A Description of the Fish Community of the Squamish River Estuary, British Columbia: Relative Abundance, Seasonal Changes, and Feeding Habits of Salmonids

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A DESCRIPTION OF THE FISH COMMUNITY OF THE SQUAMISH RIVER ESTUARY, BRITISH COLUMBIA: RELATIVE ABUNDANCE, SEASONAL CHANGES, AND FEEDING HABITS OF SALMONIDS

by

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ABSTRACT

Levy, D.A., and C.D. Levings. 1978. A description of the fish community of the Squamish River estuary, British Columbia: relative abundance, seasonal changes, and feeding habits of salmonids. Fish. Mar. Serv. MS Rep. 1475: 63 p.

The fish community at the Squamish River estuary in southwestern British Columbia was sampled during the period October 1975 to September 1976, using beach seines, gillnets and tidal creek enclosures. Seventeen species were recorded, of which 5 [staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platichthys stellatus*), surf smelt (*Hypomesus pretiosus*), cutthroat trout (*Salmo clarki*), and Dolly Varden (*Salvelinus malma*)] were considered "permanent" residents. The staghorn sculpin was probably the most numerous fish in the estuary. Judging from day-night differences in gillnet catches, most fish activity in the estuary was either nocturnal and/or crepuscular. Canonical correlation analysis was used to relate the abundance of 8 species of fish to environmental factors, including temperature and salinity. Juvenile salmonids [pink (*Oncorhynchus keta*), coho (*O. kisutch*), chinook (*O. tshawytscha*) and chum (*O. keta*)] used the estuary during spring and summer months. The salmonids in the estuary fed mainly on estuarine crustaceans and insects, especially the mysid *Neomysis mercedis* and the amphipod *Anisogammarus confervicolus*. There was no evidence of diet segregation between Dolly Varden and cutthroat trout, as has been reported in certain coastal lakes. There were no marked differences in relative abundance and distribution of juvenile salmonids when data were compared to surveys in 1972, even though other elements of the estuarine ecosystem (e.g. benthic invertebrate and algal communities) have changed because of river diversion.

Key Words: Estuaries, Fisheries biology, biological surveys, salinity, temperature, juveniles, growth.

RÉSUMÉ

Levy, D.A., and C.D. Levings. 1978. A description of the fish community of the squamish River estuary, British Columbia: relative abundance, seasonal changes, and feeding habits of salmonids. Fish. Mar. Serv. MS Rep. 1475 63 p.

Au cours de la période d'octobre 1975 à septembre 1976, on a fait l'échantillonnage des poissons de l'estuaire de la rivière Squamish, dans le sud-ouest de la Colombie-Britannique au moyen de sennes de rivage, de filets maillants et d'enceintes pour ruisseaux à marée. On a observé dix-sept espèces dont cinq [(le Chabot (*Laptocottus armatus*), la Plie du Pacifique (*Platichthys stellatus*), l'Éperlan (*Hypomesus pretiosus*), la Truite fardée (*Salmo clarki*) et la Dolly Varden (*Salvelinus malma*)] ont été considérées résidents "permanents". Le Chabot (*Laptocottus armatus*) était probablement le poisson le plus abondant de l'estuaire. D'après les différences observées entre le jour et la nuit dans les prises aux filets maillants, la plus grande partie de l'activite des poissons de l'estuaire était soit nocturne soit crépusculaire. On a utilisé l'analyse canonique pour établir une relation entre l'abondance de huit espèces et les facteurs environnementaux, y compris la température et la salinité. Les salmonidés juvéniles (rose (*Oncorhynchus gorbuscha*), Coho (*O. kisutch*), quinnat (*O. tshawytscha*) et kéta (*O. keta*) ont utilisé l'estuaire au printemps et à l'automne. Les salmonidés de l'estuaire se sont nourris surtout de crustacés et d'insectes, en particulier du mysidacé *Neomysis mercedis* et de l'amphipode *Anisogammarus confervicolus*. On n'a constaté aucune différence entre l'alimentation de la Dolly Varden et celle de la Truire fardée, comme cela avait été remarqué dans certains lacs côtiers. Il n'y avait aucune différence marquée entre l'abondance relative et la distribution des salmonidés juvéniles par comparaison aux relevés de 1972, bien que d'autres éléments de l'écosystème de l'estuaire (par exemple, les algues et les invertébrés benthiques) aient changé à cause du détournement de la rivière.

