Variations in Catch Per Unit Effort of Thermally Marked Pink and Chum Salmon Juveniles in the Gulf of Alaska during 1996 and 1998 in Relation to Adult Hatchery Salmon Returns

Edward V. Farley, Jr.[1], **Peter T. Hagen**[2], and **John H. Helle**[1]
[1]National Marine Fisheries Service, Auke Bay Laboratory
11305 Glacier Hwy, Juneau, AK 99801, U.S.A.
[2]Alaska Dept. of Fish and Game
P.O. Box 25526, Juneau, AK 99802-5526, U.S.A.

Keywords: Thermal otolith mark, pink salmon, chum salmon, Gulf of Alaska, CPUE

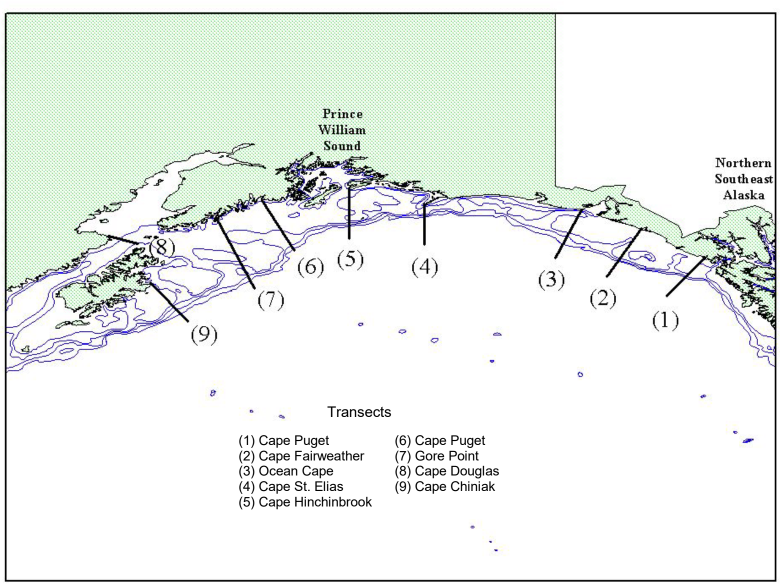
Thermal marking of salmonid otoliths has become an important, cost-effective tool to identify hatchery salmon at sea. In recent years, releases of thermally marked salmon into the North Pacific Ocean from hatcheries in Washington, British Columbia, and Alaska have numbered in the billions. The large numbers of thermally marked salmon released into the North Pacific Ocean have greatly increased the probability of recovering marked salmon during high-seas sampling thus potentially providing information on the biology and management of Pacific salmon (Ignell et al. 1997; Farley and Munk 1997; 1998; Farley et al. 1999; Kawana et al. 1999; Carlson et al. 2000; Farley and Carlson 2000; Kawana et al. 2000; Urawa et al. 2000).

In 1996, the Ocean Carrying Capacity (OCC) program at the Auke Bay Laboratory, National Marine Fisheries Service initiated a comprehensive program to study the distribution, migration, origin, size, growth, and diet of juvenile, immature, and maturing salmonids in the Gulf of Alaska (GOA; Carlson et al. 1996). One objective of this ongoing program is to collect and analyze otoliths from salmonids to determine hatchery origin of these fish and to partition hatchery from wild stocks in our samples. In this paper we summarize information on catch per unit effort (CPUE) of thermally marked juvenile pink and chum salmon caught in the GOA during July and August 1996 and 1998 in relation to adult hatchery pink and chum salmon returns one and three years later, respectively.

Juvenile salmon were captured along transects within the coastal waters of the GOA during July and August 1996 and 1998 (see Carlson et al. 1996 and 1998 for details; Fig. 1). The salmon were frozen whole and brought back to the laboratory where sagittal otoliths were removed from the juvenile salmon and examined for thermal marks. Otolith thermal mark patterns from juvenile chum salmon were compared to voucher specimens collected from Gastineau and Hidden Falls hatcheries located in northern Southeast Alaska (NSEAK; Fig. 2A); otolith thermal mark patterns from juvenile pink salmon were compared with voucher specimens collected from Armin F. Koernig, Cannery Creek, Solomon Gulch, and Wally H. Noerenberg hatcheries located in Prince William Sound (PWS; Fig. 2B).

Yearly CPUE of juvenile PWS and NSEAK hatchery pink and chum salmon was estimated by summing the numbers of these salmon caught in each haul over the entire survey then dividing by the total number of trawl hours. The CPUE data was then compared to returns of adult PWS hatchery pink salmon 1 year later and adult NSEAK hatchery chum salmon 3 years later. To make qualitative comparisons, we assumed that our 1996 and 1998 surveys sampled through the peak of the juvenile salmon migration leaving PWS and NSEAK and entering the continental shelf of the GOA.

