SALMON OF THE NORTH PACIFIC OCEAN—PART III
A REVIEW OF THE LIFE HISTORY OF NORTH PACIFIC SALMON
6. CHUM SALMON IN BRITISH COLUMBIA

by Ferris Neave, Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

SPAWNING AND INCUBATION

The spawning of chum salmon, *Oncorhynchus keta* (Walbaum), in British Columbia takes place over a considerably longer seasonal period than that of pink salmon (*O. gorbuscha*). In certain glacier-fed streams in the northern and central coastal regions of the province chum salmon arrive on the spawning grounds as early as July. In southern areas few fish appear before September, and while the timing in individual streams may be restricted, this region as a whole shows runs which reach the spawning grounds from this time until at least well into January.

As in the case of pink salmon, chum salmon frequently spawn in tidal areas and indeed have been observed to conduct digging operations in places remote from any surface freshwater streams. In their ascent of rivers chum salmon in general show less aptitude than pink salmon to surmount rapids and waterfalls, and their main spawning grounds do not extend so far from the ocean. This may be associated with the advanced state of maturity at which chum salmon enter British Columbia streams. In small coastal streams at least, chum salmon commonly spawn almost immediately after their entrance into fresh water. In the Fraser River watershed* they are essentially confined to the part below the canyon of the Fraser River (about 100 miles from salt water). In the Skeena system only insignificant numbers reach the upper Babine River (about 300 miles from the sea).

Within these confines the species frequently intermingles with pink salmon in spawning areas. However, it also occupies stream areas in which pink salmon are scarce or absent. These include streams which have a very variable runoff and some in which the substratum may consist of coarse gravel, sizable stones or even bedrock strewn with boulders.

During the spawning period individual male fish frequently attend more than one female (Hunter, 1959).

In accordance with the prolonged spawning season of the species and the varying characteristics of the streams which it frequents, a wide range of water temperature (probably from at least 16°C to 4°C) has been found at the time when fish reach the spawning grounds and deposit their eggs.

The average number of eggs produced by a female chum salmon has been found to vary from 2,400 to 3,100 in different years in the case of the run entering Hooknose Creek on King Island. A small number of samples taken from other Canadian areas gave averages which fall within the same range. (Individual fish have occasionally yielded as many as 4,000 eggs.)

While the nature of the stream bed occasionally results in eggs being merely dropped among superficial stones, they are ordinarily deposited at the bottom of depressions excavated by the female in gravel of varying coarseness. After the redd has been filled in, the eggs may lie at depths down to at least 16 inches below the surface of the stream bed.

Under similar temperature conditions, the length of the period between egg deposition and emergence of the fry from the gravel is about the same for chum as for pink salmon (Hunter, 1959). The peak of the emergence in the known instances occurs in the latter part of April or in May.

DOWNSTREAM MIGRATION OF FRY

The features of this migration are in general similar to those exhibited by pink salmon, and the two species often travel in company. The downstream movement is initially nocturnal. In Hooknose Creek, where the two species occupy the same spawning grounds, the main nightly migration of chum fry began and ended about an hour later than that of pink salmon (Hunter, 1959). Daytime migration of chum salmon has been observed at times of high water level. Schooling of the young fish sometimes occurs prior to their entrance into the sea (McDonald, 1960).

Received for publication November 1963. Original, English.
Source: Joint reporting team, Committee on Biology and Research. INPFC Document 664.
Bull. 18, Int. North Pac. Fish. Comm., 1966.

* *Ed. note:* For convenience, a map showing the major rivers and lakes referred to in this report has been printed at the back of this bulletin (p. 86).

OCEAN DISTRIBUTION

In the early stages of their ocean life (April to July), chum salmon are plentiful and generally distributed in schools of varying size along mainland and island shorelines throughout the British Columbia coast. They are often intermingled with pink salmon of similar age. By the end of July or early August nearly all the young fish have forsaken the water's edge. Individuals have been taken, however, in Georgia Strait and Dixon Entrance as late as the end of August or in early September. These had attained a length of from 12 to 25 centimeters.

Nothing is known of the movement of young chum salmon from the coastal waters of British Columbia to high seas feeding grounds. Some indications of their distribution after two or more winters in the sea are provided by a few tag returns and by scale studies. Tagged chum salmon have migrated to British Columbia waters from points in the Gulf of Alaska between 141°W and 151°30'W and in one instance from 167°W. A chum tagged near Adak Island (177°W) was recovered at Noyes Island, southeast Alaska, within 80 miles of the Canadian boundary. Studies by Tanaka *et al.* (1960) have shown that chum salmon with scales characteristic of the region comprising southeast Alaska, British Columbia, Washington and Oregon occur throughout the northern Gulf of Alaska and in small numbers westward into the central Aleutian area. The limits of distribution of strictly Canadian fish remain to be determined.

