

PHILIP GILHOUSEN

*International Pacific Salmon Fisheries Commission
New Westminster, B.C.*

Marine Factors Affecting the Survival of Fraser River Pink Salmon

THE INTERNATIONAL Pacific Salmon Fisheries Commission has studied two cyclic runs of Fraser River pink salmon (*Oncorhynchus gorbuscha*). Although our experience with pink salmon is not far advanced, we have been able to borrow many useful ideas from long experience with sockeye (*Oncorhynchus nerka*). The following discussion will relate some of the facts and concepts we have assembled concerning factors acting in the marine environment to affect pink salmon survival.

Management of Fraser River pink salmon has a twofold purpose; maintenance or expansion of the runs and division of the catch between Canada and the United States. Regulation of the fishery is important to the Salmon Commission because it determines both division of catch and amount and nature of the escapement. Adequate regulations cannot be devised unless a reliable forecast of survival is available. Knowledge of factors controlling survival are therefore of prime importance to our management program. Because measurement of freshwater survival appears to provide a poor index of adult pink salmon return, survival during the marine phase of pink salmon life history is being studied.

This spring, the first study of the early marine life of Fraser River pink salmon was undertaken. Sampling of the downstream migration in the Fraser River mouth confirmed the time of saltwater entry of pink salmon fry inferred from measurement of emergence curves in the spawning streams. It appears that the bulk of the fry enter salt water in April with a range from March to May. This rather restricted period of saltwater entry must be connected with survival or else pink salmon would never have been selected toward this specialization.

Sampling of the population of young Fraser River pink salmon in coastal waters was carried out this spring and summer on an exploratory level. Beach seine and purse seine hauls were made in several areas adjacent to the mouth of the Fraser River. Sampling was carried out in the "Gulf Islands" from Valdes Island to Saturna Island,

in the San Juan Islands, at Point Roberts, and in the outer end of Burrard Inlet near Point Grey (Figure 1.). Pink salmon young were taken at most stations, and young salmon, probably including pinks, were seen along almost every shore visited.

Young pink salmon were taken from April until August, when the sampling was terminated. The appearance of very young fry along the island shores suggests rapid dispersal from the Fraser River mouth. This is consistent with what is known concerning the movement of Fraser River outflow in Georgia Strait. At least during the period of spring freshet, from April to July, most of the river outflow is rapidly dissipated past the islands of southern Georgia Strait and thence through Juan de Fuca Strait.

A portion of Fraser River effluent moves northward along the east shore of Georgia Strait. No investigation was made concerning the movement of pink salmon fry to the north because of limited facilities.

Fraser River pink salmon fry, like those observed in other areas, spend a considerable period of their early saltwater life in the littoral zone. Very likely this zone provides

