Using Thermally-Marked Otoliths to Aid the Management of Prince William Sound Pink Salmon

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Starting in the fall of 1995, thermal marks were applied to the otoliths of all hatchery pink salmon, *Oncorhynchus gorbuscha*, in Prince William Sound, Alaska. Prior to that time, coded wire tags were used as a means of stock separation, but several assumptions used to generate stock estimates, such as those concerning tag shedding, differential mortality, and tag induced straying, were contentious and may have been flawed (Sharr et al.1995; Habicht et al.1998). Mosegaard et al. (1987), Volk et al. (1990), and Munk et al. (1993) found that carefully controlled incubation water temperature changes would mark otoliths of Pacific salmon *Oncorhynchus* spp. and Atlantic salmon *Salmo salar*. The first otolith marks were applied to pink salmon embryos in the fall of 1995 in Prince William Sound, and were highly visible on voucher samples taken from hatchery fry in the spring of the following year. For pink salmon brood years 1996 and 1997, accessory thermal marks, applied after the fry hatched, allowed identification of within-hatchery treatment groups (Fig. 1).

Double-blind tests were conducted on otoliths taken from emergent fry from brood years 1995–1997 to assess the ability of laboratory personnel to correctly identify hatchery otolith marks. The tests indicated that the probability of a successful identification between hatchery and wild pink salmon was 99.6%, 99.7%, and 99.3% for brood years 1995–1997, respectively.

Starting in 1997, thermal otolith marks were recovered from the commercial catch of pink salmon in Prince William Sound and used to estimate hatchery contributions. Because every otolith of a hatchery cohort is marked, precise estimates of hatchery contributions can be obtained with relatively few otolith recoveries. A very important prerequisite for such an estimate is that a representative sample is taken from the fishery. With this in mind, catch-sampling and estimation protocols were developed in 1995 and 1996 to ensure that estimates were usefully precise and accurate. A proportional sampling scheme was developed such that otoliths were sampled from all tenders in a manner proportional to their load. Such a sample is self-weighting and leads to many simplifications in sample size calculations and data analysis. To determine how a sample should be taken from a tender, we examined the degree of mixing of fish within the hold of a travelling tender. No significant mixing was found to occur (Table 1), and a systematic sample was therefore taken from each tender to ensure a representative sample was achieved. The systematic sample was taken by removal of a salmon from a processor belt at set intervals throughout the unloading process. The sampling interval was adjusted according to the number and speed that pink salmon were being processed. The sagittae otolith bones were extracted and placed in order of selection in numbered trays. The sample collection technique was somewhat self-weighting (larger loads generated more otoliths). After all tenders had been sampled, otoliths were subsampled from each tender collection to fine-tune the proportional sample. Ultimately, 96 otolith pairs formed the weighted systematic sample.

Fig. 1. Thermally-marked brood year 1997 (BY97) pink salmon otoliths sampled from Prince William Sound hatcheries.

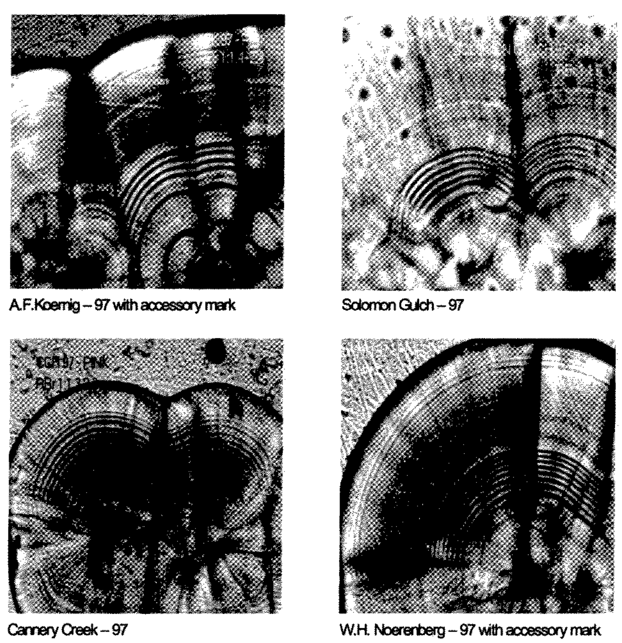

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Table 1. Tender mixing data.

Loading Location of Fin Clipped Fish on Tender	Percentage Marked by Stage in Off Loading Samples		
	Start	Middle	End
Bottom	3.3	6.8	11.7
Middle	4.0	7.4	3.3
Top	16.1	10.8	0.9

The thermal mark program has led to a number of significant improvements in estimation of hatchery contributions over the coded wire tag recovery program. In the latter, large numbers of fish had to be sampled to provide useful estimates, while the otolith program can provide more precise hatchery contribution estimates from far smaller samples. This development contributed to better management of some important fishery strata. Analysis of otolith samples from test fisheries that routinely harvest small numbers of salmon provided information that resulted in fishery openings that would not have occurred under the sample-intensive coded wire tag program. Another improvement afforded by the otolith-marking program is that hatchery contribution estimates are available much sooner. Timely information is extremely important for decisions regarding harvest. In Prince William Sound, preliminary estimates of the stock composition of an area-time specific catch were available within 24 hours after a fishery closure.

Perhaps the best asset of the Prince William Sound thermal mark program is that fishery managers and the commercial fleet believe the generated stock contribution estimates. The high degree of confidence associated with otolith-derived estimates originates in large part from the assumption-free nature of the estimation procedure, and the effort made to ensure representative sampling. The highly efficient data-tracking and data management mechanisms built into our system also contributed to this confidence. Data summaries and updates can be executed within minutes after data entry, giving managers more time to make decisions.

Otolith marks have also allowed a number of *ad hoc* studies that depend on knowledge of hatchery contributions. For example, they have allowed study of the proportion of hatchery pink salmon straying into selected wild stock streams. Many streams close to the large production hatcheries and along the migration corridors were inundated by stray hatchery-released fish. The number of stray hatchery pink salmon increased as the spawning season progressed with the highest percentage of stray hatchery salmon occurring in the last sampling strata of the spawning season. The most obvious explanation for the large contribution of hatchery salmon to these escapements lies in the numerical dominance of hatchery over wild runs. Sharp et al. (2000) estimates that 26.0 and 25.6 million hatchery pink salmon and 2.3 and 5.3 million wild stock pink salmon returned in 1997 and 1998, respectively. These stray pink salmon may also be a function of a large number of unharvested salmon remaining at the hatcheries at the end of the commercial season that were beyond broodstock needs. More information is needed on reproductive success, domestication, and gene flow of these stray pink salmon if we are to assess their effects on the wild salmon populations.

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