CHAPTER 15

History and effects of hatchery salmon in the Pacific

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Abstract
There has been a long history of production of hatchery salmon along the Pacific coast - from California's first efforts in the 1870s using eggs from chinook and rainbow trout to the recent large-scale production hatcheries for pink salmon in Japan and the Russian Far East. The rationale for this production has also varied from replacement of fish lost in commercial ocean harvests to mitigation and restoration of salmon in areas where extensive habitat alteration has reduced salmonid viability and abundance. Over the years, we have become very successful in producing a certain type of product from salmon hatcheries, but until recently we seldom questioned the impacts the production and release of hatchery fish may have on freshwater and marine aquatic ecosystems and on the sustainability of sympatric wild salmon populations. This paper addresses the history of hatcheries around the Pacific Rim and considers potential negative implications of hatchery-produced salmon through discussions of biological impacts and biodiversity, ecological impacts and competitive displacement, fish and ecosystem health, and genetic impacts of hatchery fish as threats to wild populations of Pacific salmon.

Background
Aquaculture has a long and diverse history, dating from early Chinese fish culture around 2000 BC, pre-Columbian fishponds in Central America, Roman military carp ponds, moat-culture of fish in medieval castles, and extensive aquaculture systems developed by early Hawaiian kings (Nichols 1943; Hickling 1968; Bardach et al. 1972; Balon 1974). Marine fish farming is thought to have started around 1700 AD with the Indonesian culture of juvenile milkfish brought in on the high tide. In many considerations fish culture parallels the human culture of plants and agricultural animals, with early innovative activities dedicated to the appreciation and consumption of fish by select individuals within a greater society. Over the last century we have seen increased development of production hatcheries to supplement commercial fish harvest, ocean farming of millions of salmon, and supplementation of freshwater fish for recreational purposes. Today fish farming is a worldwide industry and aquaculture accounts for approximately 20% of the world's fish production. Since the end of World War II new technologies and mechanized opportunities for the culture and harvest of fishes have had broad economic and social effects, not the least of which is the impact of hatchery fish on wild populations.

North American commercial fish culture started in Ontario, Canada. Samuel Wilmot began selling Atlantic salmon (*Salmo salar*) eggs and young throughout New England following a decline in commercial harvest of North Atlantic salmon along the Eastern seaboard in the mid-1800s (Bottom 1997; Dr. M. Gross, personal communication). Pacific salmon and trout hatchery developments in western North America officially began in 1872, when the U.S. Fisheries Commission under the direction of Spenser Baird sent Livingston Stone to began taking fish eggs for culture at Baird Station on the McCloud River in Northern California (Stone 1896; Hedgpeth 1941). Driven by his need to address the decline in New England's commercial fishes and a limited supply of Atlantic salmon eggs for culture, Baird's directive to Stone was to obtain "large numbers of eggs of the best varieties of Salmonidae and other food fishes" on the western coast for culture and shipment to the eastern U.S. (Hobart 1995; Figure 15.1).

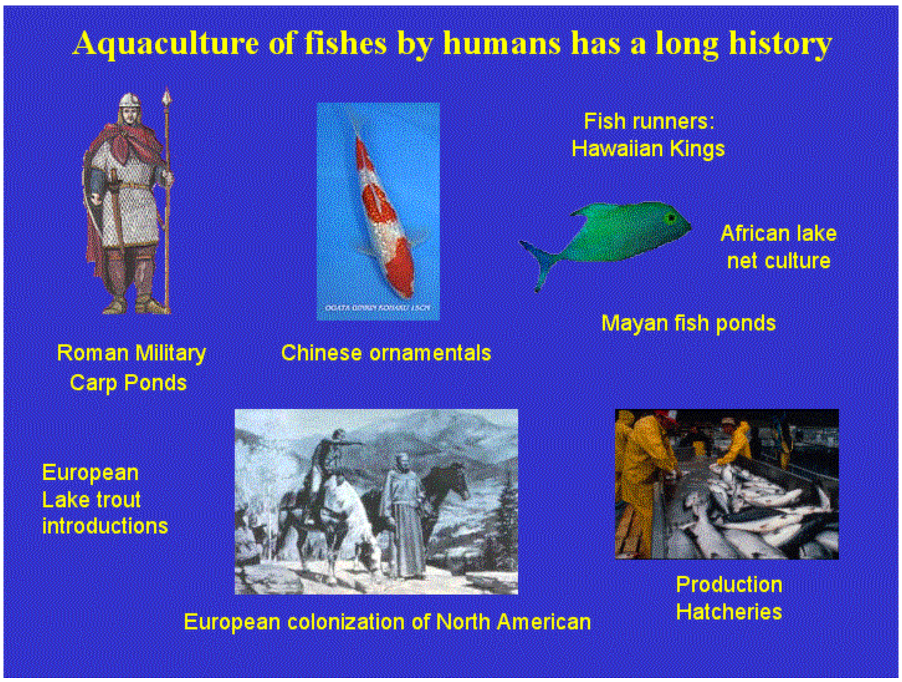

Figure 15.1. Aquaculture of fishes by humans.

