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Inshore Migration of Adult Fraser Sockeye, A Speculation

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ABSTRACT

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Because coho smolt prey on fry, pink and chum, the recent increase in abundance of smolt from hatcheries has led to a significant increase in this predation, particularly in Puget Sound and Juan de Fuca Strait. Predation has reduced the proportion of fry moving seaward through Juan de Fuca and, as returning adult sockeye are coupled to the seaward migration of fry, a greater proportion has returned via Johnstone Strait.

RESUME

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Etant donné que les alevins de saumon kéta et de saumon rose constituent une proie pour les jeunes saumons cohos, l'accroissement du nombre et de la taille de ces derniers, depuis les années 1960, en raison d'ensemencements effectués par des piscifactures, a entraîné une augmentation importante de cette prédation, spécialement dans des régions comme la baie Puget et le détroit de Juan de Fuca. La prédation a réduit le nombre d'alevins qui se rendent à la mer par le détroit de Juan de Fuca et, comme les saumons rouges adultes sont associés au mouvement migratoire des alevins, un plus grand nombre d'entre eux sont retournés à la mer, depuis les années 1960, par le détroit de Johnstone.

HMCS Ehkoli at the builder's yard in 1941 about the time of acceptance by the RCN. Ehkoli has been utilized in oceanographic survey for many years and is still in service as a Canadian Forces Auxiliary Vessel (CFAV). During the latter part of the war Ehkoli was allocated to oceanography in support of a research program* led by J.P. Tully and W.M. Cameron. Much of the field work of the program was carried out in Johnstone Strait, Strait of Georgia and Strait of Juan de Fuca.

*See for example: Campbell, N.J. 1976. An historical sketch of physical oceanography in Canada. J. Fish. Res. Board Can. 33:2155-2176.

According to Craigie (1926, p.217) G.H. Parker suggested the olfactory sense may mediate the migration of Pacific salmon; Chidester (1924, p.109) considered this unlikely. Another early reference is in the Proceedings of the 1938 Ottawa Conference on Salmon Problems (Moulton 1939, p.103) during which Dr. Huntsman referred to Mr. White's experiment (White 1934) from which it seemed "the presence of young salmon in the river determined whether the local adults would or would not ascend the river. It would be through some odorous substance that came from the young" (see also Ricker 1938, p.212; Liley 1982). In other fish, e.g. young cichlid, the ability to chemically distinguish relatives may enhance survival (Barnett 1982), while of Great Lakes fish the olfactory sense was seen a "stock-isolating mechanism" in a review by Horrall (1981). With regard to Fraser River fish Favorite (1961) suggested "that the seaward extent of dilute surface water may determine the location where homeward migrating salmon enter coastal waters" and Wicket (MS undated) suggested that this dilute water contained "concentrations of Fraser River odours that release the sock-eye's drive to enter Fraser River water". Nordeng (1977) visualized that sea-going young "establish population-specific pheromone trails leading from their respective freshwater home localities out to the salmon at sea". (see also Solomon 1973).

That adult salmon of the Fraser River may on return pass through either Juan de Fuca or Johnstone Strait has been of oceanographic interest from at least 1958 when an unusual proportion moved south through Johnstone Strait (Anon. 1959, p.3; Gilhousen 1960; Henry 1961), apparently in response to anomalous oceanographic conditions (Tully et al. 1960; Royal and

Tully 1961). Historically the percent return by Juan de Fuca has been higher (Gilhousen 1960), but in recent years an increase has occurred in the proportion returning via Johnstone Strait (e.g. Anon. 1979, p.34; 1981; 1982a; Wickett 1977; undated; note 1). Here I develop a predation scenario to explain the increased use of Johnstone Strait by adult Fraser sockeye. I speculate that one of the cues the adults utilize is the "residual scent of natural products" remaining from the passage of seaward moving fry (Barber 1979) and that through selection fry have come to move into the ocean via Johnstone Strait rather than the Strait of Juan de Fuca. For here an increased coho population, hatchery smolt and adult, preys on pink and chum fry so as to remove a disproportionate number of those fry that would in normal circumstances move seaward via Juan de Fuca Strait.