Fig. 1. Transects sampled by the OCC program during July and August 1996 and 1998.



All correspondence should be addressed to E.V. Farley, Jr.
e-mail: ed.farley@noaa.gov

Plots of hatchery pink and chum salmon CPUE by transect and year resembled a bell-shaped curve indicating our surveys sampled through the peak migration of juvenile PWS hatchery pink (Figs. 3A and B) and NSEAK hatchery chum salmon (Figs. 4A and B). Annual differences in CPUE of juvenile hatchery pink salmon was lower during 1996 than 1998 matching the pattern of returning hatchery pink salmon to PWS during 1997 (lower) and 1999 (higher) (Fig. 5A). CPUE of juvenile hatchery chum salmon was also lower during 1996 than 1998 (Fig. 5B), suggesting that the 2001 return of NSEAK hatchery chum salmon may be higher than the 1999 return of 8 million.

Our analysis of juvenile PWS hatchery pink salmon catch suggests that CPUE, as a measure of relative abundance of juvenile salmon along the continental shelf of the GOA, may prove useful in predicting adult PWS pink salmon returns one year later. The large CPUE of juvenile PWS hatchery pink salmon found during 1998 corresponds to a record return of pink salmon to PWS hatcheries during 1999. Additional years of sampling will be needed, however, to establish the significance of the association. We note that the large CPUE of PWS pink salmon during our 1998 survey does not appear to be related to the number of hatchery pink salmon released. Hatchery releases of pink salmon in PWS were larger during 1996 (642 million) than during 1998 (542 million) (McNair 1997; 1999), indicating annual differences in early marine survival of juvenile pink salmon within PWS.

Fig. 2. Locations of Southeast Alaska hatcheries (A) and Prince William Sound hatcheries (B). Figures courtesy of the Alaska Department of Fish and Game.

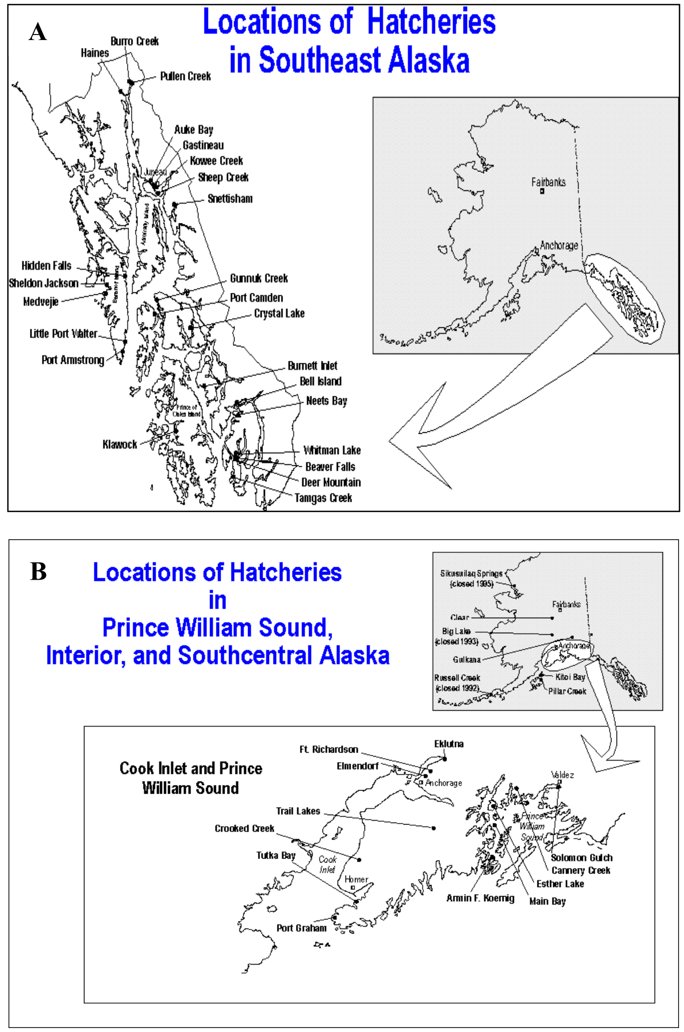


Fig. 3. Catch per unit effort of juvenile Prince William Sound hatchery pink salmon along transects sampled by the OCC program during 1996 (A) and 1998 (B).

