Adult Coho Salmon Recoveries and Their Na^+-K^+ ATPase Activity at Release

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Introduction

Many studies have examined relationships between quantitative changes in gill Na^+-K^+ adenosine triphosphatase (Na^+-K^+ ATPase) activity and migrational behavior in juvenile Pacific salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri,* (Ewing et al., 1980; Hart et al., 1981; Zaugg and McLain, 1972; Zaugg and Wagner, 1973). Although the role of this enzyme in the gill is not fully understood, it is believed to be an integral factor in "pumping" excess Na^+ ions from tissue back into the environment, particularly after the fish enters seawater. This physiological process maintains a proper balance of electrolytes throughout the body (Wedemeyer et al., 1980; Folmar and Dickhoff, 1980; and Epstein et al., 1980).

Gill Na^+-K^+ ATPase activity has been intensively studied in coho salmon, *O. kisutch,* and is observed to increase in fresh water during the spring of the second year (Zaugg and McLain, 1970, 1972, 1976; and Lasserre et al., 1978). This increase in activity appears to be associated with volitional seaward migration as well as with tolerance and adaptability of the fish to seawater. Knowing seasonal ranges of gill Na^+-K^+ ATPase activity might help hatchery personnel determine proper release times for coho salmon to achieve optimal seawater performance, an important factor in overall survival.

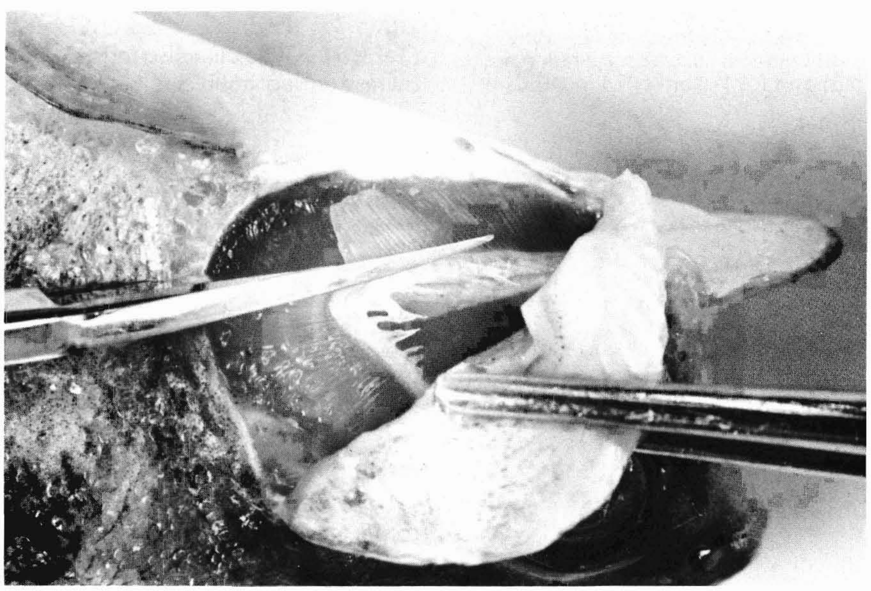
This study examines adult recoveries of hatchery-reared coho salmon whose release as normal yearlings during April and May 1976 was coordinated with gill Na^+-K^+ ATPase activity levels. Fish were released from two separate hatcheries at two separate times: 1) Before reaching maximum enzyme activity, and 2) at or near peak Na^+-K^+ ATPase levels.

Experimental Procedures

The 1974 brood coho salmon used were normal production fish reared on the Oregon Moist Pellet diet at Willard National Fish Hatchery (NFH) on the Little White Salmon River in Washington and at Eagle Creek NFH on a tributary of the Clackamas River in Oregon.

The freshwater study period was from early March to late May 1976. In March four groups of approximately 100,000 fish each were removed from the production ponds, marked, and put into separate ponds. The mark was an adipose fin-clip coupled with a coded-wire tag imbedded in the cartilage above the nares (Bergman et al., 1968). This technique is routinely used in salmonid experiments on the Pacific Northwest coast. Fish are identified in the various fisheries and hatcheries by the adipose fin clip mark, and the individual experiments are identified by removing the wire tag and identifying the binary code number.

During marking, about 2,000 fish from each of the four groups were randomly sampled to estimate the tag retention rate. The fish were released from Willard NFH on 27 April 1976 and 17 May 1976 and from Eagle Creek NFH on 28 April 1976 and 24 May 1976. Eighteen fish were removed by dip net from each test pond every 2



Gill filaments are taken for Na^+-K^+ ATPase analysis.

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weeks until release. Gill samples from six fish were pooled for ATPase determination (assayed in duplicate), thus giving three points for each pond for each sampling date. The Na^+-K^+ ATPase activities were determined as previously reported (Zaugg and McLain, 1976) with centrifuging times reduced one-half, and are reported as μ M Pi/mg protein^{-1} · h^{-1}.

