Effects of Hatchery-Origin Pink Salmon On Ecosystems and Other Pacific Salmon:

An Annotated Bibliography

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Agler, B.A., G.T. Ruggerone, L.I. Wilson, and F.J. Mueter. 2013. Historical growth of Bristol Bay Agler, B.A., G.T. Ruggerone, L.I. Wilson, and F.J. Mueter. 2013. Historical growth of Bristol Bay and Yukon River, Alaska chum salmon (*Oncorhynchus keta*) in relation to climate and inter-and intraspecific competition. Deep-Sea Res II 94, 165-177.

This study of Bristol Bay and Yukon River adult chum salmon scales from 1965 through 2006 showed that increased growth was associated with higher regional ocean temperatures but slower growth associated with wind mixing and ice cover. Lower third-year growth was associated with high abundance of Asian chum and warmer sea surface temperatures (SST) in the Gulf of Alaska. High abundances of Russian pink salmon was also associated with lower third-year growth but the effects were smaller than those shown for high abundance of Asian chum and warmer GOA SST.

Amoroso, R. O., M. D. Tillotson, and R. Hilborn. 2017. Measuring the net biological impact of fisheries enhancement: Pink Salmon hatcheries can increase yield, but with apparent costs to wild populations. Canadian Journal of Fisheries and Aquatic Sciences 74:1233–1242.

This research estimated the net effect of the largest hatchery program in North America, the Prince William Sound pink salmon. Using other Alaska regions as reference sites (Kodiak, SE Alaska, and southern Alaska Peninsula), the authors used catch data from before establishment of hatchery programs (1960-1976) and after (1988-2011). The reference sites all had smaller programs than PWS (with no southern Alaska Peninsula pink hatchery program). Post late1970s climate regime shift, all regions had higher catches, with PWS having the greatest increase. Changes in wild salmon abundance were estimated for each region. Hatchery releases did not appear to decrease year-to-year variability in catches. No net positive effects (that is, taking into account the cost of the hatchery programs and reduced wild abundance) from the hatchery programs were detected for in Kodiak or SEAK. In PWS, the net effect was an increase in catch by 28%, lower than that estimated by other studies. This does not take into account other negative effects (e.g., other ecosystem effects, smaller size of returning fish), so any increases in hatchery programs should be done with a full accounting of risks and benefits.

Armstrong, J.L., Myers, K.W., Beauchamp, D.A., Davis, N.D., Walker, R.V., Boldt, J.L., Piccolo, J.J., Haldorson, L.J. and J.H. Moss. 2008. Interannual and spatial feeding patterns of hatchery and wild juvenile pink salmon in the Gulf of Alaska in years of low and high survival. Transactions of the American Fisheries Society, 137(5), pp.1299-1316.

This research compared hatchery and wild pinks in PWS and the northern coastal Gulf of Alaska (CGOA) with regard to their summer diets and feeding patterns (e.g., prey composition) in 1999-2004 (encompassing both high- and low-survival years). Hatchery and wild pink salmon had similar diets both during their residence in PWS and after they initially migrate to the CGOA. This lack in difference means that PWS hatchery pink can compete with wild fish for the available prey. Also, it appears that faster-growing fish can migrate from PWS earlier in summer and take advantage of better feeding opportunities in the CGOA.

Atcheson, M. E., K. W. Myers, N. D. Davis, and N. J. Mantua. 2012. (abs) Potential trophodynamic and environmental drivers of steelhead (*Oncorhynchus mykiss*) productivity in the North Pacific Ocean. Fisheries Oceanography 21:321–335.

“Information on prey availability, diets, and trophic levels of fish predators and their prey provides a link between physical and biological changes in the ecosystem and subsequent productivity (growth and survival) of fish populations. In this study two long- term data sets on summer diets of steelhead (*Oncorhynchus mykiss*) in international waters of the central North Pacific Ocean (CNP; 1991–2009) and Gulf of Alaska (GOA; 1993–2002) were evaluated to identify potential drivers of steelhead productivity in the North Pacific. Stable isotopes of steelhead muscle tissue were assessed to corroborate the results of stomach content analysis. We found the composition of steelhead diets varied by ocean age group, region, and year. In both the GOA and CNP, gonatid squid (*Berryteuthis anonychus*) were the most influential component of steelhead diets, leading to higher prey energy densities and stomach fullness. Stomach contents during an exceptionally warm year in the GOA and CNP (1997) were characterized by high diversity of prey with low energy density, few squid, and a large amount of potentially toxic debris (e.g., plastic). Indicators of good diets (high proportions of squid and high prey energy density) were negatively correlated with abundance of wild populations of eastern Kamchatka pink salmon (*O. gorbuscha*) in the CNP. In conclusion, interannual variations in climate, abundance of squid, and density- dependent interactions with highly- abundant stocks of pink salmon were identified as potential key drivers of steelhead productivity in these ecosystems. Additional research in genetic stock identification is needed to link these potential drivers of productivity to individual populations.”

