowen (1970) as the product of fisheries destroyed by America's early eighteenth-century industries:

> While the decline of the inland fishery resources was not understood, an aroused public demanded corrective action. Therefore, the climate was created for the development of fish culture in America.

Fishery management in general is undergoing dramatic evolution as our knowledge of fish stocks, habitat relationships, and the effects of human activities are better understood. This dynamic is a normal process of most disciplines as technology and application evolve and the results of tested theories add to the store of knowledge.

Fishery managers generally have viewed fish culture as one of many management tools used to ameliorate the effects identified as limiting factors to reach a fishery management objective. Hence the hatchery product has been used to introduce species into new and existing waters, to supply year-classes when natural reproduction is absent or has failed, to create or maintain recreational and commercial fisheries, or to produce protein. Like the situation described by Bowen (1970), fishery management objectives are largely determined by public demand.

Cultured Fishes in Dynamic Systems

It is axiomatic that aquatic ecosystems are dynamic, in the classical sense, moving on a continuum from oligotrophy to eutrophy with species assemblages and quantity defined by location on the continuum. The practice of purposeful interruption of the dynamic by retarding succession in order to retain habitat that will support a particular species or species assemblage is antithetic to modern fish and wildlife management as expressed in the term "ecosystem management." At no time in history has the evolution and development of ecosystems and organisms been static nor shall it ever be; it is only the rate of change over time that varies. Even management efforts that interrupt the process are temporary in the relentless march of time.

Common definitions of the currently popular concept of biodiversity, as were reflected in several papers in a 1992 issue of the American Fisheries Society publication *Fisheries* (17[3]:6–38), are simply stated as the variety of life and its processes, with an inherent understanding that life refers to only native organisms. Indeed, Karr and Dudley (1981) described a comparable concept of biological integrity of communities as "species composition, diversity, and functional organization comparable to the natural habitat of the region." Thus, under these definitions, nonnative cultured fishes, and possibly even native cultured fishes that are genotypically different, would have no place in systems managed for biodiversity.

However, there are few, if any, contemporary areas that truly can be called natural in a static sense. This was eloquently characterized in 1993 during a presentation on ecological risk assessment at Tulane University by Dr. Robert Lackey of the Environmental Protection Agency. Dr. Lackey stated,

> Many people, perhaps most I think, have a view of ecosystems characterized by Ansel Adams photographs–natural ecosystems are 'perfect'–an equilibrium condition in which all the pieces operate in a predictable, desirable way. Most views of ecosystems are of 'natural, unspoiled' panoramas. They are frozen in time and any deviation from this timeless condition is 'degradation.' This is not the way the natural world is.

Commenting on the nature and long-term dynamics of ecosystems in the context of human life spans and mortality he said,

> contrary to individual humans who die, and in most cases people think that is a bad situation, ecosystems change dramatically over time, have no optimal condition, and are only healthy when compared to some desired state specified by humans. Ecosystem 'health' is strictly an anthropocentric term.

Therefore, it is entirely unreasonable to wholeheartedly discount the value of using introduced species (usually cultured) based solely on the premise that people can hope to maintain systems in a purely static or historic state.

Appropriate Uses of Cultured Fishes

This is not to say that cultured species are universally appropriate. Partly as a result of public willingness to accept readily available cultured fishes as compensation for a variety of human-induced destruction of fisheries resources and habitats, much of the public, and possibly some managers, often view fish stocking as a panacea to the problem of declining populations. Again, that was clearly the case as described by Bowen (1970). Hatchery products should not be used as an expeditious surrogate that would justify the wanton destruction or taking of natural fish production systems. When the hatchery product should be used to mitigate purposeful habitat loss is a serious question and should be decided only through an open, public, deliberative process.

As Dr. Lackey's comments so appropriately outlined, possibly the one factor over which fishery managers often have the least control is habitat. Societal decisions that result in changing land use, water diversions, atmospheric deposition of nutrients, contaminants, and other materials, as well as increasing urbanization may force managers to compensate for changes in habitat through the use of cultured species. As habitats evolve, perhaps at an accelerated pace due to human influence, they may become unsuitable to maintain species and ecological processes as these species and processes occurred there in the past. Ironically, recognizing the reality that people have greatly altered most aquatic habitats, many arguments for preserving vestigial stocks of native species continue to be premised on the theory that humans cannot reengineer evolution and that native species are better adapted to the environment or to maintain historical biological diversity. Yet these very species evolved in an environment that is completely different from what presently exists. Present environmental conditions, had they developed over an epochal period of time rather than in the rapid pace so common under human-influenced conditions, may have led to a completely different evolutionary pathway and, ultimately, species composition than may be present.

