Techno-Arrogance and Halfway Technologies: Salmon Hatcheries on the Pacific Coast of North America

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Abstract: *Humankind has adopted an arrogant and ultimately self-defeating attitude toward nature that places technological mastery over nature at the forefront of our approach to many environmental problems. This "techno-arrogance" fails to recognize limitations on, and ramifications of, attempted control of nature. An example of techno-arrogance is the flawed attempt to recover Pacific salmonid fisheries through technological application in the form of hatcheries. Countless salmon stocks have declined precipitously over the last century as a result of overfishing and widespread habitat destruction. A central feature of recovery efforts has been to build many hatcheries to produce large quantities of fish to restock streams. This approach addresses the symptoms but not the causes of the declines (an example of a halfway technology), because the habitats remain largely unsuitable for salmon. There are at least six reasons why the hatchery approach will ultimately fail: (1) data demonstrate that hatcheries are not solving the problem—salmon continue to decline despite decades of hatchery production; (2) hatcheries are costly to run, and divert resources from other efforts, such as habitat restoration; (3) hatcheries are not sustainable in the long term, requiring continual input of money and energy; (4) hatcheries are a genetically unsound approach to management that can adversely affect wild populations; (5) hatchery production leads to increased harvest of declining wild populations of salmon; and (6) hatcheries conceal from the public the truth of real salmon decline. I recommend that salmonid management turn from the symptoms to the causes of decline. Overharvest and habitat destruction must be directly addressed in a major, landscape-level effort, on a scale comparable to the hatchery pro-*

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Resumen: *La humanidad ha adoptado una actitud arrogante, y en última instancia destinada al fracaso, que pone a la maestría tecnológica por encima de la naturaleza en la vanguardia de nuestro ataque a muchos de los problemas ambientales. Esta arrogancia tecnológica falla en reconocer las limitaciones y las ramificaciones que tienen los intentos en controlar la naturaleza. Un ejemplo de arrogancia tecnológica es el intento fallido de recuperar las pesquerías salmoneras del Pacífico a través de aplicaciones tecnológicas en forma de criaderos. Innumerables stocks de salmones han decrecido precipitadamente en la última centuria como resultado de la sobrepesca y la destrucción masiva de hábitats. Una característica central de los esfuerzos de recuperación ha sido la construcción de numerosos criaderos a los efectos de producir grandes cantidades de peces para sembrar los rios. Esta estrategia esta dirigida a los síntomas pero no a las causas do la declinación (un ejemplo de tecnología a medio camino), puesto que los hábitats permanecen en su mayoría no aptos para el salmón. Existen por lo menos seis razones por las cuales la estrategia de criaderos está, en última instancia, destinada al fracaso: (1) datos demuestran los criaderos no estan resolviendo el problema; el salmón continúa declinando a pesar de décadas de producción en los criaderos; (2) los criaderos son costosos en su operación, y desvían recursos que podrían ser destinados a otros esfuerzos tales como la restauración del hábitat; (3) los criaderos no son sostenibles en el largo plazo, requiriendo un flujo contínuo de dinero y energía; (4) los criaderos son una estrategia erronea desde un punto de vista genético y pueden afectar adversamente a las poblaciones silvestres; (5) la producción de los criaderos conlleva a un incremento en la cosecha de poblaciones silvestres de salmón; y (6) las estaciones de cría ocultan al público las verdaderas causas de la declinación de las poblaciones silvestres de salmón. Recomiendo que el manejo del salmón*

gram, if salmonid fisheries are to remain a part of the ecological, recreational, commercial, and asthetic arenas in the long term.

pase de los síntomas a las causas de la declinación. La sobrepesca y la destrucción del hábitat tienen que ser consideradas en un esfuerzo de grandes magnitudes a nivel paisajístico, y a una escala comparable a la de las campañas de criaderos, a los efectos de que las pesquerías de salmón continúen formando parte de las arenas ecológicas, recreativas y comerciales en el largo plazo.

> *In the preservation of biological diversity, the use of technology is a last resort.* (Conway, 1986)

Perhaps unknowingly, and probably largely through historical momentum, humankind has adopted a shortsighted and ultimately self-defeating philosophy toward nature and our modifications of it. We seem to feel that we can solve any man-induced problem in the natural world, be it habitat destruction, the spread of exotic species, the dumping of toxicants, and even global climate change, through even further modifications using a concerted application of technology. The notion is that we can right virtually any wrong, given enough money, motivation, and innovation. We also seem to believe we can overcome most obstacles presented by nature through similar efforts. Thus, the attitude of many is, if it floods, channelize it; if it's a desert, irrigate it; if it grows too many mosquitoes, drain it or spray pesticides. And if any of those "solutions" cause unanticipated problems, simply apply more technology, perhaps calling up a different type of expertise.

