MARINE CARRYING CAPACITY

The present hatchery system for Pacific salmon was developed to produce increasingly higher numbers of fish in a constant oceanic ecosystem, believed to be near limitless in its capacity to accommodate hatchery salmon. Until recently, these oceanic systems were believed to be stable, internally regulated, and to behave in a deterministic manner. The more current view is of an open system in near constant flux - a system without long-term stability, and one that is often under the influence of stochastic factors, many originating outside the ecosystem itself. The modern view of the ecosystem is one characterized by ecological uncertainty (Mahnken et al. 1998).

Based on the assumption that ocean carrying capacity was unlimited, or had not yet been reached, the goal of increasing the size of a fishery was simply achieved by building more hatcheries and releasing more fish. As a result, for more than 20 years there has been massive growth in salmon hatchery releases in the Pacific Northwest (Mahnken et al. 1998), with more smolts entering the ocean from the Pacific Northwest hatchery system than at any time in the past. An example of this general increases in hatchery output is the Columbia River Basin. The Northwest Power Planning Council (NWPPC 1986) estimated that annual natural abundance before 1850 was 264 million smolts. Since the late 1980s, public hatcheries in the Columbia River Basin have reared between 200 - 300 million juveniles annually for release (Chapman 1986, Schiewe et al. 1989). In 1992, for example, based on releases of nearly 203 million hatchery fish and an estimated 145 million wild fish, almost 350 million smolts were in the Basin that year, or 32 % above the historic high of 1850. Such vast numbers of out-migrants clearly place a heavy demand on the food production capabilities of any ecosystem, whether in the natal streams and rivers, the coastal estuaries, or in the ocean itself. Furthermore, in the intense competition for food, which must occur, the dramatic increases in numbers of hatchery fish have obviously affected the chances for survival of the smaller numbers of native stocks.

Studies on abundance of stocks in widely separate geographic areas over time have indicated oceanic conditions are primarily responsible for changes in annual returns of adult salmon (Cooper and Johnson 1992, Beamish and Bouillon 1993, Lichatowich 1993, Olsen and Richards 1994). The way in which these physical, chemical, and biological processes conditions can impact fish populations and production trends are reasonably well known.

Based on analysis of climatic trends and the productivity of salmon fisheries in the North Pacific, Beamish and Bouillon (1993) noted that the strategy of releasing large numbers of artificially reared smolts during a period of decreasing marine survival was not appropriate. Concerns over the limits of ocean carrying capacity, and other factors, are conspiring to force a re evaluation of industrial hatchery production of North Pacific salmonids (Mahnken et al. 1998). Concerns include (i) high harvest rates of wild fish in fisheries targeted on the more abundant hatchery stocks, (ii) over-production of hatchery chum salmon in Japan, and both pink and chum salmon in Alaska, (iii) declining fish size, and (iv) altered return timing and age at maturity, and (v) widely varying ocean survivals. Concern for declining size and increasing age at maturity observed in North Pacific stocks of five salmon species suggests that large-scale hatchery production may be resulting in density-dependent growth reduction (Kaeriyama and Urawa 1992, Rogers and Ruggerone 1993, Bigler and Helle 1994).

Although ocean harvest rates are generally scaled back when the abundance or productivity of wild stocks is low and regime shifts become evident, hatchery production is not. Rather, the tendency in the 1970-90 period has been to increase hatchery production in the Pacific Northwest as ocean productivity decreased (Mahnken et al, 1998). Given that the carrying capacity of the ocean has a primary impact on salmon returns, it is eminently sensible that hatchery releases should be reduced during periods of poor ocean survival to protect wild fish. Scientific ignorance of oceanic regime shifts, and their impact on the variability of fish abundance and survival, has acted against wild fish populations through poorly informed or ill-considered hatchery production and harvest policies.

Regime shifts, or major changes in ocean productivity, occur only infrequently but are becoming increasingly predictable. By interpreting physical, chemical, and biological signals of changing oceanic productivity, certain impacts can now be anticipated. Fishery managers now know they should decrease harvest rates during periods of lower productivity, that is, they should scale fisheries to the natural spatial and temporal patterns of abundance of wild fish populations. Likewise, hatchery production should be curtailed during periods of increased density dependant mortality to protect wild stocks and to reduce monetary waste. Modern hatcheries should program their production to accommodate the natural spatial and temporal patterns of abundance in wild fish populations.

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