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Comments on the Relationship Between Gill ATPase Activities, Migration, and Salt Water Adaption of Coho Salmon

Numerous studies and observations on downstream migrations of juvenile salmon in western United States, western Canada, and Alaska have led to determinations of normal migratory periods and have provided essential information for successful hatchery programs. Wallis (1968) has reviewed much of the accumulated information on migration times of salmon and steelhead trout and has listed some recommendations for hatchery procedures in rearing and releasing these fish. He suggests that coho salmon (*Oncorhynchus kisutch*), which normally migrate from March through early June of their second spring, be released during March to May.

Several studies have indicated that temporal or seasonal preferences for salt water are exhibited by immature coho salmon. Tests by Baggerman (1960) at Vancouver, British Columbia, demonstrated that coho salmon (8.3 cm) preferred fresh water at the beginning of March, but at the end of March and during April and May chose salt water. In July the test animals again selected fresh water. McInerney (1964) also at Vancouver found that coho salmon developed a preference for water containing 3‰ Cl^- through June and July of their first year but showed no preference for more elevated concentrations through February of the following year. His studies did not extend into the period of normal migration. He concluded from studies on five species of Pacific salmon that initial preference for dilute sea water (3–6‰ Cl^-) was unaffected by previous salt water exposure. However, in the latter stages of preference development through August, either of two routes were possible. Animals kept in fresh water reverted to fresh water preference while those exposed to dilute sea water during the initial stages underwent a series of preference changes with a final preference for full strength sea water (18‰ Cl^-).

Several observations by Noble (1958) on coho in Minter Creek (Washington) are pertinent. Hand-picked coho ranging from 13.2–

19.7 cm, removed from hatchery ponds and placed in Minter Creek in December, did not migrate until the last of April. Another group of coho having migratory appearance (silver color, average length—10.4 cm) were released from ponds on July 21. Only 22% moved below the counting weir, and these shortly after release. No migration was observed after August 10. A group of fingerlings which had been converted to 100% sea water, giving no indication of stress, were liberated into Hood Canal on November 22. Immediately, great numbers returned to fresh water and remained. McInerney (1964) found the same behavior when he exposed two groups of yearling coho salmon (January 12 to February 20) to sea water (12‰ Cl^-) for 2 and 6 weeks then placed the fish in a preference chamber. Both groups showed a strong preference for water of much less salinity (3‰ Cl^-), which was the same salinity as that selected by controls. He concluded that sea water exposure did not affect initial preferences but that the preference sequence developed independently of any sea water contact.

These observations strongly suggest that coho salmon tend to reject salt water when not biologically prepared to adjust to such an environment, even when previously exposed to it.

We have recently observed a seasonal change in gill adenosine triphosphatase (ATPase) activity which corresponds closely to the normal migratory period of coho salmon (Zaugg and McLain, unpublished observations). During the latter part of March over-yearling coho salmon maintained under laboratory conditions at 10 C (50 F) showed an increase from 13 to 28 μmoles ATP hydrolyzed/mg protein/hr in the specific activity of Na^+, K^+-activated ATPase in gill microsomes. This activity dropped to 18 during July and remained at this level through October. Fish completely adapted to sea water gave activities averaging about 90. We have interpreted the March increase in this activity as an indication of biological readiness for sea water adaption. At the termination of the migratory period (July), when the ATPase activity drops to near-normal fresh water levels, the animals may lose the urge to move into sea water. Such a conclusion is supported by the tests of Baggerman (1960) mentioned above and by the observed reluctance of fish to migrate in July (Noble, 1958).

In view of the above observations it may be important that juvenile coho be released from hatcheries early enough in the spring to assure completion of downstream migration by July. Consideration should be given to decreased migration rates resulting from impoundments above dams when selecting release dates. Raymond (1969) has shown that migration rates of chinook salmon through impoundments in the Columbia River system have been slowed to about one-third the rate in free flowing streams. Thus, if the July drop in gill ATPase activity can be interpreted as an indication that there is less tendency for the fish to enter sea water, then an unusually late release or a delay in seaward migration may have a noticeable effect on the numbers of fish actually making the transition to sea water. While experiments show that in the post-migration phase there seems to be no regression in the ability of coho to adapt to sea water (Conte *et al.*, 1966) other evidence indicates that these fish will not of themselves select this environment. Our experiments showing a decreased Na^+, K^+-activated ATPase activity suggest the possibility that there may be a regressive tendency to salt water preference and/or adaption.

Although most coho production in the Columbia River system is located below The Dalles Dam, thereby avoiding migration delay by impoundments, programs have been initiated in the upper Columbia. Especially in these cases, where distance and impoundments are factors, might it be well to consider the possible importance of coho reaching the ocean by July, keeping in mind that by the end of March or the first of April they appear to be biologically ready to move into sea water.

LITERATURE CITED

BAGGERMAN, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon (*Oncorhynchus*). J. Fish. Res. Bd. Canada 17: 295–322.

CONTE, F. P., H. H. WAGNER, J. FESSLER, AND C. GNOSE. 1966. Development of osmotic and ionic regulation in juvenile coho salmon *Oncorhynchus kisutch*. Comp. Biochem. Physiol. 18: 1–15.

MCINERNEY, J. E. 1964. Salinity preference: an

orientation mechanism in salmon migration. J. Fish. Res. Bd. Canada 21: 995–1018.
NOBLE, R. E. 1958. Downstream migration of silver salmon, timing-age-size, jack silvers-growth or inheritance. Proc. N.W. Fish Cult. Conf. 48–51, mimeo. (Unpublished.)
RAYMOND, H. L. 1969. Migration rates of yearling chinook salmon in relation to flows and impoundments in the Columbia and Snake Rivers. Trans. Amer. Fish. Soc. 97: 356–359.
———. 1969. Effect of John Day Reservoir on the migration rate of juvenile chinook salmon in the Columbia River. Trans. Amer. Fish. Soc. 98: 513–514.
WALLIS, J. 1968. Recommended time, size, and age for release of hatchery reared salmon and steelhead trout. Fish Comm. of Oregon, Research Division, Clackamas, Oregon, January 1968, 61 pp.

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