Stone quickly developed production for trout (*Oncorhynchus mykiss*) and chinook salmon (*O. tshawytscha*) at Baird Station. Egg shipments from Baird Station were sent by rail and steamboat to many locations throughout the world for recreational and harvest introductions (Wales 1939; MacCrimmon 1971). Chinook from these early shipments did not survive in the rivers of the eastern U.S., but rainbow trout from Baird Station have survived in freshwater habitats on every continent around the word, with the notable exception of Antarctica (Busack and Gall 1980). Between 1900 and 1906, chinook salmon embryos shipped from Baird Station were sent to a hatchery on the Hakataramea River in New Zealand (Quinn et al. 1996). These chinook established self-sustaining runs within 10 years and remain the only known case of successful introduction of anadromous chinook from hatchery stocks outside of their natural range (McDowall 1990). The story of Stone's creation of the first Pacific salmon fish hatchery reads like a chronicle of the philosophy and dedication fish culturalists maintain today with strong roots in the personal bond that exists between human and animal and our need as humans to control or "steward" natural processes (see Lichatowich 1999).

Until recently, the artificial propagation of salmon and trout was considered a developing economy providing significant positive social gain throughout the world. Our dependence on hatcheries to supplement natural production, produce high quality flesh for human consumption, and provide strong economic advantage to producers was never questioned. Lately, however, much consideration has been given to the fact that hatcheries represent a primary human intervention in aquatic ecosystems, both freshwater and marine. Alarming declines in wild spawning Pacific salmon stocks throughout the Pacific Northwest and British Columbia and numerous federal listings for Pacific salmon under the U.S. Endangered Species Act (ESA) have focused a re-evaluation of hatchery production and the potential impacts hatchery fish may have on natural populations in both freshwater and marine habitats (Nehlsen et al. 1991, Meffe 1992, NRC 1996, Lichatowich 1999).

So many hatcheries, so little time

Over the last 130 years hatchery production across the Pacific Rim has incorporated all seven Pacific salmon species. Hatchery production has increased exponentially since the 1970s (Mahnken et al. 1998, Figure 15.2). Worldwide hatchery-produced salmon introductions into the Pacific Ocean have exceeded 6 billion fish each year for the last 10 years (ENRI 2001).

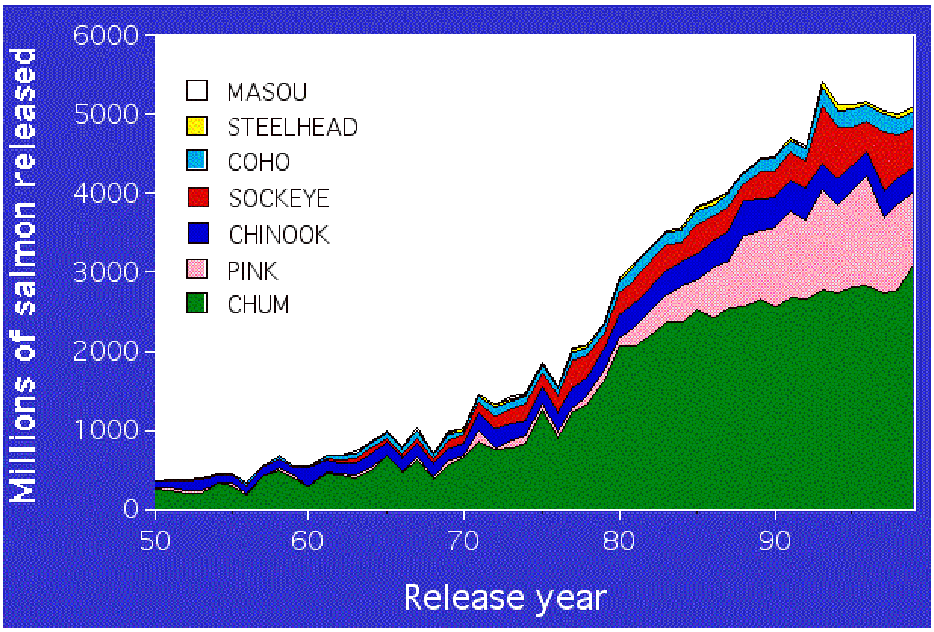

Figure 15.2. Total Pacific Rim hatchery production.