Although there are numerous examples of management to achieve historic conditions, an appropriate case history lies in the attempted reestablishment of populations of Arctic grayling *Thymallus articus* in northern Michigan. Primarily due to irreversible habitat changes caused by logging, constructed barriers to movement, and other human-induced impacts, efforts to reestablish this species have met dismal failure. In cases such as this, managers must face a decision on whether to use cultured species for public benefit or to leave these streams with altered ecosystems to provide little or no public benefit.

In some instances, habitat reclamation may be technologically feasible, but the economic cost to society or public willingness to pay is prohibitive. In the case of some hydroelectric projects, it may be possible to remove dams and restore ecosystems to a state that somewhat resembles their original condition. However, society as a whole (the people component) has chosen not to undertake the cost or suffer the sacrifices to do this. The only suitable solution in these cases may be to use native or nonnative cultured species.

In other cases, the alteration of habitat has been accompanied by severe and irreversible changes in the entire aquatic community. There is no better example of a large-scale case such as this than the Great Lakes. Once relatively low in diversity, a tremendous variety of nonnative aquatic species has now been established in the Great Lakes either unintentionally or by managers trying to restore effective predator–prey assemblages while providing public benefits in a highly altered ecosystem. The entire fish assemblage and habitat have been changed during the past century so that it is not likely from a technological standpoint, and certainly not from an economic standpoint, that the lakes could be returned to the condition that existed hundreds of years ago. Even so, the aquatic community

of the lakes is more diverse under current conditions and provides tremendously greater benefits to society than they had historically. In cases such as this, of which there are many throughout the United States, managers must be ready to utilize fish culture as a reclamation tool—both in the ecological and economic context.

Role of Cultured Fishes in Restoring Native Species

Using cultured fishes to restore native species that have been extirpated is an important part of several ongoing restoration efforts, including those for economically important species such as lake trout *Salvelinus namaycush*, Atlantic salmon *Salmo salar*, and Pacific salmon *Oncorhynchus* spp. The U.S. Fish and Wildlife Service, for example, maintains 28 hatcheries that are involved with the restoration of Threatened or Endangered fishes (including those on the proposed and candidate lists). In several cases, managers are faced with rebuilding entire stocks from remnant populations that represent a greatly reduced gene pool. In restoring specific runs of Pacific salmon in the northwestern United States, managers must consider the feasibility of maintaining the genetic integrity of hundreds of stocks of the same species. In the case of restoration of Atlantic salmon in the northeastern United States, most individual stock-specific gene pools have long since vanished, leaving managers with the task of restoring Atlantic salmon's presence in entire river systems from a very limited, nonnative gene pool. Cultured fishes will play an important role in restoring historic fish assemblages' phenotypes, although these fishes will not be genotypically native.

The Paradigm

In the future, fish culture will be affected by evolving environmental standards, and fishery managers and fish culturists will have to justify every aspect of the stocking and production process. It is said that those who do not learn from history are destined to relive it. There is a fishery with a significant aquaculture component that has raised the specter of what the future holds—the Atlantic salmon fishery.

Few fish have been as romanticized as the "silver swimmer." Its name, *Salmo salar*, means mighty leaper. It is legendary among anglers and is at the top of the list of gourmets. Its life history of traversing great oceanic distances to feed and then returning to its natal stream to spawn held naturalists in awe. The Atlantic salmon was extirpated from southern New England rivers by the industrial revolution of the late eighteenth and early nineteenth centuries. The industrial revolution was fueled by the construction of dams to harness water power. The mighty Atlantic salmon was deprived of its spawning grounds in many streams.

Interest in the culture of Atlantic salmon led to the first production hatchery built on the Rhine River in Germany in 1852. By the latter part of that same century every country with Atlantic salmon populations had a salmon hatchery and attempted to restore lost runs. To mitigate the loss of access to, or despoilment of, spawning habitat, Atlantic salmon were cultured and flushed down the rivers to accomplish little more than salve consciences. However, the New England Atlantic salmon hatcheries were so successful in producing fish that soon excess fish were being loaded into federal fish railroad cars and indiscriminately stocked from New England to Minnesota. Early in my (G. C. Radonski) career as a fishery biologist in northeastern Wisconsin, it was rare to review a lake or stream survey record without seeing an entry that Atlantic salmon had been stocked at the turn of the twentieth century. It is a wonder that we are not up to our ears in Atlantic salmon. Or, are we?