Tagged fish migrating to British Columbia localities from points in the central and western Gulf of Alaska have shown minimum average rates of travel of from 12 to 33 miles per day over distances of 700 to 1,000 miles.

In investigations of the vertical distribution of salmon in the Gulf of Alaska, chum salmon were found in the daytime from the surface to a depth of 50–60 meters in May and early June. There was a tendency for fish to be nearer to the surface at night. In late June and early July they appeared to be largely confined to levels at and above the thermocline, which at that time and place, was at a depth of 30–40 meters (Neave, 1960).

INSHORE MIGRATION

Although small numbers of chum salmon appear in salmon catches made along the northern half of the British Columbia coastline as early as June, the main fishing for the species in inshore waters takes place from August to November. As already indicated, the timing of the runs tends to be later in the southern areas.

At least some of the migrating fish enter British Columbia waters from the north, as is shown by the recovery in the Johnstone Strait area of several chum salmon tagged off the coast of southeast Alaska. The streams of the southern part of the British Columbia mainland and the east coast of Vancouver Island are supplied by large migrations entering Queen Charlotte Strait. By contrast, the numbers of chum salmon proceeding to Canadian streams via Juan de Fuca Strait appear to be relatively small. A pause in migration, of the order of one week, has been inferred (from tagging data) for chum salmon about to enter the Fraser River (Chatwin, 1953).

AGE AND SIZE

A large majority of British Columbia chum salmon mature in their third and fourth years of life. Fish in their fifth year occur regularly but usually form only a small proportion of the spawning stocks. Sixth-year fish are exceptional.

Fry of the 1947 brood year marked at Hooknose Creek, King Island, returned as 3-, 4- and 5-year-old fish in the following percentages: 19.7, 71.8, 8.5 (Hunter, 1959). At Nile Creek, Vancouver Island, in a similar experiment, the percentages were: 24, 76, 0 (Wickett, unpub.). Third- and fourth-year fish together usually constitute from 90% to 99% of commercial catches, but the proportions of these two categories vary widely. In certain years third-year chum salmon predominate in some areas. Presumably such variation is due, in part, to the varying strength of year classes. There is evidence that a few immature chum salmon are taken by the fishery.

The average individual weight of all chum salmon taken in the British Columbia fishery has varied from 11.0 to 12.8 pounds in the years 1952 to 1960 inclusive. The variation reflects the differing proportions of age groups, as well as differences in growth. Thus, the year showing lowest average weight (1960) coincided with the presence of a high proportion of third-year fish in the catches. Godfrey (1959) noted a general rise in the average weight of chum salmon caught in British Columbia during the period 1947 to 1954 followed by a decline in 1955 and 1956. These changes in general paralleled those shown by pink salmon and suggested that the two species were feeding in areas where the effects of annual variations in environmental conditions were similar. Within a given year the larger fish tend to reach inshore waters early in the season.

FOOD

Feeding of chum fry in fresh water has not been reported in British Columbia. In the early stages of

marine life, the diet of the young fish includes a wide variety of small organisms. Examination of 550 stomachs of juvenile chum salmon from various parts of the British Columbia coast in 1955 (Manzer, unpub.) showed local and seasonal differences in the food items consumed. Copepods, tunicates (Larvacea) and euphausiids frequently formed a major part of the diet. Other items included diatoms, chaetognaths, ostracods, cirripedes, mysids, cumaceans, isopods, amphipods, decapods and fish larvae. Insects (Diptera) were eaten with surprising frequency—a circumstance also noted by Annan (1958) for young salmon taken in the San Juan Island area near the southern boundary of British Columbia.

Examination of the stomachs of chum salmon, in their second year of ocean life and older, taken on the high seas of the Gulf of Alaska by Canadian research vessels, has shown that amphipods and euphausiids are major constituents of the diet. Other categories of organisms which are eaten at times in significant quantities are: fish, copepods, pteropods and squid.

RACE-FORMING TENDENCIES

Since there is evidence of a well-developed homing tendency in chum salmon, the fish breeding in each separate stream must have a considerable degree of reproductive isolation. In some streams there is also a more or less definite separation between " early " and " late " breeders although, as far as British Columbia stocks are concerned, there are as yet no data to show whether early and late fish are separate genetic lines. No criteria have yet been found for assigning individual fish caught in the sea to particular British Columbia watersheds or restricted coastal areas, although differences in scale characteristics have permitted the association of many ocean-caught chum salmon with certain broad geographic regions of the North Pacific (Shepard, 1961).