Production centers for hatchery-produced salmon include:

- The **Canadian** Salmonid Enhancement Program, started in 1977 with a goal of doubling the catch of Pacific salmon and steelhead in Canadian waters, accelerated annual stocking programs from 38 federal hatcheries and over 150 public involvement projects including spawning and rearing channels and numerous instream incubation boxes. Approximately 429 million salmon were released from British Columbia hatcheries in 1998 and up to 80% of the coho salmon caught in BC coastal waters were attributed to artificial enhancement (Noakes et al. 2000).
- **Japan** has one of the most extensive ocean-ranching programs in the world with over 300 hatcheries, mostly run by commercial fishermen cooperatives (Hiro 1998). In 1995, Japanese hatcheries released over two billion hatchery-produced salmon into the Pacific Ocean (NPAFC 1995). Hatchery salmon production in Japan has increased to over six billion releases a year in the last eight years (Nagata 2003).
- To counter declining salmon harvests in the mid-1970s **Alaska** started a hatchery salmon enhancement program. Sixteen hatcheries producing over 300 million juvenile salmon, primarily pink and chum, operated throughout the state in the late 1980s. Over 1.4 billion salmon were released from Alaskan hatcheries in 2000, and hatchery produced fish account for roughly 34% of the commercial harvest of Alaska salmon in eastern Pacific waters (McNair 2001, ENRI 2001).

- Hatchery production of salmon in **Oregon, Idaho, Washington** and **California** has a long history. The year 1877 marked the first construction of a chinook salmon hatchery in the Columbia River drainage in an effort to increase production in support of harvest for salmon cannery operations in that drainage. The construction of the Central Hatchery in 1909 near Bonneville in the lower Columbia River created a clearinghouse for the transfer of salmon eggs from and to hatcheries throughout the Pacific Northwest (Lichatowich 1999). By the late 1970s more than 300 million chinook and 200 million coho were released from hatcheries in the Pacific Northwest (Wahle and Smith 1979). In 1995 Washington released over 458 million hatchery produced salmon including chinook, coho, chum, sockeye and steelhead. Releases from Oregon in that same year equaled 80 million, California 67 million, and Idaho 17 million (NPAFC 1995, Mahnken et al. 1998).
- **South Korea** has a small hatchery program that began in 1913 and currently produces 8-16 million chum salmon each year (Seong 1998).
- Hatchery production in the **Russian** Far East started with hatcheries built by the Soviets in the 1920s on the Amur and Kamchatka Rivers. The Japanese also built a number of hatcheries in the 1920s in the northern part of Sakhalin Island and in the Kurile Islands. Following World War II hatchery production in this area increased under Russian control (Radchenko 1998). Currently the Russians operate 17 hatcheries on Sakhalin Island, four on the Amur River and one on a Kamchatka River tributary (ENRI 2001). In recent years, pink and chum salmon production for the Russian Far East has increased significantly with about 500-600 million fry released annually; approximately 52% pink and 48% chum (Khorevin 1998, Ruggerone et al. 2003a). The Russian Far East supports the largest pink salmon runs in the world, all hatchery produced, with an annual abundance of over 162 million adults in Pacific waters in odd-number years and 105 million adults in even years (Ruggerone et al. 2003b).

When tallying the numbers of hatchery-produced salmon released into the Pacific Ocean we cannot ignore the recent development of aquaculture raised Atlantic salmon (*Salmo salar*) in Pacific waters. It is estimated that 992,000 Atlantic salmon have escaped from aquaculture facilities along the eastern Pacific coast in the last 10 years (Nielsen et al. 2003). Based on the above gross estimates of recent hatchery production around the Pacific Rim in an average year over six billion artificially-produced salmon are released from rivers and streams surrounding the North Pacific Ocean.

Using hatcheries to succeed: weighing the advantages and disadvantages

Increased fish production capacity

From the very beginning of Pacific salmon hatchery production at Baird Station on the McCloud River, California, fish managers believed that hatcheries were the means to maintain a lucrative salmon harvest and natural production in the face of overfishing, development and habitat change (Lichatowich and McIntyre 1987, NRC 1996). Shifts in hatchery production varied among the different Pacific salmon species and from place to place based on local needs for harvest, expected escapement, and available resources in support of hatchery management. Increased knowledge of nutritional need, disease prevention, and early life history requirements led to improved survival and increased hatchery production in Canada and the U.S. in the 1950s and 1960s. Sharp declines in salmon stocks in the 1970s and 1980s, however, led to a change in focus for hatchery production, away from harvest management to supplementation and escapement.