Coho can prey on pink fry (note 2); indeed an early marine mortality of pink fry due largely to predation by young wild coho can be severe, approaching 80%, in a coastal waterway (Parker 1971). In Puget Sound not only has hatchery production "increased very sharply since 1960" but there has also been "an increasing trend in average release size with time", apparently beginning in 1964 (Mathews and Olson 1980, p.1377 and their Table 2); Kaczynski et al. (1973) noted that "the relatively large reduction of pink salmon stocks in recent years is reasonably coincidental to the development of the massive salmonid hatchery system in Puget Sound...". Other less evident aspects include the possibility that hatchery coho have a general tendency to remain in the general area of the release site (S.B. Mathews, personal communication), i.e. given an equal number of wild and hatchery smolt fewer of the hatchery fish move away from coast (Puget Sound and

Juan de Fuca) into the ocean. Another is that as a result of hatchery feeding techniques, hatchery fish may be more piscivorous than are wild smolts, and so could cause even greater impact on fry than has been described. The increased output of coho smolt from Oregon hatcheries since 1960 (Gunsolas 1978; McGie 1981) may also play a role. According to Pacific Packers Report (Anon. undated) 615 million coho smolt were released by public hatcheries in Washington in 1978 and about 25 million from public and private groups in Oregon. Reed (1971) said that Washington plantings rose from 20 million in the 1950's to over 60 million in 1970, while Castoldi and Rasch (1982) reported that about 371 million salmon were released in 1981 of which about 122 million were coho (p.339). Gunsolas (1978, p.4) provided a listing of Oregon releases for 1960 to 1976 during which releases rose from 14.5 million smolts to about 63 million (see also McGie 1981, p.21; note 3).

Present understanding is that salmon may utilize a variety of information in the movement out of the ocean, i.e. they use a variety of data in determination of the route, and certainly in the final stages of migration they have proven remarkably accurate (e.g. Ricker 1972, p.30). That the information may include the distribution of fry is my speculation. But what is the distribution of Fraser fry in the marine environment? The literature is not too useful, for little is known about the quantitative distribution of young in the offing; however, it is clear that distance away from the river increases rapidly in a general movement to the northwest (Royce et al. 1968; Hartt 1980). Indeed some young pink salmon must move directly seaward from Vancouver Island to become "far offshore in the Gulf of Alaska by late November" (Hartt 1980, p.45, 46).

But most stay within coastal water initially where gradually some begin to move into the ocean (Peterman 1975). This likely occurs first with those young moving northwest along the open coast of Vancouver Island, but eventually they are joined by fry moving out of Queen Charlotte Sound. Some young then are distributed in the ocean, or edge of the ocean, in time to meet and to intercept the returning adult moving toward the coast. And what determines this distribution? Again little is known, but it appears likely that the seaward movement of juvenile is under genetic control, i.e. it is innate (Raleigh 1971). Consider for example that the level of predation by coho on fry in the area of the southern Strait of Georgia and Juan de Fuca increased with the advent of hatchery coho to become depensatory with regard to those populations of fry genetically disposed to move through Juan de Fuca. That is, Fraser populations gradually through predation have come to comprise mainly fry disposed to move seaward via Johnstone Strait. A greater proportion of returning sockeye adult has thus been intercepted by young out of Johnstone Strait, to subsequently follow the residual scent of these young toward the Fraser. And how to test this speculation? It seems unlikely that the increased predation would have influenced in recognisable way the abundance of the particular fry populations - although the unusually poor marine survival of the 1963 brood of Fraser pink salmon may have been a consequence - so that study of statistics on catch and escapement would not be meaningful. It might be useful to determine in a sampling programme the present distribution of juveniles; however, there does not appear to be any other way to provide an appropriately direct test.

