CHINOOK CAPACTIY TO ADAPT TO SALTWATER

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INTRODUCTION

During their first or second year of life young anadromous salmonids undergo a physiological adaptation that allows them to migrate from the hypo-osmotic environment of freshwater rivers to the hyper-osmotic environment of the ocean. This process is commonly referred to as smoltification in yearling stream-type fish that have spent at least their first year of life in fresh water. Sub-yearling ocean type fish also must undergo this physiological adaptation, but they frequently do not undergo the visible physical changes commonly associated with smoltification of yearlings (Ewing and Birks 1972, Whitman 1987). Condition factor commonly decreases in yearling smolts but is naturally high in chinook migrating during their first year.

With pink, chum, and ocean-type chinook salmon this physiological transformation occurs within the first few months of life. With stream-type fish such as yearling chinook, coho, and sockeye the transformation (smoltification) occurs during their second year. Chum and pink salmon are unable to tolerate fresh water for more than a few months once their preference has changed to salt water (Baggerman 1960). However, coho and sockeye can revert to a preference for fresh water if they are retained in fresh water.

The preference for salt water and the physiological changes producing smoltification (Evans 1998, p. 447) appears linked to thyroid activity (Baggerman 1960). Increasing photoperiod in the spring triggers increased thyroid activity that stimulates the migratory behavior and preference for salt water.

CHINOOK ADAPTATION

As a species, young chinook are able to readily adapt to seawater both as fry, and as yearlings following smoltification. Different stocks have different capabilities according to their life-style characteristics as either ocean-type or stream-type fish. Ellis (1957) found ocean-type 3 g fall chinook fry (150/lb) adapted rapidly to high salinity with high survival to adult returns after only five days incremental adaptation to saltwater of 25-75% (~ 9 to 25‰). Tiffan et al. (2000) determined once active migrant fall chinook passed McNary Dam 470 km upstream from the Columbia River's mouth, 90% of the subyearlings were able to survive challenge tests in 30‰ seawater at 18.3° C.

Clark and Shelbourn (1985) determined very small chinook fry of 1.5 g and larger could survive and grow in seawater. Optimum regulation of plasma sodium occurred in 5.6 g fish

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that had been reared in 14°C fresh water prior to transfer to 10°C seawater (presumably 30-32‰). Maximum growth in seawater was observed in fish of 6 g transferred from 10°C fresh water to 14°C seawater in early June. They observed considerable delayed mortality in chinook they transferred to seawater that was apparently related to scale loss in fish reared in warm water. Survival to adult returns decreased somewhat with saltwater adaptation periods that lasted longer than five days or with direct release into saltwater.

Wagner et al. 1969 found that all fall chinook alevins tested were able to tolerate 15-20‰ salinity immediately following hatching. The fall chinook fry tolerated higher salinities with increasing size. They were able to tolerate 30‰ at a size of 65 mm (3 g). Wagner et al. concluded spring chinook had a delayed tolerance to salinity because they grew slower. Salinity tolerance appeared to be related to size rather than age.

Healy (1980a) found that chinook fry rear in tidal channels and marsh areas with salinities up to 24‰. Sims (1970) reported young chinook in the Columbia River that were marked on day in a fresh water area were found the next day in a high salinity area 43 km downstream. In the Situk River, Alaska, Johnson et al. (1992) found chinook fry from the lower river developed tolerance to saltwater (26-30‰) earlier than fish from the upper river. Ninety-one percent of the lower Situk River fish tolerated saltwater by mid-May. Nearly all fish 50 mm and larger tolerated saltwater. In a laboratory investigation Kepshire and McNeil (1971) found chinook fry placed in saltwater 50 days after hatching had lower growth rates than those remaining in fresh water.

Chinook fry from different watersheds can have different capacities to adapt to salt water. Kreeger (1996) identified a difference in saltwater adaptation capability of chinook fry from two Oregon watersheds. Under laboratory conditions 65% of Trask River chinook could survive 32‰ salinity at 50 days after first feeding, while only 40% of the Rogue River fish could tolerate the same high salinity. Both populations were similar in that they required 108 days following first feeding to competently osmoregulate in seawater.

However young chinook do not necessarily move immediately to saline waters even when in the immediate vicinity. Sacramento-San Joaquin chinook fry less than 70 mm tend to rear in the upper fresh water portion of this internal delta for about two months (Kjelson et al. 1982). Chinook fry larger than 70 mm migrate through the brackish delta bays. Kask and Parker (1972) collected young chinook (43-90 mm) in the Somas River estuary on Vancouver Island above the halocline, where they remained in low salinity water even though they were in an estuary that was predominantly more saline at greater depths.

Movement for fresh water to saline water apparently does not place high metabolic demands on young salmon. Bullivant (1961) found young chinook had no significant difference in oxygen consumption rates when in fresh water, dilute sea water, or sea water (35.4‰). He interpreted this lack of difference in oxygen consumption as an indication the energy expended on osmoregulation was a small portion of the total energy consumption.

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