Mots-clefs: estuaires, biologie du poisson, relevés biologiques, salinité, température, juvéniles, croissance.

INTRODUCTION

The Squamish River estuary, located 45 km north of Vancouver, B.C., has been under considerable development pressure for the last several years. Log storage facilities, a chemical plant, a bulk loading terminal, supplemental land transportation facilities, and navigational channels have alienated the majority of the intertidal habitat at Squamish. In addition, a river training dyke completed in 1971 drastically altered flow patterns in the estuary. Two culverts were installed through the dyke to allow some fresh water through the blocked river channel (Fig. 1). Further development plans, which involved the construction of a coal port in the estuary, were blocked on environmental grounds in 1972 (Environment Canada 1972; Hoos and Vold 1975). One of the major considerations leading to this decision was an appreciation of the importance of this habitat as a rearing area for the Squamish River system salmon stocks. Juvenile coho, chinook, and chum salmon, after a variable period in freshwater, migrate downstream to the Squamish estuary, where they reside and grow before continuing their migration into offshore marine environments.

Because of the vulnerability of this estuary to future development, as well as an incomplete understanding of the estuarine phase in the life history of salmon, a comprehensive survey of the fish community in the Squamish estuary was undertaken in 1975 and 1976. This report outlines the results of these investigations.

METHODS AND MATERIALS

FIELD METHODS

Previous sampling (Goodman and Vroom 1972) identified the Central Basin of the Squamish estuary (Fig. 1) as having the highest densities of juvenile salmon. Consequently, field sampling during the present study was restricted to this area. Station 2 was sampled infrequently due to the presence of underwater debris, although salmonids were caught there on occasion, both in the beach seine and the gillnets. Substations 1.1, 1.2, 3.1, 3.2, and 3.3 were the locations for regular beach seine sampling, and were chosen because of the lack of log snags. An inflatable boat (5 m) was used for sampling and R/V ACTIVE LASS (14 m), moored at the Squamish Government dock, was used as a base of operations. Fish were sampled by a variety of methods (see below) and Secchi depth, salinity, and temperature measurements recorded at the time of sampling. A Beckman *in situ* salinometer (Model RS5-3) was used for the latter 2 measurements.

GILLNET SAMPLING

A series of monofilament gillnet of dimensions 8 ft x 50 ft (2.43 x 14.24 m) and of different mesh sizes, varying from 0.75 to 2 inches (1.9 to 5.1 cm) along a stretched diagonal, were used to sample fish on a monthly basis. Gillnets were anchored in subtidal regions and were hung in the direction of the prevailing tidal currents. The nets were set in the morning or early afternoon, and emptied twice; first in the late afternoon, and then in the early morning of the following day.

BEACH SEINE SAMPLING

A beach seine of dimensions 8 ft x 120 ft (2.43 x 36.57 m) having $\frac{1}{4}$ inch (0.6 cm) mesh size in the central bag section and $\frac{1}{2}$ inch (1.3 cm) mesh size along the wing portions, was used to sample fish on a monthly basis when juvenile salmon were absent, and every two weeks when they were present (March - August). The net was set out at the end of 100 foot (30 m) ropes, on a rising tide, at about the 8 foot (2.4 m) tide level and immediately retrieved. Beach seine locations are shown in Fig. 1.

TIDAL CREEK SAMPLING

On several occasions the beach seine was used to trap fish specimens from the main tidal creek of the Central Basin (Fig. 1). This was accomplished by stationing the net at the mouth of the creek at high tide and affixing it in position by means of two stakes along the margins of the creek. After the tide level had dropped to about the 5 foot (1.5 m) level, the fish were sufficiently concentrated in the bag section of the net and a subsample could be easily dip netted.

After capture, fish were identified and counted, and a subsample preserved in a 10% formaldehyde solution for stomach analysis. Identification of salmon smolts was later confirmed by counting numbers of pyloric caecae and using other criteria explained in McConnell and Snyder (1972).