Coho salmon (*O. kisutch*), for example, moved from a relatively undeveloped aquaculture species prior to World War II (less than 25 million fish annually) to one of the most successful hatchery produced species in the U.S. and Canada. In coastal Oregon alone a high of 198 million hatchery coho were released into the Pacific Ocean in 1981 (Mahnken et al. 1998). However, the decline in many wild coho salmon stocks throughout the Pacific Northwest and British Columbia has brought the role of hatcheries into question. Coastal coho from southern Oregon and northern California were listed as a threatened species under the

U.S. Endangered Species Act in 1997. In a highly controversial move, the National Marine Fisheries Service is currently re-evaluating their determination of Oregon coho as a threatened species to determine the role hatchery fish may play in their designation of coho salmon Evolutionarily Significant Units (ESUs) in this region. The likely future role of coho hatcheries in British Columbia depends more on whether they benefit wild stocks than on their contribution to a commercial harvest (Perry 1995).

Aquaculture has expanded at a rate of over 10% per year since 1984, primarily driven by a growing demand for fish products (FAO 2000). A large part of this growth is represented by the exponential growth of net-pen aquaculture of salmon. Atlantic salmon grown in marine net habitats for food production has not been without environmental controversy (Anderson 1997). High-density net pens concentrate large amounts of waste and pollutants from unused food, feces, urine and dead fish into the surrounding marine environment (Goldburg et al. 2001). Net-pen aquaculture has significantly increased demand for aquaculture feed derived from fish meal leading to developing concerns about the depletion of forage-fish resources to feed the net-pen culture industry and a net loss in actual fish protein (Pauly and Christensen 1995, Wackernagel and Rees 1995, Naylor et al. 2000; Chapter 14, Rees). Inadvertent escape of domesticated salmon from marine net pens has led to concerns about the spread of disease, interbreeding with wild fish, and invasive competition with wild stocks (Johnsen and Jensen 1994, Todd et al. 1997, Gross 1998, 2001; Kapuscinski and Brister 2001, Nielsen et al. 2003).

Sport fish restoration and enhancement

Hatcheries have played an important role throughout the world in sport fish restoration and enhancement. River, lake and reservoir sport fishing contributes important economic and cultural value throughout the distribution of Pacific salmon, including areas where they have been artificially introduced, such as the Great Lakes where coho salmon were first introduced in 1968 and chinook in 1969 (Lang et al. 1995). Many management activities by state and provincial fisheries authorities still reflect the sport fish priorities of their constituents, i.e. anglers.

As early as 1989, Miller et al. discussed the role of introductions for sport harvest on the extinction of North American fishes over the last 100 years. That study attributed numerous extinctions of native fishes to the introduction of hatchery fish associated with sport fish development. Extinction and decline of native fishes due to introductions of hatchery fish for recreational angling has been well documented (Behnke 1980, Bartley and Gall 1991, Courtenay and Moyle 1996, Jones et al. 1998).

Chinook are the least abundant salmonid in southeast Alaska due to limited freshwater spawning and rearing habitats (Mahnken et al. 1998). The number of hatcheries raising chinook salmon in southeast Alaska grew from one (1971) to 15 in the 1990s. Annual chinook production from southeast Alaskan hatcheries ranged from 25,000 to 112,000 in the period from 1985 to 1992 (Heard et al. 1995). Some of these facilities release hatchery chinook smolts into marine net-pens positioned at remote locations for 4-8 weeks in an effort to create adult returns in rivers some distance from the hatcheries for specific commercial or recreational marine fisheries (Josephson and Kelly 1993). However, variable results from the mariculture and ocean ranching of salmonids around the Pacific Rim suggest caution in supplemental introductions of Pacific salmon for marine harvest. Interactions among and within species in both freshwater and marine habitats, density-dependent survival, and changing marine conditions introduce significant uncertainty in ocean rearing programs at the local and greater ecosystem scales (Peterman 1991, Ruggerone et al. 2003b).

Management needs for endangered species

A new use for salmon hatcheries has developed over the last 50 years – the propagation of captive broodstocks for recovery of threatened or endangered Pacific salmon populations (Ryman and Utter 1987, Griffith et al. 1989, Johnson and Jensen 1991). The development of captive broodstock to protect and expand the natural genetic material in ESA listed endangered species of salmon has been implemented for Snake River sockeye (Lichatowich and McIntyer 1987, Flagg et al. 1995) and Sacramento River winter-run chinook (Hedrick et al. 1995). These aquaculture activities are run with the intent of raising progeny to augment the natural population, either for direct release into their natural habitats or as a safeguard against total collapse.

Unintentional changes in genetics and adaptation during captive breeding can compromise the success of reintroduction of offspring (Lynch and O'Hely 2001). Genetic concerns over low population size, increased inbreeding and loss of genetic variation resulting in lower long-term fitness are now part of recovery plans for endangered species, including salmon (Ryman and Laikre 1991, Waples and Do 1994, Wang et al. 2002 a, b). Captive populations destined for reintroduction need to be managed to minimize genetic adaptation to captivity (Gilligan and Frankham 2003). Simulation studies by Waples and Do (1994) indicated that the single most important population genetic characteristic in efforts to sustain or increase abundance of ESA species with captive broodstock programs was whether the natural population remained large following termination of introductions. Evidence from this study suggested that the application of fish culture to mitigate fish declines is not sufficient in isolation from fixing the underlying causes for the decline in the first place; i.e., over-harvest, loss of habitat, and population fragmentation (Nehlsen et al. 1991, Meffe 1992).