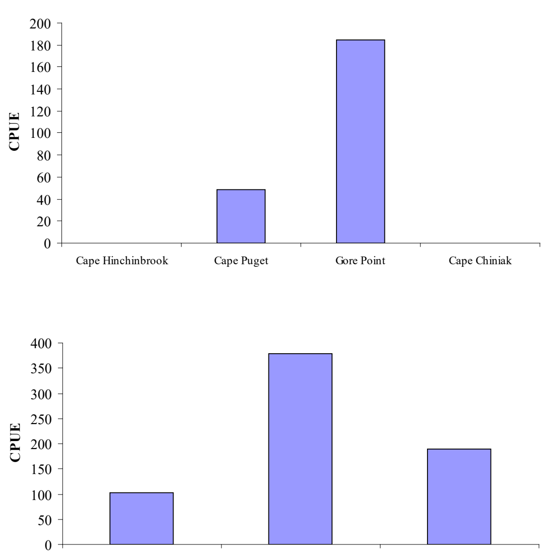
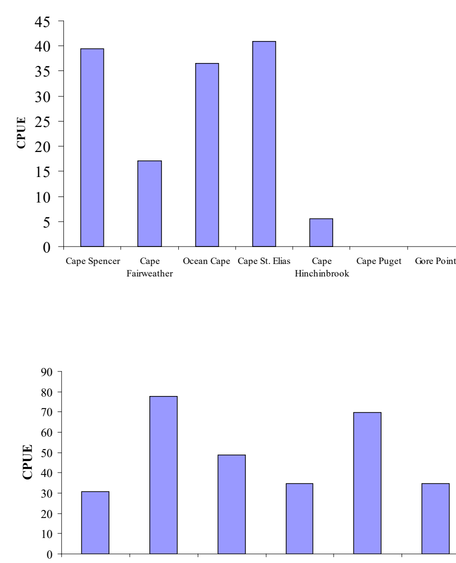


Fig. 4. Catch per unit effort of juvenile northern Southeast Alaska hatchery chum salmon along transects sampled by the OCC program during 1996 (A) and 1998 (B).



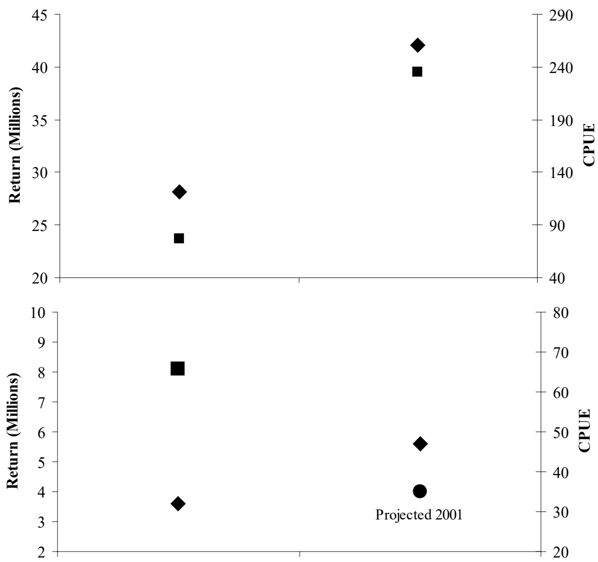


Fig. 5. Catch per unit effort (CPUE) of juvenile Prince William Sound hatchery pink (A) and northern Southeast Alaska hatchery chum (B) salmon (diamonds; first year) in relation to adult hatchery returns (squares; second year) one year and three years, respectively. The circle in Fig. 5B represents the projected return of northern Southeast Alaska hatchery chum salmon during 2001.

If the CPUE-adult return relationship shown in the pink salmon data holds true and is applicable to chum salmon, then the higher CPUE of juvenile NSEAK hatchery chum salmon observed during 1998 could indicate a larger adult return of hatchery chum salmon to NSEAK during 2001 than observed during 1999. The forecast for adult hatchery chum salmon returns to NSEAK in 2001, however, predicts a nearly 50% reduction over 1999 returns (McNair 2001). We note that NSEAK hatcheries only mark a portion of their chum salmon during incubation, increasing the variation in and covariance between juvenile NSEAK hatchery CPUE from our survey and adult hatchery returns to this region 3 years later.

The forecast could be artificially low due to possible changes in maturation of chum salmon during ocean residence. The forecast includes a sibling model based on the number of returning 3-year old chum salmon in the prior year. Three year old chum salmon were noticeably absent in both the wild and hatchery chum salmon returns to southeast Alaska during 2000. Absence of 3-year old chum salmon is often a good indicator of brood strength, but not always. In some years, either due to competition for food resources or reduced food abundance, chum salmon mature at older ages. Could the high densities of pink and chum salmon juveniles seen in the summer of 1998 and the small size of adult pink salmon returning in 1999 be an indicator that chum salmon from the 1997 brood are going to mature later? The age and abundance of chum salmon returns to southeast Alaska in 2001 should be very interesting to observe.