LABORATORY METHODS

Preserved fish were first rinsed in fresh water, blotted dry, measured to the nearest mm, and then weighed to the nearest 0.1 g. Animals retained for stomach analysis were dissected open and the stomach removed by means of incisions at the esophagus and the junction of the pyloric caecae with the intestine. Prey organisms were identified with the aid of a compound microscope or a magnifying glass and enumerated by two methods - percent volume and percent frequency. The percent frequency method of stomach analysis expressed the proportion of a given prey type as a percentage of the total number of prey organisms. The percent volume method used an estimate of the volumetric displacement of each prey category (assigned visually) and expressed as a percentage of the total volume of the stomach contents. Since most of the prey organisms eaten by fish in the estuary were roughly similar in size, the results of the percent volume analysis agree very closely with the results of the percent frequency analysis (Fig. 11-29).

RESULTS

ENVIRONMENTAL DATA

Salinity and temperature fluctuations in the surface water at Station 3 for a 1-yr period are shown in Fig. 2. During the period that juvenile salmon were abundant, from March to August, salinity was generally low, less than 10 parts per thousand, and water temperature averaged about 11°C. There appeared to be no significant local differences in temperature or salinity between the different sampling stations (Table 1). Secchi depth values were high during March and April (greater than 2.5 m), dropped to slightly less than 2 m during May and were less than 1 m during the period when juvenile salmon were abundant (June to August).

FISH OCCURRENCE

The fish species in the Squamish estuary can be divided into two groups-permanent and temporary residents. Permanent residents (staghorn sculpin, starry flounder, surf smelt) were caught on most sampling dates. Cutthroat trout and Dolly Varden were also caught frequently, their absence in April and May (Table 2) may merely indicate a sampling artifact since these two species were only caught in low numbers with the gear types used. All other species of fish, including the four species of salmon present in the Squamish system were temporary residents in the estuary and occurred there for only part of the year. The following lists are derived from Table 2 and show the species roughly in order of abundance caught in the gear:

<u>Permanent Residents</u>

Staghorn sculpin	- *Leptocottus armatus*
Starry flounder	- *Platichthys stellatus*
Surf smelt	- *Hypomesus pretiosus*
Cutthroat trout	- *Salmo clarki*
Dolly Varden	- *Salvelinus malma*

<u>Temporary Residents</u>

Herring	- *Clupea harengus*
Chum salmon	- *Oncorhynchus keta*
Coho salmon	- *O. kisutch*
Chinook salmon	- *O. tschawytscha*
Spiny dogfish	- *Squalus acanthias*
Snake prickleback	- *Lumpenus sagitta*
Prickly sculpin	- *Cottus asper*
Shiner perch	- *Cymatogaster aggregata*
Threespine stickleback	- *Gasterosteus aculeatus*
Pink salmon	- *O. gorbuscha*
Eulachon	- *Thaleichthys pacificus*
Sand lance	- *Ammodytes hexapterus*

The latter six temporary residents were caught infrequently during the study (Table 2). Prickly sculpins occurred at various times throughout the year and probably spawned in the estuary - on April 22, 1976 two gravid females were caught at Station 3. Shiner perch were seasonally abundant in the fall (September and October) and occurred once in April. Threespine sticklebacks were caught near Station 1 on several occasions, and large numbers of juveniles were frequently observed in tidepools and tidal creeks at low tide. Only two pink salmon juveniles were caught in beach seines in the estuary. One eulachon was caught in a gillnet in August, and one sand lance obtained in a beach seine in April.

GILLNET CATCH-PER-UNIT-EFFORT

Numbers of the eight most abundant types of fish caught in gillnets in the Squamish estuary (involving 9 species since the category "smolts" includes both chinook and coho salmon) are shown in Tables 3 and 4. The relative catch-per-unit-effort (CPUE = number of fish caught per gillnet hour) for all species is much higher for the overnight catch records. Thus most fish activity in the estuary is probably nocturnal and/or crepuscular. Figure 3 shows the change in the relative CPUE for staghorn sculpins, the most abundant fish species in the gillnet catches, at Station 3 at different sampling times. The increase in CPUE in late summer and early fall is evident both in the daytime and the overnight catches, and a similar pattern is seen at Station 1 (Fig. 4).