There may however be other relevant considerations, e.g. that the coastal distribution of coho may be altered by peculiar ocean conditions as well as by output from hatcheries (note 4). The long term cycle in both Wickett's data and Gilhousen's (see again note 1) suggests that the predation hypothesis might be applicable to Gilhousen's earlier qualitative observations. For example, a northward intrusion along the coast of a more southerly and different water mass could have altered the normal (prehatchery) distribution of coho and the associated predation on pink and chum fry moving into the ocean through Juan de Fuca; perhaps only those fry moving through Johnstone Strait attained the ocean in particular years. The main weakness here is that we know little of the nature of these intrusions, or how to recognise them. If they comprise a warmer water, as is generally believed, then I note correspondence with Gilhousen's indication of an anomalous return in 1936 (e.g. Fig.1) and Tully's (1937) comment about warmer water temperature in the summer of 1936. There is then correspondence between several factors: the ocean condition, the anomalous returns in 1938 and 1958, and the sunspot cycle. (This is a recurring theme, e.g. in 1981 Love and Westphal remarked a congruence between crab catch and sunspot cycle). But what of the ocean condition in other years of anomalous return noted by Gilhousen, i.e. 1903-1904, 1915, 1926, and 1947? In 1947 at Amphitrite Point (Vancouver Island) sea surface temperature in July and August was warmer than usual, but not as warm as in 1936 or 1958 (Hollister and Sandnes 1972, p.62; see also Tabata 1957), while at William Head in 1926 sea surface temperature was well above average for the 20 years of data available there (Hollister and Sandnes 1972, p.80). In

1960 Roden and Groves showed that relatively strong positive surface temperature anomalies occurred just off the coast of Washington in 1926 and 1936, but I have not located data on coastal water temperature for 1903-1904. Even without data for 1903-1904 then there is good indication that southerly intrusions, as indicated by warmer water, have been significant to the route taken by returning adult. These intrusions presumably can be anticipated to recur, but have not been particularly strong since 1958, although both 1978 and 1981 will likely prove anomalous (e.g. Duggins 1981; Freeland and Giovando 1982; Dungan et al. 1982). But what of future hatchery production of coho? Some levelling appears likely in Oregon and Washington, but in British Columbia output is to increase, particularly in water around Vancouver Island, so that an enhanced predation there on fry (pink and chum) is anticipated. If so, and assuming that adult Fraser sockeye could attain the river using a variety of cues, perhaps only a long-term cycle will be seen, as in Gilhousen's data.

My speculation in part follows from the belief of Parker (1971) that the observed high intensity of coho smolt predation on pink fry "can exert strong influence on evolutionary development..."; his concern was to survival and in laboratory experiment he showed a selection by smolt for size, i.e. for small size. I do not suggest that size selection has significance in the predation scheme I propose, but it may. Nevertheless, the scheme is one of selective predation wherein an influence on abundance (a decrease) is seen for those young moving seaward via a particular route.