I will call this approach to nature "techno-arrogance," borrowing from Ehrenfeld's (1981) work, *The Arrogance of Humanism.* In that book, he decries the arrogant and prevailing attitude of our species that we can control most of the important aspects of our lives and of nature through technology, irrespective of ultimate and perhaps devastating consequences. Such arrogance fails to recognize or accept limitations and ramifications of the attempted control of our human environment and of nature.

I wish to address a particular conservation problem that is the result of techno-arrogance and that is being "solved" through further application of technology. I refer to the precipitous loss of various salmonid fishes (salmon and anadromous trout) along the Pacific coast of North America. The problem is clear: numerous genetic stocks are being lost quite rapidly, largely through overharvest and a host of environmental effects, including hydropower development, clearcutting, siltation, channel manipulation, water diversion for agriculture, and pollution (Northwest Power Planning Council [NPPC] 1987; National Marine Fisheries Service [NMFS] 1991). For example, the annual return of anadromous salmon and trout to the Columbia River Basin has decreased from an estimated 12–16 million individuals in the 1880s to 2.5 million in the 1980s (NPPC 1987). Furthermore, Nehlson et al. (1991) identified 214 stocks of Pacific salmonids from California, Oregon, Idaho, and Washington that they considered to be of special concern, as they face a high or moderate risk of extinction.

A central feature of the mainstream solution to this debacle is technological: build hundreds of hatcheries to spawn thousands of fish and produce millions of eggs to stock back into the environment. There is a fundamental problem with this approach, however: much of the natural environment remains largely unsuitable for salmonid survival, reproduction, or migration, and continues to deteriorate. Millions of fish are being placed into degraded or even lethal environments and have little chance of survival to maturity and reproduction.

I maintain that a management strategy that has as a centerpiece artificial propagation and restocking of a species that has declined as the result of environmental degradation and overexploitation, without correcting the causes for decline, is not facing biological reality. Salmonid management based largely on hatchery production, with no overt and large-scale ecosystem-level recovery program, is doomed to failure. Not only does it fail to address the real causes of salmonid decline, but it may actually exacerbate the problem and accelerate the extinction process. There are at least six reasons why the current use of hatcheries in salmonid management is counter-productive and should be reconsidered:

First, the data demonstrate that hatcheries are not solving and likely will not solve the problem of salmon decline. Salmonids have continued to decline throughout the Pacific Northwest, despite decades of hatchery production and the expenditure of millions of dollars (see, Federal Register 1991; Hilborn 1991, 1992; Matthews & Waples 1991). It should be obvious that this is not a reasonable solution to the problem, as it clearly is not working. For example, as of this writing, the 1992 oceanic fishing season is in danger of being reduced or eliminated altogether, due to the now alarming decline of both natural and hatchery runs of fish.

Second, hatcheries are enormously costly to run. Severely limited state and federal monies spent on hatcheries could be redirected to local and ecosystem-level habitat restoration, or to prevention of further decline

through land purchases. The latter would also benefit other species and maintain ecosystem services in the region (Ehrlich & Mooney 1983).

Third, hatcheries are not sustainable in any long-term sense. They require continual infusion of energy and money, and they are only a piecemeal, year-to-year approach to the problem. Will hatcheries continue to operate in fifty years? Five hundred years? Five thousand years? At some point, for economic or other reasons, hatcheries will cease to operate, and the system will collapse. A long-term, self-sustaining solution is needed.

Fourth, hatcheries are a biologically unsound approach to management that can result in negative genetic changes in natural populations (Allendorf & Ryman 1987, and references therein). The most basic concept in quantitative genetics is that an individual's phenotype reflects genotypic and environmental influences, plus interactions of these factors; hatcheries have never demonstrated the ability to properly manage either the genotype or the environment in any way that reasonably approximates nature. Although hatchery management practices have been changing to accommodate genetic concerns (see, Ryman & Utter 1987), most hatcheries have historically ignored basic principles of population genetics, such as genetically effective population size, and have purposely transferred stocks among subbasins and drainages, disregarding potential local adaptations and site fidelities. This has resulted in the genetic and ecological interaction of native and hatchery stocks, with repeated degradation or loss of native populations (Hindar et al. 1991, and many references therein).