There are significant concerns and risks associated with conservation breeding programs and only 11% of all serious attempts in vertebrates have led to recovery (Ebenhard 1995). Attempts to use artificial propagation to supplement declining populations of Pacific salmon have yielded variable results (Miller 1990, Cuenco et al. 1993, Flagg et al. 1995). The arguments around this issue seem to migrate between the need to fix the habitat problem that caused the population decline in the first place and a "quick-start" in natural production from the captive program before all is lost (Kapuscinski and Jacobson 1987, Waples 1991, Hard et al. 1992, Kincaid 1993, Waples et al. 1993).

It is clear that there are inescapable risks, trade-offs and uncertainties associated with endangered species management strategies involving artificial propagation (Busack and Currens 1995), and we have been repeatedly warned against application of the "Noah's Ark Paradigm" for endangered species in the wildlife literature (Wiese and Hutchins 1994). A clear analysis of net benefits of such programs (to society, the salmon, and their shared ecosystems) is needed with an accounting of the actual cost of these programs in dollars balanced by potential benefits (Waples 1999).

Another gap in our understanding of conservation hatcheries for declining species is basic research, both in the laboratory and in the field. While some critical genetic issues are well defined theoretically, actual empirical studies of population decline are few and far between. Even our understanding of the theoretical basis for conservation breeding remains incomplete. For example, the long-term cryopreservation of gametes, or gene banking, is in its infancy and still very experimental (Ebenhard 1995), but may serve as a valuable tool for conservation breeding in Pacific salmon. Some idea of the minimum number of effective spawners in declining populations (Waples and Do 1994), and a better understanding of reproductive success and gene flow in small populations (Charlesworth 1997, Nielsen 1999) are needed before intervention with conservation hatchery programs becomes necessary or efficient.

Genetic manipulation

Two new applications of genetic technology are available for fish and fisheries enhancement through hatchery operations: chromosome manipulation to produce sterile fish populations lacking the ability to interbreed with wild stocks (Thorgaard 1992, Ferguson 1995) and the production of transgenic fish (MacLean and Penman 1990, Du et al. 1992, Rodemeyer 2003). These powerful applications of DNA-based technologies can be used to monitor and/or reduce the effects of hatchery releases on wild populations, enhance traits selected for their contribution to superior broodstock, or to confer adaptive advantage in the culture of fish in novel environments.

Sterilization of fish through chromosome manipulation involves the application of temperature, pressure or chemical shocks to fertilized eggs to add extra chromosomes to each egg. The effectiveness of this approach is highly dependent on the species, methods used, and the quality of the original gametes. The results are frequently a matrix of chromosomal states, both within and among individual fish, and sterilization success rates can vary greatly (10-95%; Maclean and Laight 2000). Kapuscinski (2001) suggested manual pre-screening of all putative tetraploid fish before release into natural environments. However, even with certain sterilization, introduced sterile fish still carry physiological and behavioral characteristics that may introduce competition and interfere with reproductive success and spawning in wild sympatric populations (Kitchell and Hewitt 1987, Cotter et al. 2000).

Growth-enhanced transgenic Atlantic salmon are genetically engineered to contain a DNA construct of the promoter region for cold tolerance (sometimes called an "antifreeze" gene) from the ocean pout (*Macrozoares americanus*). This DNA promoter region regulates the activity of the genes linked to it, keeping them active in cold water habitats, a requirement for successful survival for ocean pout in arctic waters. Unmodified Atlantic salmon produce little growth hormone in cold temperatures, but by putting the salmon's hormone gene under the control of the ocean pout's promoter region these salmon produce growth hormone all year long. These fish convert food more efficiently and reach market size in half the normal time (Fletcher et al. 1999, Cook et al. 2000).

As was the case with Atlantic salmon in Pacific waters, escapes of transgenic fish into wild populations holds the potential for considerable unintended impacts. Accelerated age at sexual maturity has been shown to offer a major advantage on the potential net fitness of transgenic fish in the wild (Rodriguez-Clark and Rodriguez 2001). Transgenic coho salmon and rainbow trout containing novel growth hormone genes have been shown to reach sexual maturity earlier in life than their wild counterparts leading to potential spread of transgenes through wild populations subjected to interbreeding (Devlin et al. 1994, 2001). The so-called "Trojan Gene" hypothesis suggests that even with reduced adult viability in transgenic fish, enhanced mating success could result in a rapid decline of interbreeding wild populations (Muir and Howard 1999; Hedrick 2001).