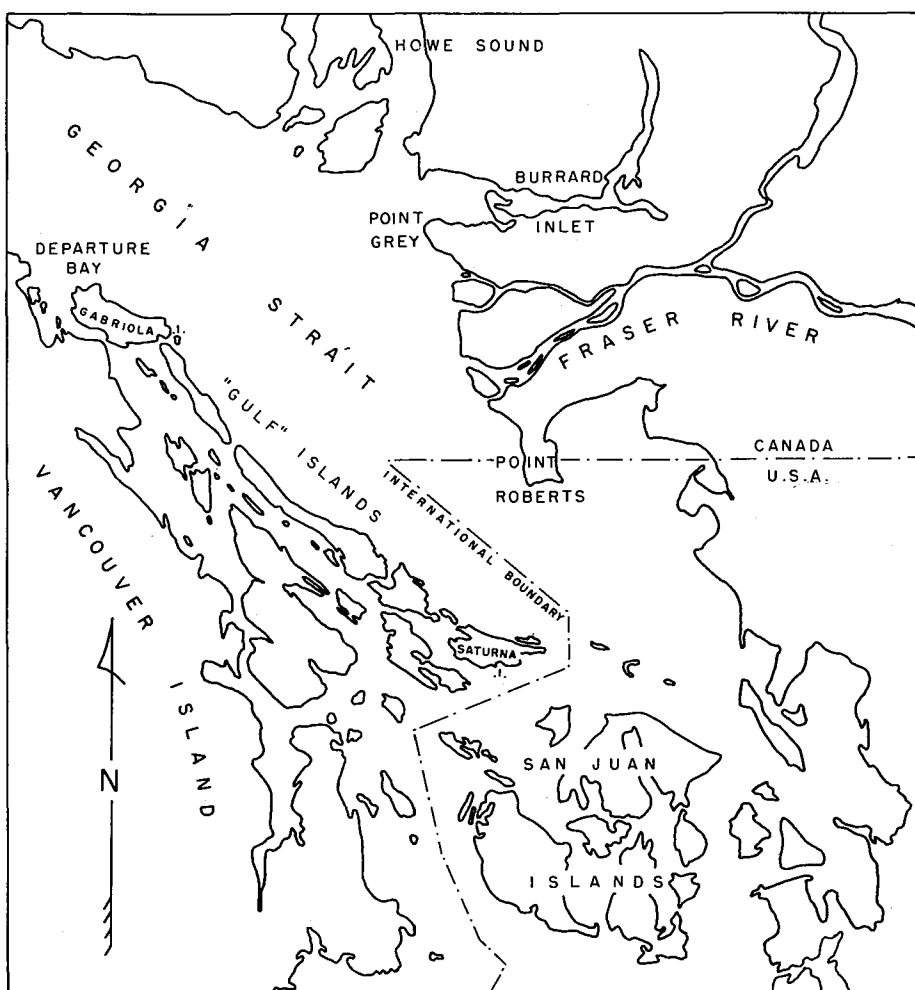


FIGURE 1.

AREAS ADJACENT TO THE MOUTH OF THE FRASER RIVER WHERE YOUNG PINK SALMON WERE CAPTURED IN THE SPRING AND SUMMER OF 1960.

Marine Factors Affecting the Survival of Fraser River Pink Salmon

them with both a food supply and shelter from their enemies. Preliminary examinations of stomach contents shows that much if not all of their food is littoral in origin.

Comparisons have been made of the size of young pink salmon taken along the shores with beach seines and those taken farther offshore with purse seines. The smaller fish appear to stay closer to shore than the larger young. This edging away from shore as the young grow is probably part of the general movement away from the land and to the open ocean. Presumably, young pink salmon must stay in the shelter of the shore until they reach sufficient size to venture to the open water.

Several investigators have concluded that conditions occurring during the early marine life of pink salmon are exceedingly important to overall survival. Mr. Vernon's examination of environmental factors (1958) showed a useful relationship between seawater temperature and salinity in the lower portion of Georgia Strait in spring and summer, and subsequent pink salmon catches in the next year. The best single factor for predicting the return of Fraser River pink salmon appears to be the mean April to August seawater temperature from Departure Bay, a point about 35 miles from the mouth of the Fraser River (Figure 1). Although other factors, such as salinity, were found to have a partial relationship to survival none approached the usefulness of the inverse relationship with seawater temperature. Many of the factors studied were partially inter-dependent, making it difficult to determine basic causes.

Seawater temperature could affect young pink salmon directly, but if the relationship is in fact valid, it more likely acts through the food supply or predator distribution, or through the distribution of young pink salmon in relation to these factors. We feel that possibly hot weather and warm water along shore cause young pink salmon to stay farther offshore where predators take a higher toll than in years of cool weather. We have not yet investigated such predation but there is a long list of possible predators. The theory of variable predation is strengthened by the recent finding in South-eastern Alaska of herring feeding on young pink salmon, especially since there are large herring populations in Georgia Strait.

The relation of pink salmon catch to conditions early in marine life appears to act semi-independently of escapement and therefore possibly of fry production in fresh water. Apparently conditions for survival in the marine environment have been so variable that variations in fry abundance have had a secondary effect on total survival. Records of extremely large runs of Fraser River pink salmon in early years (Rounsefell and Kelez, 1938) presents the possibility of obtaining, by proper management of fry production, much larger returns than are currently being obtained for any given level of marine conditions.