Fifth, hatchery production leads to greater harvest of salmonids, including those from natural populations, resulting in decline of the very stocks being protected. Hilborn (1991) stated that "There is wide concern throughout the Northwest that we have allowed our fisheries harvest rates to match the potential productivity of hatchery stocks, causing wild stocks to be overfished." He continues with an example: "Just north of Puget Sound... harvest rates on Coho Salmon are as high as 95%, sustainable only by the most successful hatchery stocks. The net result of these high harvest rates is that as hatchery production has increased, wild stocks have declined. But the Canadians have no more Coho now than they did 15 years ago. They have swapped hatchery fish for wild fish." Successful hatchery production seems to provide a psychological license to increase harvest rates, which reduces wild stocks, thus defeating the initial purpose of hatcheries.

Sixth, hatcheries are at best a palliative that conceals from the public the real problems and dangers facing a valued resource. This, I believe, is the most serious objection to the hatchery approach. By financially supporting hatchery production as a standard mitigation practice, the hydropower companies and other development projects that are largely responsible for environmental degradation can "buy out" of their moral responsibilities for salmonid losses and habitat destruction by demonstrating their concern for and dedication to the declining resource. They, along with the fishing industry, have created a popular mythology, foisted on managers and the public, that hatcheries are a viable solution to environmental destruction and loss of salmon. This is an insidious deception of the public trust, and this particular mythology must be challenged. The taxpayer and voter is deceived (whether by commission or omission) into believing that technological advances can simultaneously allow environmental degradation and sustained production of an economically, aesthetically, and recreationally valuable resource. The public is also led to believe that their native salmonids are in reasonable condition and in good hands. Consequently, the public is insulated from the reality that their rivers and terrestrial ecosystems are rapidly degrading, and that native fishes, including the salmon they like to catch and eat, are disappearing.

The hatchery approach to salmon conservation is a good example of what Lewis Thomas (1974) has called "halfway technology," a reference to medical practices that treat symptoms rather than eliminate causes of disease. To quote Frazer's (1992) essay on sea turtle conservation,

> Thomas defined halfway technology as "the kinds of things that must be done after the fact, in efforts to compensate for the incapacitating effects of certain diseases whose course one is unable to do very much about. It is a technology designed to make up for disease, or to postpone death." In short, halfway technology does little or nothing to address the cause or the cure of disease. It's what we use to treat a disease when we don't really understand it.

Essentially, halfway technology in salmonid management recognizes the symptom (fewer fish) and treats that symptom (grow more fish) without making a concerted effort to identify and eliminate the underlying causes (environmental destruction and overexploitation). Hatchery rearing of millions of fish does nothing to address the causes of declining populations of fish but simply tries to make more fish available. A medical analogy would be to save the life of a bleeding patient by continual blood transfusions rather than by identifying and stopping the source of bleeding.

Again borrowing from Frazer's work on sea turtle conservation:

> In short, my point is simple. If the cause of the problem (disorientation of adult or hatchling sea turtles) is lighting on the beaches, the solution should address lighting on the beaches. If the cause of mortality is incidental capture in shrimp trawl nets, the solution should address the capture of turtles in nets. Unfortunately, at

> present, the problem is too often defined simply as there being too few turtles, and the solution is likely to be viewed as anything that increases the numbers of turtles. This is short-sighted and cannot serve to ensure the cohabitation of the planet by humans and sea turtles in the long run. We would do well to concentrate our efforts on reducing our own negative effects on sea turtle populations instead of attempting to tip the balance between the turtles and their nonhuman predators.

Change "sea turtles" to "salmonids," and "lighting on the beaches" and "shrimp trawl nets" to "hydropower dams" and "siltation from logging," and Frazer has nicely described the Pacific salmonid situation. Halfway technology for salmonids ignores the many causes of decline, focuses on reduced numbers, and invents technological methodologies to increase those numbers. It ignores the fact that, no matter how many millions of eggs or fry or juveniles are "headstarted" in hatcheries, most are doomed in their riverine and oceanic environments: they will not grow and return to the ocean; if they happen to grow and reach the ocean, they will be harvested before their return migration for reproduction; if they should escape harvest and attempt to return, they will not be able to pass the many dams and reservoirs in their way; if they happen to pass them, they cannot reproduce in their natal streams due to siltation, pollution, or other habitat change; if they happen to reproduce, their offspring probably will not make it back to the marine system. Such is the fate of the contemporary Pacific salmonid.

