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Measuring the net biological impact of fisheries enhancement: pink salmon hatcheries can increase yield, but with apparent costs to wild populations

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ABSTRACT

Hatchery production of juvenile fish for release into the wild has been practiced for well over a century in an effort to increase the number of salmon available to harvest. In this study, we evaluate the net impact of the largest such program in North America, the hatchery program for pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound (PWS), Alaska. At the same time the hatchery program was increasing in output, there was a major change in productivity in the North Pacific so that throughout Alaska pink salmon increased dramatically in abundance between the 1970s and the 2000s. Using other regions of Alaska as reference sites, we estimate that the PWS hatchery program has increased the total catch by an average of 17 million fish, of which 8 million have been allocated to pay hatchery operating expenses. We estimate that the maximum sustainable yield (MSY) of wild spawning fish in PWS has increased slightly (28%), while in regions of Alaska without pink salmon hatchery programs the MSY has tripled. Our results support the use of a precautionary approach to future large-scale stock enhancement efforts.

CONCLUSION

There is accumulating evidence that pink salmon have far- reaching impacts on ocean ecosystems. Patterns of alternating abundance in species that share ocean habitat with pink salmon strongly suggest impacts of competition (Ruggerone and Nielsen 2004). Such patterns have been observed in other salmon species, including comparatively valuable Bristol Bay sockeye salmon (*Oncorhynchus nerka*) (Ruggerone et al. 2003) and threatened Puget Sound Chinook salmon populations (Ruggerone and Goetz 2004). Recent analysis of long-term data on seabird populations in the North Pacific demonstrated similar patterns in reproductive success, implying that pink salmon also compete directly or indirectly with higher trophic levels (Springer and van Vliet 2014). There is also growing concern that large hatchery releases from around the North Pacific may be resulting in density-dependent declines in growth and survival for all salmon species as oceanic carrying capacity is approached (Cooney and Brodeur 1998; Kaeriyama et al. 2009). When considered in this broader ecosystem context, the analysis of stock enhancement becomes much more complex. With an increasing focus on ecosystem-based management of the oceans, the broader impacts of future enhancement efforts are likely to be heavily scrutinized (Pikitch et al. 2004; Samhouri et al. 2014). Ultimately, if these efforts are to be compatible with ecosystem-based principles, it will be critical to understand the biological capacity for enhancement and the potential unintended consequences of large-scale hatchery releases.