BEACH SEINE CATCH-PER-UNIT-EFFORT

The mean number of chum, chinook and coho salmon juveniles caught in beach seine hauls is shown in Fig. 5, 6 and 7 respectively. The wide range in chum salmon numbers is probably due to the schooling nature of this species, tending to make beach seine catches highly variable. Nevertheless, two peaks in the abundance of chum salmon in the estuary can be recognized - the first in late April and the second in early June (Fig. 5). Comparison of Fig. 6 and 7, as well as the occurrence data in Table 3, show that there was some degree of temporal segregation in the occurrence of chinook and coho salmon juveniles in the estuary. Coho salmon are present one month before chinook salmon, and show two periods of peak abundance - the first in early June, and the second in early July (Fig. 6). In contrast, chinook salmon show one period of peak abundance in early July (Fig. 7). Similar seasonal patterns were reported in Goodman and Vroom (1972).

SEASONAL CHANGE IN LENGTH OF JUVENILE SALMON

The change in the mean fork length of juvenile chum salmon from March to September is shown in Fig. 8. There was a progressive increase in size, probably attributable to estuarine growth, as well as an increase in the variability in size, attributable to the staggered downstream migration of recently hatched juvenile salmon fry. The mean length of both juvenile coho and juvenile chinook salmon (Fig. 9 and 10) initially was fairly uniform and did not show an appreciable increase until July. By September, there was much variability in the mean size of both coho and chinook smolts.

The weight-length relationships for chum, coho and chinook salmon are shown in the appendix.

CANONICAL CORRELATION ANALYSIS

In order to investigate relationships between the fish species caught in the Squamish estuary and measured environmental factors, canonical correlation analysis was undertaken. The procedure closely follows an example given in Lee (1971, p.81). The data were grouped into two classes: fish catch variables and environmental variables. Fish catch variables include numbers of staghorn sculpins, dogfish, cutthroat trout, Dolly Varden, herring, salmon smolts (combined chinook and coho), surf smelt, Because of their small sample sizes in the gillnet catch records, chinook and coho smolts were combined for the purposes of the analysis. Environmental variables include surface temperature, surface salinity, Secchi depth, station location, mesh size, set duration, and time of day. Only the first three canonical roots (Table 5) are statistically significant and the following interpretations are based on relatively large values of the canonical variates shown in Table 6.

1. The first canonical root indicates that a large gillnet mesh size, a night set, and long set durations were factors associated with a high staghorn sculpin catch.

2. The second canonical root indicates that high water temperature, nearness to the mouth of the estuary (Station 1), and a short set duration at night, were factors associated with a high sculpin and prickleback catch, and a low cutthroat trout and surf smelt catch.

3. The third canonical root indicates that a high Secchi depth (clear water), location near the mouth of the estuary (Station 1), and night-time were factors associated with a high dogfish catch.

4. The fourth canonical root indicates that low salinity, small mesh size, and location near the head of the estuary (Station 3) were factors associated with a high salmon smolt and surf smelt catch.

Since the lack of statistical significance does not necessarily indicate the lack of a correlation of this type of analysis (Anderson 1958) the latter canonical root is interpreted although it was not statistically significant. The remaining three canonical roots were neither statistically significant nor biologically meaningful.

FOOD OF SALMONIDS

Salmonids in the Squamish estuary acquired the following prey types in differing proportions:

Neomysis mercedis - an estuarine opposum shrimp
terrestrial insects
insect larvae - mostly chironomids, occasionally dolichopodids and others
insect pupae - mostly chironomids
copepods - both cyclopoids and harpacticoids
unidentified fish
Leptocottus armatus - juvenile stages of staghorn sculpins
Anisogammarus confervicolus - an epibenthic estuarine amphipod
Corophium spinicorne - a tube-dwelling estuarine amphipod
Gnorimosphaeroma oregonensis - an estuarine isopod
Crangon sp. - an estuarine shrimp

CHUM SALMON

The diet of juvenile chum salmon was examined monthly for April, May, and June (Fig. 11-13). There was some discrepancy between the results of the percent volume and percent frequency methods of stomach analysis (e.g. Fig. 12) due to the variation in the size of the prey organisms ingested. Insect pupae, terrestrial insects, and insect larvae were important at Station 3.2 on April 23, 1976, *Anisogammarus* and copepods were important at Station 1.1 on May 6, 1976, and *Neomysis* and terrestrial insects made up the bulk of the diet at Station 3.1 on June 27, 1976. Additional stomach content data for chum salmon in the Squamish estuary are given in Levy (1977) and Goodman and Vroom (1972).