HOMING

Experimental proof of the return of chum salmon to the streams in which they originated is less extensive than for sockeye and pink salmon. In British Columbia the marking, by fin-clipping, of migrating fry has been performed at Nile Creek, Vancouver Island, and at Hooknose Creek, King Island. At the former locality the release of 40,000 marked fry in 1946 produced 25 returning adults in 1948 and 1949. At Hooknose Creek the release of 55,000 marked fry in 1948 produced 259 returning adults in 1950, 1951 and 1952. In neither of these experiments were any marked adult fish found in surveys of the populations of other nearby streams. These surveys were necessarily less thorough than the examination of fish in the natal streams and while it is concluded that the chum salmon shares the strong homing tendencies characteristic of other species of Pacific salmon, there are no data to indicate the frequency of departures from this habit.

MORTALITY AND SURVIVAL

Quantitative observations on the mortality occurring during stages of the life history have been made in Canada in three small streams, namely, Nile Creek, Hooknose Creek and Wahleach Creek (tributary of the lower Fraser River).

The general factors causing mortality in fresh water are the same for this species as for the pink salmon (Neave, 1966), although their quantitative effects are not necessarily identical. Since many of the British Columbia chum runs enter the streams at a later time than pink salmon, at a season when rains are frequent, they are less subject to the hazards of low water levels at this stage. Losses from this cause have been noted, however, in some Vancouver Island streams in seasons of low rainfall.

Since chum salmon in general show little tendency to migrate upstream beyond rapids and waterfalls, the construction of fishways has had relatively little effect in promoting the reproductive success of the species, nor have dams, water diversions or landslides severely affected any major runs in British Columbia. However, the stocks inhabiting various small streams near centers of expanding human population have undoubtedly suffered from influences associated with the removal of cover, construction of buildings and roads, and disturbance of migratory and spawning activities.

In areas outside these influences, the losses incurred at the time of spawning, through non-fertilization of eggs and through failure of females to deposit all their eggs, are believed to be very small. Hunter (1959) estimated that the percentage of eggs retained by females at Hooknose Creek in the years 1951 to 1956 varied from 0.2% to 4.7%. Cameron (1940) found indications that non-fertilization of deposited eggs was of insignificant importance in Vancouver Island streams.

During the period in which they are buried in the gravel, chum salmon eggs and alevins are exposed to the same kinds of mortality as those noted in the account dealing with pink salmon (Neave, 1966). Since chum salmon frequently occupy streams in which the runoff is very variable, mortality through the effects of floods can be severe. Losses can also occur through a drop in water level to below that at which eggs were deposited (Hunter, 1959).

At Nile Creek, which is liable to destructive winter floods, the total freshwater survival of natural populations from eggs to migrating fry varied from 0.08% to 13.6% in the course of eight years. In three of these years, fry production was less than 0.5% (Wickett, unpub.).

In Hooknose Creek, floods are less violent and the percent fry production has usually been considerably greater. In this stream chum and pink salmon occupy the same grounds and the time of their peak spawning is not greatly different. Although survival varies greatly from year to year, it has usually been similar for the two species in any given year, indicating a common response to external conditions (Table I).

TABLE I. Percent survival of pink and chum salmon from egg deposition to migrating fry at Hooknose Creek, on King Island, British Columbia.

Brood year	Pink	Chum
1947	0.88	0.96
1948	8.17	7.70
1949	6.45	6.34
1950	15.12	15.09
1951	16.47	16.92
1952	14.42	19.41
1953	13.95	16.36
1954	3.22	6.34
1955	6.76	3.87
1956	3.14	1.84
1957	2.80	2.82
1958	12.63	15.33
1960	37.20	22.00

At Wahleach (Jones) Creek, Hourston and MacKinnon (1957) reported a survival of 30% from egg deposition to migrating fry in a natural chum salmon population spawning in a prepared channel with controlled water flow. In this instance predation on the emerged fry was minimal. Hunter (1959) estimated losses due to predation of from 23% to 85% of migrating pink and chum fry in different years at Hooknose Creek.

