The Need for International Cooperation to Reduce Competition Among Salmon for a Common Pool of Prey Resources in the North Pacific Ocean

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In recent decades, many populations of Pacific salmon (*Oncorhynchus* spp.) have shown long-term decreases in age-specific body size, which reduce the economic value of catches and fecundity of spawners. Several hypotheses have been proposed to explain these trends, including deteriorating environmental conditions, size-selective fishing, and density-dependent growth associated with the large increases in pink (*O. gorbuscha*), chum (*O. keta*), and sockeye salmon (*O. nerka*) abundances in the North Pacific Ocean (Ricker 1981; Peterman 1984a; Ishida et al. 1993; Ruggerone et al. 2003). The density-dependent hypothesis, which is based on competition among salmon for limited food, has the greatest support. That evidence is based on overlapping geographic distributions of pink, chum, and sockeye salmon populations, their stomach contents, and analyses of scale-growth patterns as well as abundances. Some sockeye populations have also suffered reduced productivity (adult recruits produced per spawner) in addition to reduced growth when present with high abundances of competitors, particularly pink salmon populations that vary dramatically in abundance between even and odd years (Ruggerone et al. 2003).

This evidence of density-dependent growth and survival rate among salmon in the North Pacific Ocean raises a concern about the detrimental effects of hatchery-released Pacific salmon. Hatchery-released pink and chum salmon constitute a substantial and growing portion of total wild plus enhanced salmon in the North Pacific Ocean, and plans exist to expand hatchery releases in the future, especially in Alaska and Russia (Ruggerone et al. 2010). Such plans are worrisome, given the magnitude of density-dependent processes on the high seas that reduce body size, and in some cases productivity, of both hatchery-origin and wild salmon. Smaller increments in net benefits (i.e., total benefits minus costs) as abundance increases mean that additional social and economic net benefits from incremental investments in hatcheries may decrease with increasing hatchery releases of salmon (Fig. 1A; Peterman 1991). However, if density-dependence in mortality rates is severe enough, further increasing hatchery abundances could potentially also decrease the total benefits derived from all production of hatchery and wild salmon (Fig. 1B; Peterman 1991).

Therefore, it is important that salmon-producing nations begin serious discussions on how to deal with this problem caused by competition for prey of salmon in the North Pacific. This situation of potential overuse of a limited

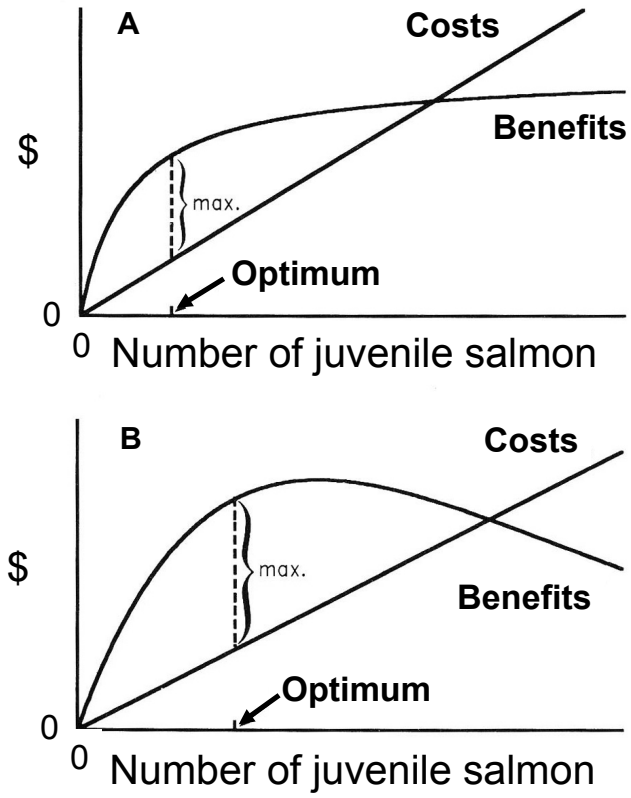

Fig. 1. Two possible situations relating total benefits (total dollar value of biomass yield from harvesting Pacific salmon populations) and costs of generating those benefits to the number of juveniles produced (from wild and artificially enhanced populations, including those from hatcheries). Adapted from Peterman (1991). A: Additional net benefits from each increment in hatchery investments may decrease with increasing salmon hatchery releases of juvenile salmon. B: If density-dependent mortality is severe, further increasing hatchery production could decrease benefits from all production of hatchery and wild salmon.