What then do I suggest for the management of salmonid fisheries? We must re-orient recovery efforts from the *symptoms* of decline to the *causes* of decline. The present hatchery-led approach deludes the public (and probably the managers themselves) into thinking we are really doing something beneficial toward restoration of native salmon fisheries in the Pacific Northwest. In fact, those fisheries continue to decline (Matthews & Waples 1991) and many are headed toward extinction (Nehlson et al. 1991), even after and perhaps partly because of decades of intense hatchery production.

Running a multitude of expensive hatcheries while ineffectively dealing with turbines and dams, diversion of water for irrigation, dumping of mine tailings, sedimentation from road building and logging, overgrazing of watersheds, overharvesting, and genetic homogenization of populations, is halfway technology at its worst. Valuable and limited resources are being invested in a dead-end technology, while the causes of the problem continue unabated and even increase. Hatcheries may placate some individuals in the short-term, may please politicians, and may even sustain some fish populations for the present, but they will not rejuvenate a dying system without a great deal of effort being put into the fish's environment. This requires complete reevaluation of our basic philosophies of nature, technology, and resource use. This line of reasoning with respect to salmonids was beautifully developed by Scarnecchia (1988) and will not be further pursued here, other than to borrow a quote: "Rational salmon management is not just a search for technologies: it is a search for values." I contend that hatchery-centered management is based on misguided values.

The only sensible basis for management of salmonid fisheries (or any species in nature) is a clear understanding and acceptance of the evolutionary history of the species and adoption of measures that work within the constraints of that history. We know that anadromous salmonids must have both healthy riverine and marine systems to complete their life cycles. We know that free passage for adults returning upstream and juveniles migrating downstream is essential. We know that high mortality on the open seas will result in fewer adults available for spawning. We know that spawning site fidelity is high, and that changes in river odors may disrupt navigational abilities. These and many other life history facts are the result of thousands to millions of generations of evolutionary history and cannot be easily molded to the needs of man without seriously disrupting the system.

We as a society have adopted a techno-arrogant and self-defeating approach in trying to alter evolutionary history to the short-term benefit of humans. It seems more biologically reasonable to use our intellectual powers to recognize the limitations and liabilities of this approach and instead modify our own behavior through cultural change, rather than to manipulate the natural history of other species. We will not change the nature of salmonid life history quickly enough to allow the fish to respond successfully to polluted, dammed, and over-exploited waterways. If we want these species to continue to exist and to be a usable resource, we need to make our polluted, dammed, and over-exploited waterways more compatible with salmonid life history.

I do not wish to imply that hatcheries are all bad; they may in fact be able to play a valid role in recovery of some salmonid populations. However, their purpose and operational philosophy needs to change from production to genetic conservation. Hatcheries can potentially play a critical role in genetic rehabilitation of depleted or genetically degraded stocks if they adopt strict genetic operational guidelines (Meffe 1986; Allendorf & Ryman 1987; Kapuscinski & Jacobson 1987; Kapuscinski et al., in review). Designation of genetic resource reserves for salmonid stocks (Currens et al., in review), along with ambitious genetic rehabilitation of decimated populations in hatcheries, would go a long way toward restoring a once remarkable system. However, no reasonable progress can be made without a concerted effort toward environmental restoration.

I also do not wish to imply that all salmonid managers are enamored with the hatchery response. Many, in fact, are quite opposed to this approach and feel that hatch-

eries are not the answer and actually contribute to the problem (Hilborn 1992). An active and healthy debate is ongoing in the Pacific Northwest between the pro- and anti-hatchery management groups (Goodman 1990; Martin et al. 1992), the outcome of which should be of interest to all conservationists.

The problems discussed here are by no means restricted to Pacific salmonids. A nearly identical situation occurs with the various species of endangered sea turtles, mentioned above. A litany of endangered vertebrates, plants, mollusks, insects, and other life forms throughout the world speaks volumes to the degraded environments that techno-arrogance has created. Such species can be maintained through halfway technology only for limited periods; money or available space will eventually run out, if genetic decline does not destroy the species first. Reasonable habitat appropriate to the species of concern must be the central goal of any recovery program, as technology can take us only partway, and often down the wrong path at that.

The ultimate outcome of our techno-arrogance is the increasingly intensive and essentially perpetual management of a multitude of species in a world unfit for their natural existence. Besides being prohibitively expensive, it represents techno-arrogance to the point of absurdity. We would do well to remember the centuries-old admonition of Francis Bacon: "Nature is only to be commanded by obeying her." We seldom have obeyed, or even considered, nature with respect to salmonid fishes, and our techno-arrogance has gotten us and salmonids into quite a mess; a large dose of humility is in order to help get us out.

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