Young pink salmon apparently leave inshore waters in midsummer and move to the open sea. We do not have direct evidence as to what areas they inhabit in the year spent in the Pacific Ocean. The migration routes followed on the spawning migration suggest a wide distribution both north and south of the Fraser River. During the Fraser River pink salmon runs of odd years, salmon trollers have taken pink salmon at least as far south as Northern California (Figure 2). Along the Oregon and Washington coasts, a definite northward movement of adult pink salmon has been detected. A similar southward movement of pink salmon has been noted from the Queen Charlotte Islands toward Juan de Fuca Strait.

A considerable portion of Fraser River pink salmon are known to approach the Fraser River via Johnstone Strait (Figure 2). A complex migration of this type poses a problem in regulating a pink salmon run. A fishery exists in Johnstone Strait as well as along the southern migration route. Because the efficiencies of the two fisheries are

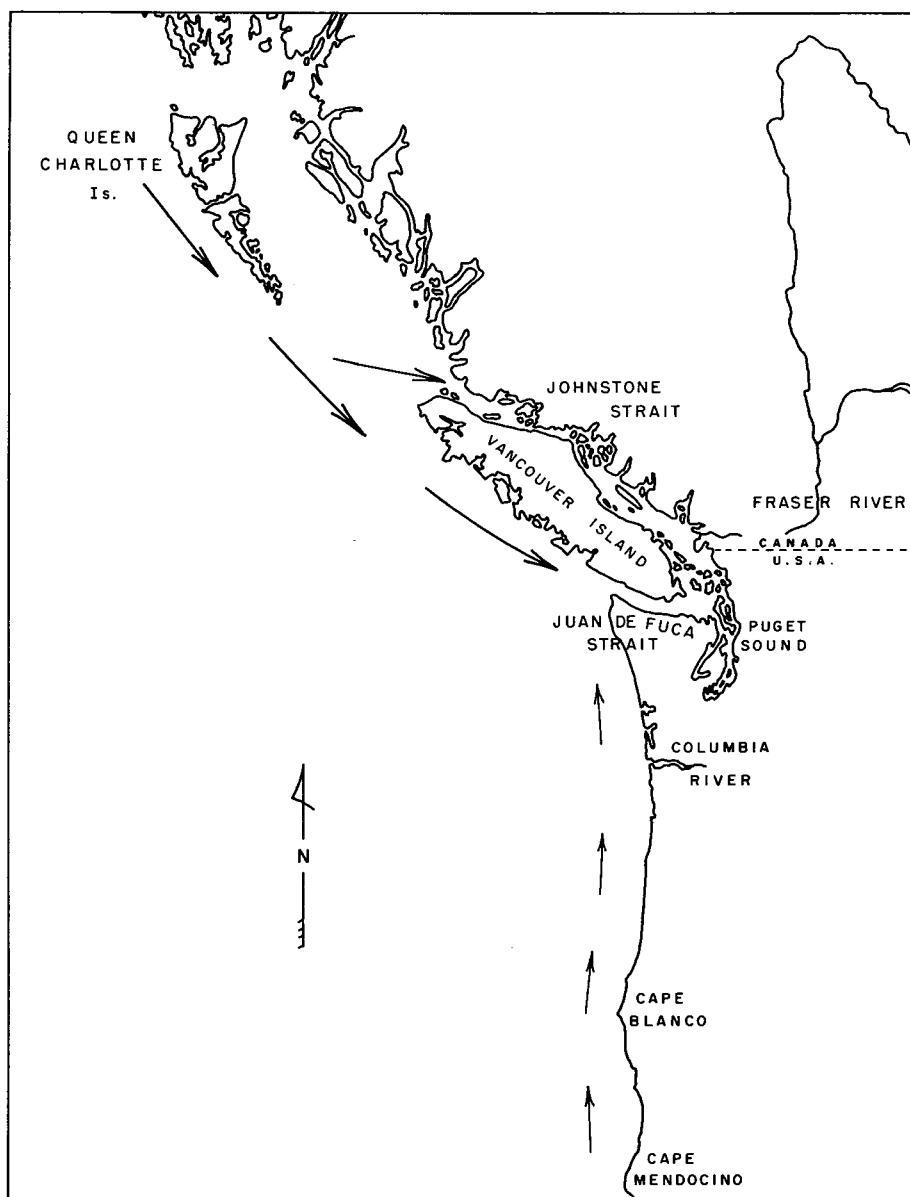


FIGURE 2.

MIGRATION ROUTES OF PINK SALMON IN THE OPEN OCEAN BOUND FOR SPAWNING GROUNDS IN OR NEAR THE FRASER RIVER.

not exactly known, one is never sure just what proportion of the escapement is coming from each route.

Fraser River pink salmon have been divided into two overlapping segments, one early and one late in migration. At present, there is no way to distinguish between fish from the two segments until they separate when approaching the spawning grounds. Regulation of the two groups in the fishery must be based on the timing of previous year's runs whereas sockeye runs may for practical purposes be separated by scale pattern variations noted during the course of fishing.

Marine Factors Affecting the Survival of Fraser River Pink Salmon

A feature of the pink salmon spawning migration worth mentioning is the delay in migration before river entry. Ward (1958) demonstrated a delay of about a week and a half off the mouth of the Fraser River for the major (early run) segment of the 1957 Fraser River pink salmon migration. This was confirmed by the results of tagging experiments carried out in 1959. Also, in 1959, a delay of at least this length could be demonstrated for the late run pink salmon.