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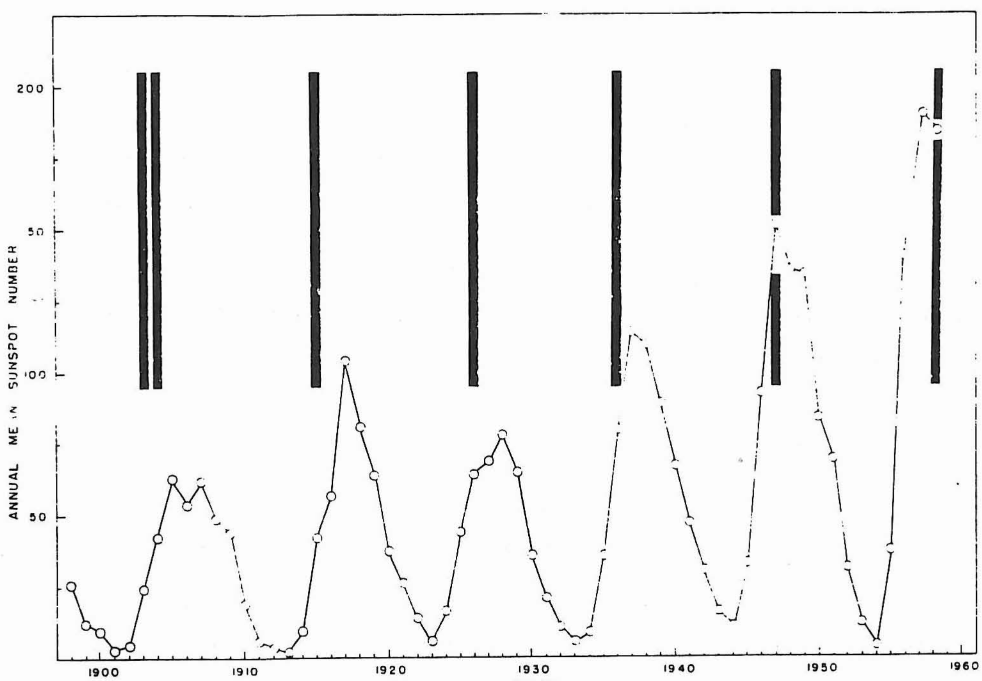

Figure 1. "Years of heavy migration through Johnstone Strait (bars)" and "annual means of sunspot numbers" (from Gilhousen 1960).

Notes

1) Analysis of the data tabulated by Wickett (undated, his Table 1) indicated a significant correlation with time (r = 0.6) and the occurrence of two peaks in the auto-spectrum, one relatively short of two years and one at longer term of between 11 and 14 years. Gilhousen (1960; Fig.1) in earlier data saw a longer period which he associated with the so-called sunspot cycle (see also Anon. 1982a). The shorter, 2 year, period suggests an association with the life cycle of pink salmon; Wickett's data indicate greater percentages in many even years, i.e. in years pink fry of the Fraser on-year migrate into the ocean. This relation with the relatively large fry out-migration in even years and the likelihood that an increased level of predation would attend the increased hatchery output of coho smolt led to the speculation.

2. Although there is ample evidence for coho predation upon juvenile chum and pink salmon in the spatially-restricted fresh-water environs, there is essentially no substantiation of significant predation by either coho or chinook in estuarine or marine environs and there is much evidence to the contrary, i.e. few juvenile chum or pink have ever been found in the thousands of stomachs analysed in this region. Parker (1971) is, as here, pure unsubstantiated speculation.

This portion of a referee's comment appears to reflect the opinion of many fisheries scientists. For example, at the February 1982 Symposium of Fisheries and Oceanography of the Strait of Georgia at Nanaimo (Ellis 1982) several participants remarked on their frequent observation of spring and coho preying on chum fry in an estuary, but apparently most were without such experience. Coho can prey on pink fry (Pritchard 1936; Cameron 1958; Hunter 1959; Walker 1960*, Parker 1971*; Kaczynski et al. 1973*; Robinson et al. 1982*), chum fry (Synkova 1951; Semko 1954; Hunter 1959; Sano 1966; Parker 1971*; John R. Sibert pers. comm.*; Fresh et al. 1981*; Robinson et al. 1982*) and "fry of _kisutch_ and other species of Pacific salmon" (Neave 1958, p.26; see also Synkova 1951; Pritchard and Tester 1944*, p.15; Semko 1954, p.91). Many of these references are to predation on pink and chum fry in a stream, but some (those marked with an asterisk) concern predation in the marine environment.

3) In 1982 the Alaska Department of Fish and Game released 178.4 million juvenile salmon of which less than 3 million were coho (Anon. 1983, p.28).

4) In years of large diversion useful prediction has been achieved using physical oceanographic variables, e.g. surface transport and sea surface temperature (Anon. 1982b, p.25).