Figures for the mortality of chum salmon between the time of their entrance into the sea and their return as adults are less satisfactory than those for pink salmon, because of the different ages at which the fish return and the degree of absorption which is commonly shown by the scales of the fish entering fresh water. On the basis of a marking experiment, Hunter (1959) calculated the ocean survival of chum salmon of the 1947 brood year of Hooknose Creek to be 2.58%. By summing the outgoing fry and returning adults for the brood years of 1947 to 1953, he estimated a general ocean survival for this period of 0.85%. These are considerably lower than the corresponding figures for pink salmon of this stream. The effect of the fishery on these runs is not known.

Neave (1953) suggested an average fishing mortality of 40% to 50% for the central coastal region of British Columbia in the period 1934–49. For the Johnstone Strait area, estimates of 50% to 52% fishing mortality were made on the basis of tagging experiments conducted in 1945, 1950 and 1953. As in the case of the other species of salmon in British Columbia, increasing efforts are being made to regulate the fishery on the basis of escapement requirements rather than to aim at taking a fixed percentage of the runs.

CHANGES IN ABUNDANCE

In Nile Creek the percent survival from eggs to migrating fry has varied from 0.08% to 13.6%, i.e., a 170-fold range. In Hooknose Creek the observed range has been from 0.96% to 22% (23-fold). The smaller range at Hooknose Creek is no doubt in part a reflection of the greater physical stability of this stream. However, in both cases the variability is obviously great enough to produce the possibility of great changes in abundance in consecutive generations. A survival from egg to migrating fry of 0.08% would necessitate an ocean survival of about 92% (after both natural and fishing mortality) to replace the parent spawning stock. A freshwater survival of 22% would require an ocean survival of only about 0.3%.

The statements made for pink salmon (Neave, 1966) concerning the compensatory and depensatory effects of freshwater mortality apply also to chum salmon in the instance (Hooknose Creek) in which sufficient data are available.

As mentioned previously, differences in the size of populations in consecutive generations are less readily assessed for chum than for pink salmon because of the mixture of brood years represented in the annual runs. Hoar (1951) showed that there was great variation in the success of return from one generation to the next, as judged from commercial catches. Recent estimates (also for catches only) in various statistical areas of British Columbia show ratios of up to 4 : 1 between a year class of adults and its adult progeny (Milne *et al.*, unpub.).

PREDICTION OF RUNS

The problems of predicting chum salmon runs are similar to those encountered for pink salmon with added complications caused by the varying age at which the fish mature and, frequently, greater difficulty in estimating the size of escapements which are

spread over a long season and are often accompanied by high water levels in the spawning streams.

No attempt has yet been made in British Columbia to measure the fry output of any large river. Eventually it may be feasible to make some assessment of the relative abundance from year to year of young fish in the sea.

REFERENCES

ANNAN, M. E. 1958. Notes on the food of the young of three species of Pacific salmon in the sea. *Can. Fish Cult.*, Vol. 23, pp. 23–25.

CAMERON, W. M. 1940. The efficiency of fertilization in the natural spawning of Pacific salmon. *Fish. Res. Bd. Can., Progress Report, Pacific Coast Stations*, No. 45, pp. 23–24.

CHATWIN, B. M. 1953. Tagging of chum salmon in Johnstone Strait, 1949 and 1950. *Fish. Res. Bd. Can., Bulletin*, No. 96.

GODFREY, H. 1959. Variation in the annual average weight of chum salmon caught in British Columbia waters, 1946 to 1958. *J. Fish. Res. Bd. Can.*, 16(4) : 553–554.

HOAR, W. S. 1951. The chum and pink salmon fisheries of British Columbia 1917–1947. *Fish. Res. Bd. Can., Bulletin*, No. 90.

HOURSTON, W. R., and D. MACKINNON. 1957. Use of an artificial spawning channel by salmon. *Trans. Amer. Fish. Soc.*, Vol. 86, pp. 220–230.

HUNTER, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. *J. Fish. Res. Bd. Can.*, 16(6) : 835–886.

MCDONALD, J. 1960. The behaviour of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. *J. Fish. Res. Bd. Can.*, 17(5) : 655–676.