Azumaya, T., and Y. Ishida. 2000. Density interactions between Pink Salmon (*Oncorhynchus gorbuscha*) and Chum Salmon (*O. keta*) and their possible effects on distribution and growth in the North Pacific Ocean and Bering Sea. North Pacific Anadromous Fish Commission Bulletin 2:165–174.

Data from Japanese salmon research vessels from 1972-1998 were analyzed to evaluate the long-term spatial and temporal distribution of chum and pink salmon. Chum salmon distribution varied out-of-phase with the odd-even differences in pink salmon abundance (pinks having higher abundance in odd years). Chum salmon growth was not directly affected by pink salmon abundance but was affected by chum salmon abundance (higher abundance = slower growth), indicating that intra-species competition was more important than inter-species competition. Dietary (stomach content) research would shed more light onto the importance of inter-specific competition.

Batten, S. D., G. T. Ruggerone, and I. Ortiz. In press. Pink Salmon induce a trophic cascade in plankton populations in the southern Bering Sea and around the Aleutian Islands. Fisheries Oceanography. DOI: 10.1111/fog.12276.

This study examined time series (2000-2014) of phytoplankton and copepod abundances around the Aleutian Islands and the southern Bering Sea and compared those numbers with pink salmon abundances, which were eight times higher in odd years than in even (2000-2012). In 2013 (odd year), the abundance was 73% lower than previous odd years and the next year, pink abundance was relatively high (although lower than the average odd year abundance). There are opposing biennial patterns in abundances of large phytoplankters and copepods relative to pink salmon abundances: in odd years, pink salmon abundance and large diatom abundance is high, while copepod (prey of pink salmon and grazer of diatoms) abundance is low. These associations were stronger than comparisons to "stanzas", the 4-6 year cycle of warm or cold temperatures found in the Bering Sea.

Beamish, R. J., R.M. Sweeting, T.D. Beacham, K.L. Lange, and C.M. Neville. 2010. A late ocean entry life history strategy improves the marine survival of Chinook salmon in the Strait of Georgia. NPAFC Doc. 1282. 14 pp. (Available at www.npafc.org).

One aggregated population of Georgia Strait Chinook salmon (South Thompson drainage of the Fraser River) has increased in recent years while most other Georgia Strait Chinook populations have declined. The South Thompson Chinook juveniles are not abundant in Georgia Strait in July but are by September, and by November are moving to sea, probably through the Strait of Juan de Fuca. Harrison River sockeye salmon are also a "late-entry" juvenile and doing better than others. It is theorized that high populations of pink and chum salmon present in Georgia Strait at the same time as earlier-entry populations of Chinook and sockeye are the reason why these populations of Chinook and sockeye are not doing as well as late-entry populations. Focused research is needed.

Brenner, R. E., S. D. Moffitt, and W. S. Grant. 2012. Straying of hatchery salmon in Prince William Sound, Alaska. Environmental Biology of Fishes 94:179–195.

The authors (all ADFG employees) sampled streams in PWS to determine stray rates using data gathered in two time periods, 1997-1999 and 2008-2010. Percentages of hatchery pink salmon in spawning areas varied from 0 to 98%. Most (77%) of spawning locations had pink salmon from three or more hatcheries, and the escapement at 51% of locations consisted of more than 10% hatchery pink salmon during at least one year surveyed. Application of an exponential decay model indicates that many streams would have over 10% hatchery pinks, even if distant from a hatchery. Besides the implication of genetic effects on wild populations, the authors express concern that estimates of wild escapement may be inflated by the assumption that all fish seen in weirs or in aerial surveys are assumed to be wild.