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food resource is an example of the classic "common-pool resource" issue in economics where shared resources, such as pastures and water, benefit multiple users, each user reduces the available resource, and no one is excluded from using the resource (Ostrom et al. 1994). However, in many cases, such users may have little immediate indication of the effect of their use of the resource on reducing the value of the resource to other users. If users do not cooperate to restrict their use of the common-pool resource, a frequent outcome is depletion of the resource to the point where all users' benefits are drastically reduced (e.g., overgrazed public pastures), often called the "Tragedy of the Commons" (Hardin 1968; Ostrom et al. 1999).

We therefore recommend that discussions about controlling competition among salmon be initiated by the North Pacific Anadromous Fish Commission (NPAFC) after appropriate amendments are made to its mandate. The objective for such discussions would be to identify and implement collective actions to prevent further increases in competition among salmon from different nations or even reduce it (Peterman 1984b; Heard 1998; Holt et al. 2008). Action on this problem of multi-national grazing of salmon food is long overdue. In an analogous situation over 20 years ago, the NPAFC reduced exploitation of salmon in the North Pacific Ocean by banning directed fishing on salmon in waters beyond territorial limits. However, there are currently no analogous regulations to deal with the next lower trophic level, i.e., to restrict the "harvest" of a common pool of North Pacific prey by salmon populations that come from different nations. Many precedents exist worldwide for creating appropriate incentives to sustainably use such limited common-pool resources. One of the more successful agreements has been the North Pacific Fur Seal Treaty of 1911 among Russia and the United States of America (on whose islands fur seals breed) and Japan plus Canada (which harvested fur seals in international waters at the time). That Treaty eliminated harvesting of fur seals on the high seas and restricted it to the breeding grounds. It also created incentives for long-term cooperation through sharing of benefits from harvested pelts among all four nations and making side-payments from the U.S.A. to Japan and Canada (represented by Britain) to change the incentive structure (Barrett 2003).

Over 900 international environmental treaties have come into force since 1970 (Anonymous 2011), so there is considerable experience in developing such accords and learning which processes work best for coming to agreement and generating effective implementation. Some of the lessons are to have: (1) clearly stated goals and objectives, as well as measurable indicators to assess progress toward meeting them, (2) flexibility to adapt to changing situations, (3) formal processes for taking new information into account, (4) robust implementation and enforcement, and (5) ongoing updates on the effectiveness of the agreement (Anonymous 2011). Multi-national discussions to develop an agreement should be based on principles such as (1) respecting sovereignty issues, (2) ensuring fairness and equity among all parties, (3) aiming to increase the benefits of all parties above what they would obtain if they did not cooperate in an agreement, (4) being open to considering "side payments" to achieve such added benefits (FAO 2002), and (5) developing an action plan over time. Key features of such sustainable-use systems have been identified from extensive experience (Ostrom 2009).

Although some may argue that in the case of Pacific salmon the incremental benefits are too small to justify acting now to limit the number of hatchery salmon, the history of fisheries management has numerous examples of cases where meaningful action was delayed until situations were in a crisis. In such cases, it has been much more difficult to resolve long-standing historical access issues and still meet long-term management objectives. Furthermore, if the productivity of the North Pacific Ocean should return to lower levels like those seen prior to the mid-1970s, and/or if future climatic changes lead to less suitable habitat for Pacific salmon, then pressures will be intense to increase hatchery releases, rather than reduce them to be more commensurate with reduced habitat quality. We therefore urge initiation of discussions now among the nations of the North Pacific Rim that produce wild and artificially-enhanced salmon (through hatcheries, lake enrichment, spawning channels, and other methods of increasing survival rate at early life stages).

The NPAFC is uniquely positioned to become a leader in resolving this environmental issue. For decades, it has performed a key role in management of Pacific salmon around the North Pacific Rim through data collection, monitoring, and enforcement. The good will and international collaborations among the member nations has already created a solid foundation for moving into this new realm of cooperation. Thus, the NPAFC has an excellent opportunity to begin discussions, which will not be easy, but which should ultimately lead to benefits for all member nations over and above the current situation.

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