Hatchery-wild interactions

Inevitably, hatchery salmon released into natural environments – both freshwater and marine - will encounter and interact with wild fish. The implications of these interactions have been reviewed extensively in the literature (Fausch 1988, Campton 1995, White et al. 1995, Waples 1999). Most of these concerns evolve from two concepts:

1) Domestication of hatchery progeny; i.e. hatchery fish with acquired physiological, genetic and behavioral traits that are inappropriate for life in natural habitats (Woodward and Strange 1987, Olla et al. 1991, Ruzzante 1994, Berejikian 1995, Hard et al. 2000, Fleming et al. 2002, Marchetti and Nevitt 2003);
2) Successful hatchery fish; i.e. those that survive in natural habitats, compete with wild fish for limited resources thereby reducing fitness factors in wild stocks (Nickelson et al. 1986, Reisenbichler and McIntyre 1986, Jonsson 1997, Unwin and Glova 1997, Reisenbichler and Rubin 1999, Fleming et al. 2000, Chilcote 2003).

It seems domestication hinders survival of hatchery fish in natural habitats, but in many cases where these fish do survive they have been shown to have detrimental effects on sympatric wild stocks. This conundrum stems from poorly defined culture objectives, products and processes that remain greatly oversimplified, and significant confusion in the public on the roles of fish culture and stocking in resource management (White et al. 1995).

Most hatchery-wild salmon interactions have been studied in freshwater habitats, but several issues of carrying capacity in the ocean have been published (Peterman 1984, Heard 1998, Hobday and Boehlert 2001, Mueter et al. 2002, Ruggerone et al. 2003b). Marine community structure in the North Pacific Ocean has undergone significant change due to well-documented climate regime shifts (Beamish and Bouillion 1993, Mantua et al. 1997, Anderson and Piatt 1999, Figure 15.3). These shifts are thought to change the prey base available to Pacific salmon in the North Pacific Ocean and can have significant impacts on productivity (Pearcy 1992 and 1996, Pearcy et al. 1999).

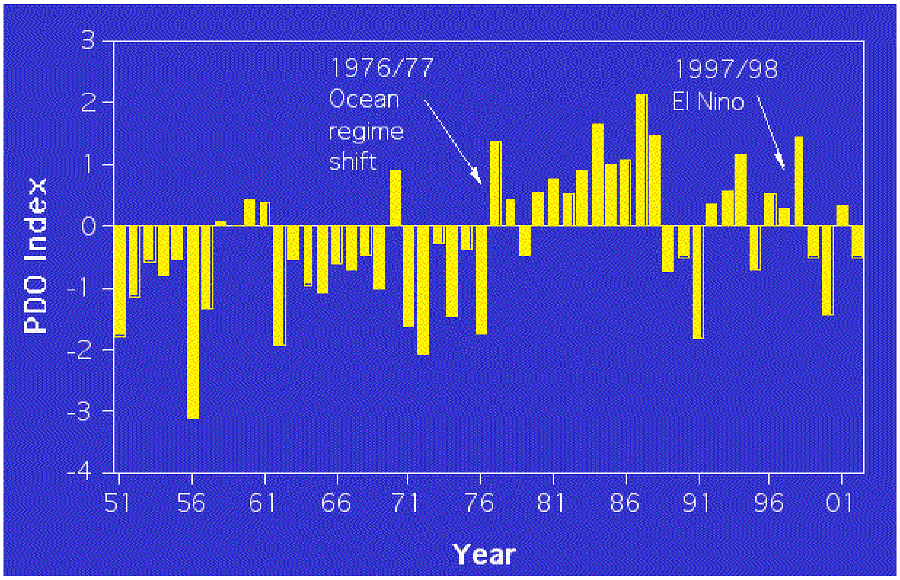

Figure 15.3. Pacific Decadal Oscillation (PDO) and species abundance shift.

Over the last three decades the proportion of hatchery fish, especially pink salmon from Asian hatcheries, which feed in the North Pacific Ocean, has increased significantly (Figure 15.4).