The delay in migration of some salmon runs off the mouth of their native river offers several problems to salmon management. One of these is the problem of causing variation in time of spawning by selective regulations in the fishery. Retention of chronological order of individuals in a salmon migration has been demonstrated for both sockeye and pink salmon. What happens if a salmon migration stops for several days? Does the run maintain the same chronological order after the delay as it had before the delay in migration? Or does the run rearrange itself in a random fashion? The results of recent tagging experiments on Fraser River pink salmon indicate that the same chronological order is in fact maintained throughout the migration despite a delay off the Fraser River mouth of almost two weeks. The nature of the spawning population can therefore be controlled by selective fishing regulations applied *before* a delay.

The consequences of altering the natural timing of spawning to make it earlier or later are not obvious. However, one must reflect upon the restricted spawning period that nature has produced in unit salmon runs. Also the existence of fry survival rates which vary with spawning time has been reported by Mr. Merrel in a previous paper of this symposium.

Fishing regulations have been designed considering the nature of the spawning populations. Because the Fraser River pink salmon run is composed of at least two independent, overlapping segments, the Salmon Commission has tried to maintain a uniform fishing pressure throughout the temporal extent of these segments or races. Thus the pattern of spawning will be little changed from what would have occurred had there been no fishery. The only variation from this principle is the technique of selective protection of the peak of a race in which the average time of spawning will be little changed from that of an unfished run.

LITERATURE CITED

- MERRELL, T. R., 1962. Freshwater survival of pink salmon at Sashin Creek, Alaska. Symposium on Pink Salmon, Univ. Brit. Columbia, H. R. MacMillan Lectures in Fisheries.
- ROUNSEFELL, G. A., and G. B. KELEZ. 1938. The salmon and salmon fisheries of Swiftsure Bank, Puget Sound, and the Fraser River. U.S. Bur. Fish., Bull. 49 (27): 693-823.
- VERNON, E. H. 1958. An examination of factors affecting the abundance of pink salmon in the Fraser River. Internat. Pacific Salmon Fish. Comm., Prog. Rept. New Westminster, B.C., Canada.
- WARD, F. J. 1959. Character of the migration of pink salmon to the Fraser River spawning grounds in 1957. Internat. Pacific Salmon Fish. Comm., Bull. 10. New Westminster, B.C., Canada.