Debertin, D. J., J. R. Irvine, C. A. Holt, G. Oka, and M. Trudel. 2017. Marine growth patterns of southern British Columbia Chum Salmon explained by interactions between density-dependent competition and changing climate. Canadian Journal of Fisheries and Aquatic Sciences 74:1077–1087.

The authors report the results of a study of 39 years of scale growth measurements of chum salmon from Big Qualicum River (BC) in regard to climate variation and competition with other

North American salmon (chum, sockeye, and pink). When the North Pacific Gyre Oscillation was positive, growth increased (attributed to higher primary production). Growth at all ages was negative when the combined biomass of NA salmon was high. Competition effects increased when the NPGO was more positive and the Pacific Decadal Oscillation was more negative. The authors recommend the use of biomass estimates over abundance estimates to take into account inter-species variations and the observed trend of smaller returning salmon. The authors believe this study is the first to use a longitudinal model to examine growth versus the interactions of climate and density dependent competition. If their results are typical of wild salmon populations, reductions in hatchery releases should be considered.

Grant, W.S., 2012. Understanding the adaptive consequences of hatchery-wild interactions in Alaska salmon. Environmental Biology of Fishes, 94(1), pp.325-342.

This is a review of hatchery-wild interactions with an emphasis on genetic effects to wild populations. While the author acknowledges that some may argue that studies conducted elsewhere may not be applicable to Alaskan salmon populations for a variety of reasons, the near-universal result that introgression between hatchery fish and wild fish leads to reduced fitness in wild populations is a fact that must be considered when evaluating hatchery programs. The adaptive potential of wild populations must be preserved as a buffer against climate change and diseases.

Gritsenko A.V. and E.N. Kharenko. 2015 (abs). Relation between biological parameters of Pacific salmons of the genus Oncorhynchus and their population dynamics off the northeastern Kamchatka Peninsula. J Ichthyol 55:430–441.

"Results are provided of a 7-year study of biological parameters in females of three Pacific salmons of the genus *Oncorhynchus* (pink salmon *O. gorbuscha*, chum salmon *O. keta*, and sockeye salmon *O. nerka*) in the Olyutorsky and Karaginsky gulfs, Bering Sea. Abundance of the pink salmon is identified as the main determining factor of the interannual dynamics of maturity index in female Pacific salmon in coastal waters. Maturity index rises at high levels of abundance as a result of differently directed changes in two parameters: decreasing body weight and increasing ovary weight. In female chum salmon, maturity index depends on the age structure of the population and body weight dynamics of different age groups, factors influenced by high abundance of some pink salmon generations, and does not depend on the abundance of spawning chum salmon. The revealed association between pink salmon and sockeye salmon in dynamics of their biological parameters may result from the similarity of their diets; during the last year of fattening in the sea, the sockeye salmon is affected by the pink salmon, the most abundant of the three species. The interannual variation of biological parameters in pink salmon and chum salmon is more pronounced in Olyutorsky Gulf than in Karaginsky Gulf."

Heard, W.R., 2012. Overview of salmon stock enhancement in southeast Alaska and compatibility with maintenance of hatchery and wild stocks. Environmental Biology of Fishes, 94(1), 273-283. PC022 5 of 24

This review of the hatchery programs of SEAK, as well as some relevant studies of wild-hatchery interactions, acknowledges that some interactions between hatchery salmon and of wild salmon are unavoidable, but concludes that "obvious adverse impacts from the current levels of hatchery releases and population trends in Alaska's wild salmon populations are not readily evident." The author believes that SEAK hatchery chum programs have been successful in increasing numbers for fisheries, but says that additional increases (which have been requested) should be limited to "gradual incremental steps" given concern over straying in some streams, until better information is generated on the possible impacts of hatchery programs on wild populations.

Hilborn, R. and D. Eggers. 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129:333-350.

Wertheimer, A. C., W. W. Smoker, T. L. Joyce, and W. R. Heard. 2001. Comment: A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 130:712–720.

Hilborn, R. and D. Eggers, 2001. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska: Response to Comment. Transactions of the American Fisheries Society 130:720–724.