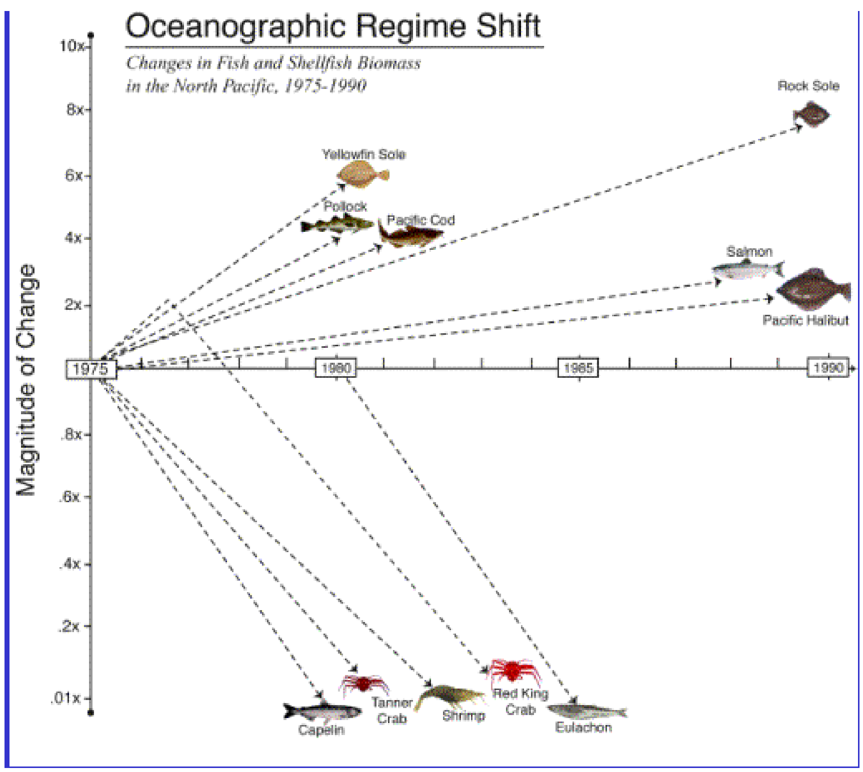

Figure 15.4. Oceanographic regime shifts impact marine populations.

The impacts of hatchery production on ocean carrying capacity for Pacific salmon are not limited to mortality, but also include growth effects. The recent publication by Ruggerone et al. (2003b) suggested that the overlap in ocean distribution of hatchery pink salmon from Asia and wild Bering Sea sockeye salmon from Alaska (Figure 15.5) has had a significant impact on sockeye salmon growth during their 2nd and 3rd years at sea (Figure 15.6). Based on yearly average landing prices for Alaskan sockeye, the interaction between Asian hatchery pink salmon and wild sockeye would have equaled a loss of over $310 million to the Alaskan commercial salmon industry from 1977-1997 (Ruggerone et al. 2003 b).

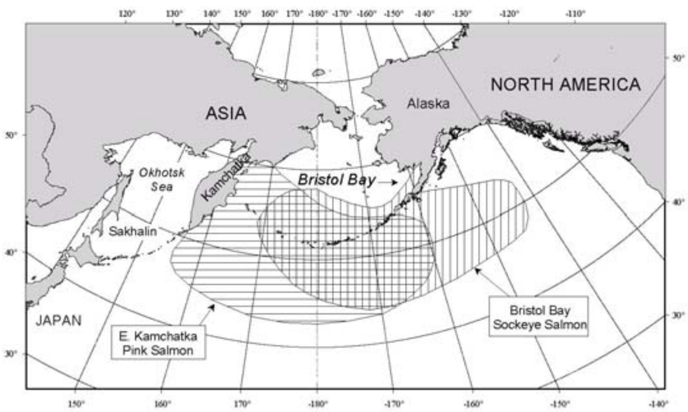

Figure 15.5. Overlap of Asian pink & Bristol Bay sockey salmon: location and diet.

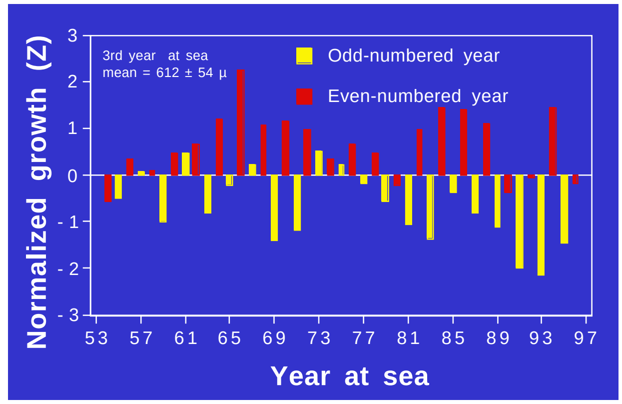

Figure 15.6. Sockeye growth reduced during odd years at sea (2nd & 3rd yrs).

Three implications can be drawn from data suggesting competition in ocean habitats between hatchery and wild Pacific salmon. It is most important that we realize that hatchery production may have unintended impacts on distant wild stocks. We currently have no clear idea where different salmon stocks go in the ocean and what habitat features are critical for their survival. With ocean competition, hatchery production to supplement and enhance declining salmon populations may have unintended impacts on ESA protected salmon species. The potential for ocean carrying capacity and competition between hatchery and wild stock also implies that we need to include the ocean in our dialogue for "ecosystem management" in salmonids.