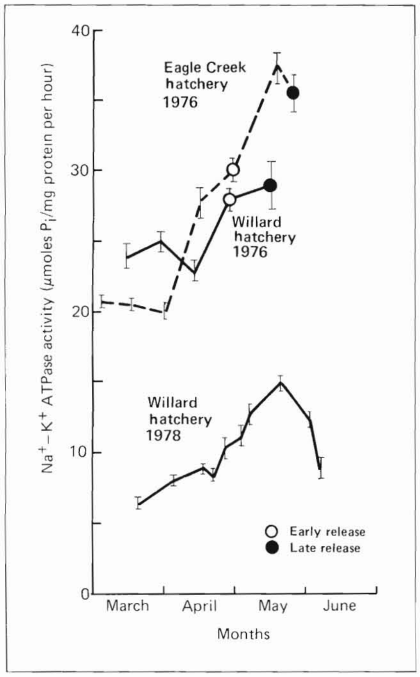

Figure 1.—Gill Na^+-K^+ ATPase activities of coho salmon at Eagle Creek and Willard National Fish Hatcheries in 1976. For comparative purposes ATPase activities using a less purified enzyme preparation are shown for Willard NFH in 1978.

Na^+-K^+ ATPase Activity and Survival

Na^+-K^+ ATPase activity in the gills of coho salmon from Eagle Creek and Willard NFH increased during April and May 1976 (Fig. 1). ATPase activity in fish gills from Eagle Creek NFH rose more uniformly and to a greater level than in the Willard hatchery coho. A profile of gill Na^+-K^+ ATPase activity obtained from coho salmon at Willard NFH in 1978 is shown for comparison with that of salmon released in 1976 (Fig. 1). Although the 1976 data were more erratic than the 1978 data, it is reasonable to assume that since climatic conditions were normal, the May release occurred near or at maximum activity. The first release from each hatchery occurred while the ATPase activities were still increasing; the second release occurred near or at peak activity in both the Eagle Creek and Willard NFH coho salmon.

The estimated total percentage recovery in all fisheries sampled plus hatchery returns from the late groups was 2.8 times more than the early release group for the Willard NFH coho and 3.1 times more than the early group for the Eagle Creek NFH fish (Table 1). These data also indicate that there were no appreciable geographic distribution shifts made by these two stocks due to delayed release. However, geographic distribution variations have been shown to occur with delayed releases of some salmon stocks (Novotny, 1980).

Implications

The results indicate that time of release from the hatchery and survival through maturity are related. Further evidence indicates that releasing coho salmon later than the normal late-April or early-May period has increased total survival as much as fourfold in other Columbia River hatcheries (Novotny, 1980). There is also evidence that survival can be increased still further by the correct combinations of fish size and time of release (Bilton, 1980; Novotny, 1980).

One possible factor contributing to the greater survival of coho salmon released later than normal is their marked increase in seaward migration rates (Zaugg, In press a, b). Coho released in June and July 1979 from three hatcheries on the Columbia River and its tributaries migrated nearly twice as fast as fish released in May, despite lower water flows. Although the June and July releases occurred after gill Na^+-K^+ ATPase activities had returned to lower levels, these fish rapidly re-elevated enzyme activities once they were liberated from the hatcheries. May releases, on the other hand, were made near peak ATPase activity. There is now evidence that fall

Table 1.—Number marked, average weight, percentage tag retention, and ATPase activity of coho salmon released from Willard and Eagle Creek National Fish Hatcheries and the areal distribution of recoveries by time of release.

						Recoveries						
						Fishery area and hatchery[1]						
Hatchery	Date of release	Number of fish marked	Percent tag retention	Average fish weight (gm)	ATPase activity	Wash.	Oregon	Calif.	Col. Riv.	Hatchery	Total number	Percentage of release
Willard	4/27/76	95,901	96.1	18.4	Ascending	107 (13.9)	224 (29.1)	14 (1.8)	16 (2.1)	408 (53.1)	769	0.8
	5/17/76	95,408	96.4	20.9	Maximum	339 (16.0)	300 (14.2)	4 (0.2)	68 (3.2)	1,404 (66.4)	2,115	2.2
Eagle Creek	4/28/76	97,931	97.4	29.3	Ascending	324 (37.4)	321 (37.1)	13 (1.5)	48 (5.6)	159 (18.4)	865	0.9
	5/24/76	96,608	96.6	34.1	Maximum	832 (31.3)	896 (33.7)	116 (4.4)	204 (7.7)	610 (22.9)	2,658	2.8

[1]Number of fish above and (in parentheses) percentage of total recoveries.

chinook salmon, *O. tshawytscha,* released before developing elevated gill Na^+-K^+ ATPase activity, migrate seaward much more slowly than fish released during or after enzyme activity development (Zaugg, In press b). It is likely that coho salmon exhibit the same characteristics; the April releases from the Willard and Eagle Creek NFH did not migrate as rapidly as fish released in May. In addition, fish released in April were probably more subject to predation than were fish released in May.

Also, later releases may have survived better because more food was available both in the river and the ocean. Nevertheless, if speed of seaward migration is important for overall survival, then release timing becomes important in its regulation. The level of gill Na^+-K^+ ATPase activity can be used as an indicator to time releases for maximum migration speed.

Although total recoveries of released 1974 brood coho salmon from Willard and Eagle Creek NFH were not high (Table 1), the data suggests that coho salmon releases based on the gill Na^+-K^+ ATPase activity cycle will result in increased total returns to hatcheries. More extensive studies of the relationship between release time and survival through maturity were undertaken in 1978, 1979, and 1980, and a cursory examination of the available data from these releases clearly supports the results of the early study.

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