Hilborn and Eggers used ADF&G catch data from four Alaska regions. The initial paper concluded that while the PWS hatchery program was successful in producing fish to be harvested, the overall increase in harvest wasn't necessarily due to the PWS pink salmon hatchery programs, because other AK regions (with no, or geographically separated hatchery programs) experienced an increase in wild pink production. In fact, increases in pink salmon harvest in PWS occurred before large-scale hatchery programs there. Therefore, the hatchery-produced pink salmon replaced rather than augmented the wild fish. A decline in wild production in PWS was attributed to lower wild escapements and hatchery releases (the authors claim no evidence has been produced to show that the Exxon Valdez oil spill was detrimental to longterm pink salmon production).

Wertheimer et al. (2001) commented that Hilborn and Eggers vastly over-estimated wild pink production and therefore underestimated the proportion of the PWS pink harvest that could be attributed to hatchery production. They also used a longer time-series of catch data, along with other approaches to the data. Hilborn and Eggers (2001), in a response, stand by their conclusions and point out that in this case a longer time-series is not appropriate (positive changes in pink salmon habitat after the 1964 earthquake). They maintain that an increase in PWS pink production was evident before large-scale hatchery releases took place, and that hatchery releases replaced rather than augmented wild production.

Holt, C.A., Rutherford, M.B, and R.M. Peterman. 2008 (abs). International cooperation among nation-states of the North Pacific Ocean on the problem of competition among salmon for a common pool of prey resources. Marine Policy 32, 607–617.

"A common-pool problem in the North Pacific Ocean that remains largely ignored in international policy is competition for prey resources among salmon populations (*Oncorhynchus* spp.) from different countries. Hatcheries release large abundances of juvenile salmon into the North Pacific and the resulting decrease in mean body size of adult wild and hatchery salmon may lead to reductions in benefits. We examine incentives and disincentives for cooperation among nation-states on this issue. We recommend that either a new international organization be created or that amendments be made to the mandate and powers of an existing organization. The resulting organization could encourage collective action to reduce competition among salmon from different nations by using side-payments to change the incentive structure, by establishing a multi-national scientific assessment team to create a common frame of reference for the problem, and by implementing policy prescriptions."

Irvine, J. R., and M. Fukuwaka. 2011. Pacific salmon abundance trends and climate change. ICES Journal of Marine Science 68:1122–1130.

This study compared abundance of five species of salmon (represented by commercial catch data) in both Asia and North America with five climate regimes (1925-1946, 1946-1976, 19771988, 1989-1998, and 1999-2009). Higher catches in the western north Pacific are attributed to hatchery programs (both releases and better hatchery technology resulting in healthier fry). The results confirm earlier studies indicating regime "shifts" in 1947, 1977, and 1989. Higher catches of pink and chum since 1990 in all regions have occurred and can be attributed to hatchery releases in only the northwestern Pacific region because only Russia has significantly increased hatchery releases.

Jeffrey, K. M., I. M. Coté, J. R. Irvine, and J. D. Reynolds. 2016. Changes in body size of Canadian Pacific salmon over six decades. Canadian Journal of Fisheries and Aquatic Sciences 74:191–201.

Commercial catch data for five salmonid species from 1951-2012 were analyzed along with climatic variables (four Pacific Ocean indices), latitude of catch, and total salmonid biomass to determine if size of caught fish has changed, and if so, what variables are associated with the changes. Catch data from the least-selective method were used to minimize any size-selective gear bias. Analyses from the earlier part of the catch dataset agree with the results of previous research. The results from this study indicate changes in body size over time from oceanic changes as well as density-dependent effects. Pink salmon size declined initially but has changed relatively little over the last 20 years. Body size of Chinook, chum, and coho was most influenced by the total biomass of sockeye, chum, and pink salmon in the Gulf of Alaska. Inclusion of Asian chum salmon did not improve model performance. Pink salmon size was reduced as total biomass increased, with odd-years (higher abundances of pinks) showing a more pronounced effect. Chinook and coho body size increased with total salmon biomass,possibly reflecting better overall environmental conditions, given the lack of overlap in diet preferences between Chinook and coho vs. the other three species.

Jenkins, E.S., Trudel, M., Dower, J.F., El-Sabaawi, R.W. and A. Mazumder. 2013. Density-dependent trophic interactions between juvenile pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) in coastal marine ecosystems of British Columbia and Southeast Alaska. North Pacific Anadromous Fish Commission Technical Report 9:136-138.