DISCUSSION

- MR. MANZER: You made reference to the sizes of pinks along the Gulf Islands. They were smaller along the beaches and increased in size further offshore. Were these samples taken about the same time?
- MR. GILHOUSEN: I would like to say in that respect that I didn't do the work. The work was done mostly by Mr. Verhoeven and Mr. Vernon. I think Mr. Verhoeven could answer than better than I could.
- MR. VERHOEVEN: One comparison we have made was from fishing at San Juan Island. We had a beach seine sample and a purse seine sample taken at the same time. The fish in the purse seine sample were much larger than the largest fish in the beach seine sample. Later on, when we were still able to get fish by purse seine, we could no longer observe nor were we able to catch them with the beach seine.

Symposium on Pink Salmon

- DR. KOO: My question is in regard to the migration routes of the pink salmon as you indicated on the map. I might have missed some of your points, but I was wondering just how you arrived at these migration routes of the pink salmon northward from the California coast and southward from the Queen Charlotte Islands?
- MR. GILHOUSEN: Coming from the south, the Fraser River pink salmon run is the only run of any size, so it seems logical that there would be little but Fraser River pink salmon that would be caught in numbers by salmon trollers south of the Juan de Fuca Strait. However, to the north there are other pink salmon runs, and this complicates the matter. The nearby non-Fraser runs in the odd numbered years, when the large Fraser River pink salmon is on, appears to be considerably smaller. Moreover the catch by the troll fleet is so much larger than in even years that we infer that the catch is largely Fraser River pink salmon even as far north as the Queen Charlotte Islands.
- Also, there was mention made yesterday, I believe, of one pink salmon tagged off the islands of southeastern Alaska that turned up in or near the Fraser River. I don't know whether it was a Fraser River or Washington State pink salmon, but anyway it does show that pink salmon can migrate from that area.
- DR. KOO: Does the Commission have any plans of proving these migration routes by tagging or other studies?
- MR. GILHOUSEN: Not that I know of.
- MR. HIRSCHORN: How did you show in your tagging that the delay did not affect chronological order?
- MR. GILHOUSEN: We used tags applied in salt water in an area far enough away from the mouth of the Fraser River that they would not be in the zone of delay. We compared the time of tagging with the time of recovery as dead fish on the spawning grounds. If you know something about the nature of spawning in salmon, there is usually a fairly uniform period between the time of spawning and the time of death, so that the time of death would indicate the time of spawning. We found a very good correlation between the time of tagging and the time of spawning as inferred from the time the dead fish were recovered, and our dead recovery was quite considerable. It wasn't just a spot effort; it was an every day careful examination on the spawning grounds.
- MR. SHERIDAN: I don't think, you mentioned this, but do you think it is possible that the low temperatures in the estuary would depress the urge or the ability of the small pink salmon to feed, regardless of whether there was food available for them or not?
- MR. GILHOUSEN: We have no idea of that. The only thing I can say in that regard is reference to Dr. Ricker's statement that possibly in southeastern Alaska you are working in the lower range of temperature tolerance of the young salmon in coastal areas, and we are working at the upper end of tolerance in some way.
- DR. HOURSTON: You mentioned the possible theory of warm water driving the small salmon offshore where they would be more susceptible to predation. I was wondering on what basis you would consider that they would be more susceptible to predation offshore. Surely there are major sources of predation inshore. One factor you mentioned was the herring. Except for the resident population, the stock of herring in the Gulf at the time is not too large and generally their food sources are primarily organisms smaller than young salmon, although they certainly will feed on the larger type organisms such as small salmon or small herring on occasion. I wouldn't consider that herring would be a major source of influencing survival of young salmon. Have you anything in mind besides them?
- MR. GILHOUSEN: No, this was just a possibility we discussed. We haven't carried on any detailed observations on the herring. I have heard they tend to stay a little further offshore than salmon do.
- My own feelings are that temperature does not have any direct effect on these salmon as far as mortality goes. I can't see that it could act directly, but must act somehow through the food or lack of it, or through competitors. Beyond that, we can't go at this time.
- MR. VERNON: I would like to mention in addition, since I was involved in some of this work, that we were rather impressed with the lack of predation in shallow areas. We have no information on deep water for comparison, but the fish we found in shallow water did not prey on pink salmon.
- DR. MCHUGH: This differential distribution, inshore, offshore, according to size is not an unusual phenomenon at all. It is very common, for example, in the herring-like