Hatcheries in the future

Currently there is great discussion within the fisheries management community on the role of hatcheries. Proposals for "rehabilitation", "mitigation", "augmentation" or "supplementation" hatcheries and "adaptive management" in hatchery operations are often discussed as alternatives to production hatcheries. These alternative hatcheries are built around various plans by which resource managers can mitigate hatchery and wild fish interactions and reduce the genetic and ecological impacts of hatchery fish (Kapuscinski 1997). The importance of maintaining genetic and ecological diversity in salmon stocks is the goal of most new hatchery plans, but our ability to meet this goal and the actual costs involved in such production are often not discussed. It is difficult to estimate the actual on-the-ground costs needed to monitor genetic and ecological integrity of wild stocks sympatric with hatchery fish in freshwater, much less marine habitats. But that is exactly what is needed in our dialogue over salmon hatchery production in the future.

We need a clear evaluation of all operational costs, the monetary value of harvested fish (both commercial and sport), and a full accounting in dollars of the social and ecological costs and benefits of hatchery production and monitoring programs (White et al. 1995). If we are really ready to accept "adaptive management" in hatchery production, we should clearly document the social and economic costs involved in shutting a hatchery down, either intermittently or permanently, if the scale of production exceeds reasonable, predetermined ecological or genetic goals for no-impact to wild stocks. The costs of such shutdowns must be built into our initial estimate for the costs of production.

Is sustainability of salmon at the local level really possible through hatchery stocks (NRC 1996, Lichatowich 1999)? Many people think the days of wild salmon are over. The exponential increase in human population and their subsequent demand for resources may be incompatible with wild fish (Chapter 14, Rees). But that really depends on how you define "wild". Are there really any wild salmon left that can respond and adapt to a diversity of natural habitats at a local level outside of Alaska and the Russian Far East? How do we go about defining future relationships we may develop with natural conditions that affect salmon without a clear definition of what we mean by "wild"?

Lichatowich (1999) suggested working toward "building a new salmon culture" and rethinking society's 19th century focus on "conquest over nature" where we turned free flowing rivers into dams and reservoirs and wild salmon into hatchery fish. According to Lichatowich (1999), a new relationship between man and salmon is required for future interactions, "one that is in harmony with the ecosystems". As local communities take interest in urban rivers and begin to value salmon in these ecosystems, grassroots efforts at restoration become part of a new social agenda. Are salmon populations locked into limited urban river ecosystems truly "wild" even if they are self-sustaining? Does that really matter? It all depends on how you define "wild." Social and economic trends can lead society to an acceptance of the consequences of our industrial economy with hatcheries and dams, and move forward with a focus on our obligation to coexist with salmon for future generations (Nielsen and Regier 2003, Chapter 14, Rees). But that relationship, what we as a society really need from salmon, remains to be defined.

That does not mean that hatcheries will not play a role into the future. We have interfered with the salmon's struggle for existence and put up many obstacles to their recovery. The skills of husbandry and propagation learned in the development of today's salmon hatcheries will be needed for many years into the future to support recovery and sustainability of salmon stocks throughout the world. In many parts of the world the difference between hatchery and wild salmon is less contentious than it is in the Pacific Northwest. But the application of our skills as culturists of salmon needs to be focused toward reasonable goals that fit the current social and economic framework for persistence and sustainability of salmon (however we define them) with open dialogue on all the latent and potential problems built into hatchery production (Waples 1999).

It is important to stipulate, however, that hatcheries cannot fix or mitigate the underlying problems of habitat fragmentation and destruction, overfishing, and ocean carrying capacity faced by salmon populations throughout the Pacific Rim (NRC 1996, Lichatowich 1999, Jackson et al. 2001). The National Research Council focused this issue clearly in 1996 by stating "reliance on hatchery production does not change the basic human behaviours leading to fluctuations in salmon abundance" (Anon., 1996). The myth of an agrarian utopia based on hatchery production and the transfer of fish stocks from stream to stream, or ocean to ocean is not working and has lost favour in the public eye.

Enthusiasm for new technologies dedicated to fish and fisheries has become increasingly controversial, especially considering pen-reared salmon and genetically modified fishes. Recent scientific discussions on salmon and their ecosystems have focused resource management away from the "control-of-nature" paradigm to a search for accommodation between nature and human endeavours (Bottom 1997, Nielsen and Regier 2003). Changes in human behaviour in support of a new philosophy of resource management focus our responsibilities for products from the past and forge a new path of integration between culture and salmon. As these trends reach maturation on a global scale they will educate and encourage humans in acts of coexistence with salmon and their ecosystems for generations to come.

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