This study employed stable isotopes to determine the degree of dietary overlap between juvenile chum and juvenile pink salmon (the southern end of SEAK to the northern end of Vancouver Island), and how that is affected by temperature, abundance (juvenile salmon), and prey availability. Juveniles were collected 2000-1 and 2004-5. The niches of pink and chum overlapped more when abundance was high and prey availability was low. The size difference between the species was not significantly correlated with overlap. It appears that when competition was greater (fewer prey items) both species became less selective and therefore they overlapped more. Hatchery releases resulting in greater numbers of juveniles may thus increase competition.

Kaev, A. M. 2012 (abs). Wild and hatchery reproduction of Pink and Chum salmon and their catches in the Sakhalin-Kuril region, Russia. Environmental Biology of Fishes 94:207–218.

"In the Sakhalin-Kuril region hatchery culture of pink and chum salmon is of great importance compared to other regions of the Russian Far East. During the last 30 years the number of hatcheries increased two-fold, and significant advances were made in hatchery technologies. As a result, chum salmon capture in regions where hatcheries operate (southwestern and eastern Sakhalin coasts, and Iturup Island) was 9 times as high during 2006–2010 than during 1986–1990, whereas wild chum salmon harvest markedly declined. Recent dynamics in pink salmon catch appear to track trends in natural spawning in monitored index rivers, suggesting natural-origin pink salmon play a dominant role in supporting the commercial fishery. It remains uncertain as to whether hatcheries have substantially supplemented commercial catch of pink salmon in this region, and I recommend continued research (including implementing mass marking and recovery programs) before decisions are made regarding increasing pink salmon hatchery production. Location of hatcheries in spawning river basins poses problems for structuring a management system that treats hatchery and wild populations separately. Debate continues regarding the existence and importance of density-dependent processes operating in the ocean environment and the role hatcheries play in these processes. Loss of critical spawning habitat for chum salmon in the Sakhalin-Kuril region has lead to significant declines in their abundance. I conclude by recommending increases in releases of hatchery chum salmon numbers in the region to help recover depressed wild populations and provide greater commercial fishing benefits in the region."

Kaev, A. M., and J. R. Irvine. 2016. Population dynamics of Pink Salmon in the Sakhalin-Kuril region, Russia. North Pacific Anadromous Fish Commission Bulletin 6:297–305. PC022 8 of 24 I the central Bering Sea. Mar Ecol Prog Ser 478:211–221.

Run size (catch plus escapement) data and numbers of hatchery and wild fry were estimated for eight areas around Sakhalin Island and the southern Kuril islands over the 1975-2015 period. Marine survival was also indexed by dividing run size by the number of fry for each area. Odd-year runs are greater than even-year runs, with the difference increasing over time. The recent increase in pink salmon catch does not appear to be the result of hatchery releases (greater numbers of fry) but instead is the result of environmental conditions in early life stages. Increasing size of adults is attributed to conditions in the common area where pinks (from a number of investigated areas) mingle later in life.

Kaga T., Sato S., Azumaya T., Davis N.D., and M-a. Fukuwaka. 2013. (abs) Lipid content of chum salmon Oncorhynchus keta affected by pink salmon *O. gorbuscha* abundance in the central Bering Sea. Mar Ecol Prog Ser 478:211–221.

“To assess effects of intra- and inter-specific interactions on chum salmon in the central Bering Sea, chum salmon lipid content was analyzed as a proxy for body condition. We measured the lipid contents of 466 immature individuals collected during summer from 2002 to 2007. Individual variation in log-transformed lipid content was tested using multiple regression analysis with biological and environmental variables. A regression model that included chum salmon fork length and pink salmon CPUE (number of fish caught per 1500 m of gillnet) was the most effective in describing variation in lipid content. Path analysis showed that the negative effect of pink salmon CPUE was stronger than the effect of chum salmon CPUE on chum salmon lipid content. Stomach content analysis of 283 chum salmon indicated non-crustacean zooplankton (appendicularian, chaetognath, cnidarian, ctenophore, polychaete, and pteropod) was higher under conditions of high pink salmon CPUE. Increased consumption of non-crustacean zooplankton containing a low lipid level could lower the lipid content of chum salmon. Thus, chum salmon lipid content could be affected directly by their shift in prey items and indirectly by interspecific competition with pink salmon.”