Our results demonstrate that sufficient numbers of thermally marked hatchery salmon can be recovered during coastal salmon surveys to provide significant new stock-specific information on distribution, migration, and CPUE. We plan to continue analyzing stock specific CPUE during future July–August (2001–2004) coastal GOA surveys and relating CPUE to adult returns. We encourage all agencies to mark 100% of their hatchery releases, so that future marine sampling efforts will yield a better picture of hatchery and wild salmon interactions.

REFERENCES

Carlson, H.R., K.W. Myers, E.V. Farley, H.W. Jaenicke, R.E. Haight, and C.M. Guthrie III. 1996. Cruise report of the F/V *Great Pacific* survey of young salmon in the North Pacific—Dixon Entrance to western Aleutian Islands—July–August 1996. (NPAFC Doc. 222) 50p. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Juneau, AK, USA.

Carlson, H.R., E.V. Farley, E.C. Martinson, and C.M. Kondzela. 1998. Survey of salmon in the North Pacific Ocean and Gulf of Alaska—Dixon Entrance to Unimak Pass July–August, 1998. (NPAFC Doc. 345) 25p. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Juneau, AK, USA.

Carlson, H.R., E.V. Farley, Jr., and K.W. Myers. 2000. The use of thermal otolith marks to determine stock-specific ocean distribution and migration patterns of Alaskan pink and chum salmon in the North Pacific Ocean, 1996–1999. N. Pac. Anadr. Fish Comm. Bull. No. 2: 291–300.

Farley, Jr., E.V., and H.R. Carlson. 2000. Spatial variations in early marine growth and condition of thermally marked juvenile pink and chum salmon in the coastal waters of the Gulf of Alaska. N. Pac. Anadr. Fish Comm. Bull. No. 2: 317–323.

Farley, E.V., and K. Munk. 1997. Incidence of thermally marked pink and chum salmon in the coastal waters of the Gulf of Alaska. Alaska Fisheries Research Bulletin. 4: 181–187.

Farley, E.V., and K. Munk. 1998. Incidence of thermally marked pink, chum, and sockeye salmon in the coastal waters of the Gulf of Alaska, 1997. (NPAFC Doc. 341) 18p. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Juneau, AK, USA.

Farley, E.V., K. Munk, and P.T. Hagen. 1999. Incidence of thermally marked pink, chum, and sockeye salmon in the coastal waters of the Gulf of Alaska, 1998. (NPAFC Doc. 446) 24p. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Juneau, AK, USA.

Ignell, S.E., C.M. Guthrie III, J.H. Helle, and K. Munk. 1997. Incidence of the thermally-marked chum salmon in the 1994–96 Bering Sea pollock B-season trawl fishery. (NPAFC Doc. 246) 16p. Auke Bay Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Juneau, AK, USA.

Kawana, M., S. Urawa, G. Anma, Y. Kamei, T. Shoji, M. Fukuwaka, K. Munk, K.W. Myers, and E.V. Farley. 1999. Recoveries of thermally marked maturing pink salmon in the Gulf of Alaska in the summer of 1998. Bull. National Salmon Resources Center 2: 1–8.

Kawana, M., S. Urawa, G. Anma, S. Takagi, Y. Kamei, T. Shoji, M. Fukuwaka, K. Munk, P. T. Hagen, and E.V. Farley. 2000. Recoveries of thermally marked maturing pink salmon in the Gulf of Alaska in the summer of 1998 and 1999. (NPAFC Doc. 489). 9p. National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062-0922, Japan.

McNair, M. 1997. Alaska salmon enhancement program 1996 annual report. Regional Information Report 5J97-09. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK. USA. 49 p.

McNair, M. 1999. Alaska salmon enhancement program 1998 annual report. Regional Information Report 5J99-02. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK. USA. 35 p.

McNair, M. 2001. Alaska salmon enhancement program 2000 annual report. Regional Information Report 5J01-01. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau, AK. USA. 35 p.

Urawa, S., M. Kawana, G. Anma, Y. Kamei, T. Shoji, M. Fukuwaka, K. Munk, K.W. Myers, and E.V. Farley, Jr. 2000. Geographical origin of high-seas chum salmon determined by genetic and thermal otolith markers. N. Pac. Anadr. Fish Comm. Bull. No. 2: 283–290.