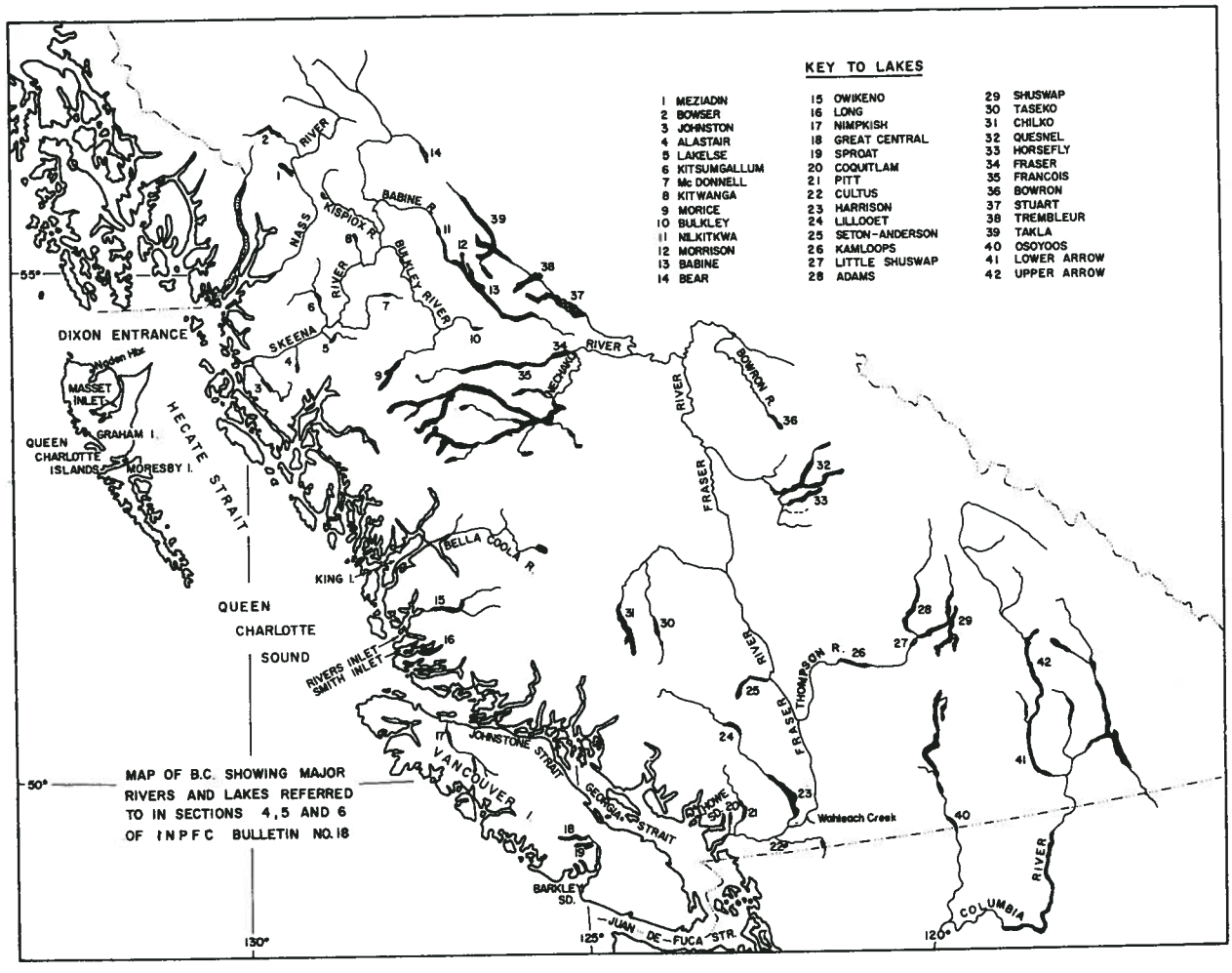
NEAVE, FERRIS. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. *J. Fish. Res. Bd. Can.*, 9(9) : 450–491.

NEAVE, FERRIS. 1960. Observations on the vertical distribution of salmon in the northeast Pacific, 1960. Unpublished working paper, Biological Station, FRB, Nanaimo, B.C.

NEAVE, FERRIS. 1966. Pink salmon in British Columbia. *In*: Salmon of the North Pacific Ocean—Part III, A review of the life history of North Pacific salmon. *Int. North Pac. Fish. Comm., Bulletin*, No. 18, pp. 71–79.

SHEPARD, M. P. 1961. Distribution and racial origin of chum salmon on the high seas of the North Pacific Ocean and Bering Sea. *Fisheries Research Board of Canada, Manuscript Report Series (Biological)*, No. 731.

TANAKA, S., M. P. SHEPARD and T. H. BILTON. 1960. Scale characteristics of chum salmon (*Oncorhynchus keta*) in coastal areas and on the high seas of the North Pacific Ocean. Unpublished working paper, Biological Station, FRB, Nanaimo, B.C. (in two parts).



MAP OF B.C. SHOWING MAJOR RIVERS AND LAKES REFERRED TO IN SECTIONS 4, 5 AND 6 OF INPFC BULLETIN NO. 18