Due to diminishing quantity and quality of spawning habitat, and serious commercial overexploitation, wild Atlantic salmon in the market became limited and expensive in the best tradition of supply and demand. Natural stocks were producing about 10,000 tons annually. In the early 1970s the Norwegians began farming Atlantic salmon. In those early years the farmed production almost equaled the natural production. But cultural techniques and market demand for the high-quality cultured product produced a rapidly growing cultural infrastructure to the point where production in 1992 was in excess of 225,000 tons! That rapid growth unfolded the wide array of problems facing aquaculture including, but not limited to, genetic pollution, competition with wild stocks, aesthetics associated with facility siting, spread of parasites and diseases, water quality impairment, and interruption of the economic stability of other fisheries (such as Pacific salmon). There is a litany of benefits that offset the problems. However, benefits are enjoyed, problems must be dealt with.

The international body that coordinates the management of Atlantic salmon is the North Atlantic Salmon Conservation Organization, headquartered in Edinburgh, Scotland. The North Atlantic Salmon Conservation Organization has diligently followed

the growth of Atlantic salmon culture, and we recommend their numerous studies and publications on the impacts of Atlantic salmon aquaculture for your review.

The Pendulum Swings

As with any issue, opinions regarding the use of cultured species span a wide spectrum. The arguments can often become very heated and polarized between the "greens"—those who would like to see absolutely no use of cultured fishes at all—and those who would prefer to return to the old days when cultured fish were freely dispensed with little or no regard for historic ranges, complex ecological effects, disease, or other factors. The current political climate among policy makers, particularly in Washington, D.C., is toward the greener side of the issue. Interpretations of responsibilities under federal mandates such as the Non Indigenous Aquatic Nuisance Prevention and Control Act (16 U.S.C.A. §§4701 to 4751), the Endangered Species Act (16 U.S.C.A. §§1531 to 1544), and others tend to be made through a romanticized vision of returning to a more natural state, which excludes or severely restricts the use of cultured species. President Carter's Executive Order (Number 11987, 24 May 1977), which was written to reduce introductions of species "not naturally occurring either presently or historically in any ecosystem of the United States," is currently being interpreted in some cases as prohibiting further stocking of species that have occurred for decades in some areas.

Although this is the mood of some of the current political factions, there is a question as to whether the American public as a whole is supportive. Recent articles in popular outdoor magazines are showing a backlash to such restrictions. In other arenas, the public is beginning to question the cost in terms of dollars and the sacrifice of alternative uses of the resources to maintain fish populations without the aid of artificial propagation where it is appropriate.

In Conclusion

Nine years ago, I (G. C. Radonski) keynoted the AFS-sponsored symposium, *Fish Culture in Fisheries Management*. My presentation was titled, "Fish Culture is a Tool, Not a Panacea" (Radonski and Martin 1986). We were tempted merely to recycle that presentation for this symposium. Upon review of that paper, we found it chronicled the past, and the past does not change. It described many fish culture success stories while noting that there were things done wrong in the developing fish culture science. As problems were identified, they were addressed and usually corrected. Most were corrected because of a strong and abiding ethic on the part of the fish culture practitioners toward the fishery resource and aquatic habitats. Other problems were dealt with in response to outside public pressure. In no case that we know of were these problems ignored. The process has not changed but the criteria have in response to evolving public fishery policy. We characterized this change in criteria as "modern fishery management." Modern fishery management would have natural systems with native biota and the presence of optimal biodiversity. We are not sure that we understand that in its fullest context, but we see the direction in which it is going. On the fishery management spectrum that goes from no management to intensive management, public fishery policy is moving toward no management. This symposium will play a role in the formation of that public policy. Neither end of the spectrum will prevail in an absolute sense. With hope, we will learn from each other in the process and the end result will be sound public policy that captures the social and economic benefits which can be obtained from the renewable common property fishery resource.

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PODIUM PRESENTATIONS

Fisheries Management Needs:

Sport Fish Restoration

and Enhancement