Marine Factors Affecting the Survival of Fraser River Pink Salmon

fishes in general and a good many estuary fishes on the east coast have similar habits. So really, it seems to me very reasonable to assume that predation would be more serious offshore than in the inshore waters because they would come in contact with larger individuals of the same species which would be likely to eat the small salmon.

MR. HIRSCHORN: I was thinking back on some earlier work I did on young herring, and it depends a lot, on where the young salmon are found inshore. If they are found in areas where you are more likely to get sea bass or cod, such as around wharves, and that sort of thing, you have a tremendous source of predators which will feed on young fish of any kind when they are available.

In just spot examinations, I have opened some of these fish for stomach counts and found up to 50 small fish which were recently taken by these fish, mixtures of young salmon and herring.

DR. THOMPSON: A point I would like to bring out: If I understand it correctly, there are colonies of pink salmon spawning in many streams on Puget Sound beyond the Fraser River, and I have personal recollection of fish spawning in northern California. Your evidence of movement north would have to be pretty strong if there isn't a possibility that those small colonies would not explain the occasional catch of pink salmon to the south of the Straits.

MR. GILHOUSEN: I am not familiar with the details of the catches made by the trollers, but I assume they have been of sufficient proportions to eliminate most of these local streams and, also, they appear to occur only in the odd years.

MR. VERHOEVEN: In regard to this question of evidence for the dispersal of pink salmon both north and south we have some isolated instances, and they do not necessarily pertain only to Fraser fish. They might be Puget Sound fish, or they might be fish going to areas in southern B.C. But of pink salmon that were artificially propagated and marked at Hood's Canal in the State of Washington, one was recently reported taken off Oregon, which would show a dispersion southward.

In regards to northern areas, I remember in 1957 that one of the Fisheries Research Institute's marine tags, was picked up in the Vedder River. I personally picked up one in Spuzzum Creek. It had been put on at Noyes Island off Prince of Wales Island. Of course, these are just isolated bits of information.

MR. WICKETT: There are some other isolated reports as Pritchard's returns of marked fish presumably marked in the Queen Charlottes which were recovered on the Fraser. This is giving you a reverse twist. They were marked as fry in the Queen Charlottes and recovered as adults in the Fraser.

DR. TULLY: I would like to ask the speaker in that part of Puget Sound between Los Angeles and Kodiak, how long—

(Laughter)

—how long are the pink salmon found in the coastal waters, what time do they first appear in that troll fishery?

MR. GILHOUSEN: I am not familiar with the details. I assume that it (appearance of pinks in the troll fishery) would be just through the summer (of the spawning migration).

VOICE: July, I would guess.

DR. TULLY: They enter the coastal waters in July, approximately?

VOICE: Yes.

DR. TULLY: And what time do they enter the ocean going on the seaward migration? I am not talking about the Strait Juan de Fuca. I mean getting out past, say, Swiftsure, or thereabouts.

MR. GILHOUSEN: We have no direct evidence, but presumably it is in the summer or early fall at the latest.

DR. TULLY: I have really been trying to get some information on this because it affects the time consideration when these beasts are exposed to an ocean environment.

H. R. MacMILLAN LECTURES IN
FISHERIES

Symposium on Pink Salmon

A SYMPOSIUM HELD AT
THE UNIVERSITY OF BRITISH COLUMBIA
OCTOBER 13 to 15, 1960

Edited by N. J. Wilimovsky

INSTITUTE OF FISHERIES
THE UNIVERSITY OF BRITISH COLUMBIA
VANCOUVER

1962