Malick, M.J. and S.P. Cox. 2016. Regional-scale declines in productivity of pink and chum salmon stocks in western North America. PloS one, 11(1), p.e0146009.

Historical population data from 99 wild chum and pink stocks in WA, BC, and AK were assessed, and trends in productivity noted. While productivity of some pink stocks in Alaska declined over time, others increased. The authors believe that the productivity of pink and chum stocks in western North America is driven by common processes “operating at the regional or multi-regional spatial scales.” The effects are not constant but can change over time. While some environmental factors operating at the regional scale (and thus, are potential drivers of productivity) were identified, they were not investigated. “Mechanisms that operate over these spatial scales may include freshwater or marine processes such as disease or pathogens, changes in stream flow and stream temperature, competition with abundant hatchery salmon, or shifts in oceanographic condition such as the timing of the spring phytoplankton bloom or sea surface temperature.” They found that most chum and some pink salmon stocks declined, in contrast to Stachura et al. (2014) and other reports. PC022 9 of 24

Malick, M.J. 2017. Multi-scale environmental forcing of Pacific salmon population dynamics. PhD thesis, Simon Fraser University, School of Resource and Environmental Management, Burnaby, BC. http://summit.sfu.ca/system/files/iritems1/17425/etd10171_MMalick.pdf

This researcher considered variable environmental factors (e.g., phytoplankton phenology, horizontal and vertical transport patterns) and their influence on salmon productivity (*see* Malick and Cox 2016). The thesis also contains a section on policy analysis where the author outlines the problems that arise from management of migratory anadromous fish species, e.g., multiple national and sub-national polities, the fact that management decisions of one entity can impact the resources of another, and incomplete use of real-time data to make management decisions.

The author believes that an “international ecosystem synthesis group” could integrate information from various managers and provide “strategic management advice” based on their synthesis of the various information they receive. Because of the complexity of managing Pacific salmon, a multi-faceted approach is warranted.

Manhard, C.V., Joyce, J.E., Smoker, W.W. and A.J. Gharrett. 2017. Ecological factors influencing lifetime productivity of pink salmon (*Oncorhynchus gorbuscha*) in an Alaskan stream. Can. J. Fish. Aquatic Sci. 74(9), 1325-1336.

A study of the pink salmon populations (both even- and odd-years) of a short (323 m) lake-outlet stream indicated that early marine survival was the primary determinant of overall productivity. An overall downward trend in productivity was associated with an observed decline in freshwater spawning habitat quality. A nearby hatchery released large numbers of pink fry 1988-2002 but no difference in marine survival was noted between that time period and afterwards (with no hatchery releases). “[W]hile commercial harvest and hatchery straying do occur, the effects of these processes on adult recruitment are more likely to be stochastic than deterministic.”

Morita, K. 2014. Japanese wild salmon research: toward a reconciliation between hatchery and wild salmon management. North Pacific Anadromous Fish Commission Newsletter 35:4–14.

This English-language article summarizes some Japanese-language literature on wild and hatchery salmon management in Japan. The author believes that wild salmon productivity is higher and more important than many people believe. Most large rivers in Japan have hatchery programs, and protecting wild populations is a way to guarantee continued success of the hatchery programs (e.g., genetic reserve, source of broodstock in integrated programs). Integrated hatchery programs are probably the best management option in highly-developed, hatchery-dominated Japanese watersheds.

Morita, K., S. H. Morita, and M. Fukuwaka. 2006. (abs) Population dynamics of Japanese Pink Salmon (*Oncorhynchus gorbuscha*): are recent increases explained by hatchery PC022
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programs or climatic variations? Canadian Journal of Fisheries and Aquatic Sciences 63:55–62.

“Hatchery programs involving the mass release of artificially propagated fishes have been implemented worldwide. However, few studies have assessed whether hatchery programs actually increase the net population growth of the target species after accounting for the effects of density dependence and climatic variation. We examined the combined effects of density dependence, climatic variation, and hatchery release on the population dynamics of Japanese pink salmon (*Oncorhynchus gorbuscha*) from 1969 to 2003. The population trends were more closely linked to climatic factors than to the intensity of the hatchery programs. The estimated