COHO SALMON

With the exception of the May 17, 1976 sample (Fig. 14) of coho salmon which had been feeding primarily on unidentified fish, coho salmon in the Squamish estuary fed largely on *Anisogammarus* and *Neomysis* (Fig. 14 to 19). There was a marked divergence in the relative proportions of these two crustaceans in the diet corresponding to the distribution of the fish - samples from Station 1 containing a higher proportion of *Anisogammarus* and samples from Station 3 containing a higher proportion of *Neomysis*. For example, on June 21, 1976 *Anisogammarus* made up over 80% of the diet of coho salmon at Station 1.2 (Fig. 18). In contrast, *Neomysis* comprised over 60% of the diet of coho salmon sampled at the same time at Station 3.3 (Fig. 19). The distribution of *Anisogammarus* in the Squamish estuary correlates strongly with the distribution of sedges (Levings 1973) which predominate at Station 1 and are virtually absent at Station 3. Thus coho salmon in the Squamish estuary apparently respond to local variations in the relative density of different food types.

CHINOOK SALMON

The diet of chinook salmon consisted primarily of *Neomysis mercedis* (Fig. 20 to 22). The proportion of *Anisogammarus* in the diet at Station 1.2 was lower for chinook salmon (Fig. 20) than for coho salmon sampled at the same time (Fig. 18).

DOLLY VARDEN

A total of 18 Dolly Varden containing recognizable stomach contents were caught at different times of the year, most frequently at Station 3. Pooled samples showed that, in order of decreasing proportions, the diet consisted of *Anisogammarus*, *Neomysis*, fish (mostly juvenile *Leptocottus armatus*) and *Crangon* sp. (Fig. 23).

CUTTHROAT TROUT

The results of analysis of the stomach contents of 28 samples of cutthroat trout containing recognizable prey (pooled over a 1-yr period) are shown in Fig. 24. As with Dolly Varden, most of the cutthroat trout were captured at Station 3. Over 50% of the diet was composed of *Anisogammarus* with *Neomysis* making up over 25%. The rest of the diet was composed of *Gnorimosphaeroma*, *Corophium*, fish, and *Crangon*. In order to test whether there was any qualitative difference in the diet of different sized trout, the fish were divided into two size classes - less than 25 cm and greater than 25 cm in fork length - and the stomach contents compared. The results (Fig. 25 and 26) show little difference in diet for the two groups of fish. There was, however, a slightly higher proportion of *Gnorimosphaeroma*, fish and *Crangon* in the diet of large trout, and a slightly higher proportion of *Neomysis* and *Corophium* in the diet of small trout. Seasonal differences in the diet of trout in the estuary were analysed by dividing the samples into three groups - those obtained between October 1975 and January 1976 (Fig. 27), those obtained between February 1976 and May 1976 (Fig. 28), and those obtained between June 1976 and September 1976 (Fig. 29). The major component of the diet of the fish in the first two groups (October - January and February - May) was comprised of *Anisogammarus*. There is a difference in the last group (June - September) however, *Neomysis* being the dominant constituent of the diet. Apparently, cutthroat trout switch from feeding upon *Neomysis* during the summer months to *Anisogammarus* during the fall and winter.

DISCUSSION

INTERACTIONS BETWEEN SPECIES

A detailed study of the estuarine life history of cutthroat trout in three estuaries in Oregon (Nestucca, Alsea and Siuslaw) was reported by Giger (1972). The results of his study indicate seasonal differences in the occurrence of adults, kelts, and juveniles. In contrast, in the Squamish estuary adults were present all year round, and juveniles (individuals less than 20 cm in fork length) occurred from June to August, which is later than the April to June occurrence of juvenile cutthroat trout in the Alsea estuary. This difference implies that there is considerable variability in the life history and timing of migration of cutthroat trout. Estuarine crustaceans, especially *Anisogammarus* formed the bulk of the diet of cutthroat trout even in large adults, and larger prey items (e.g. fish), were not a major component of the diet. It is not known what causes the dramatic shift in diet, from mostly *Anisogammarus* to mostly *Neomysis* during the summer months in the Squamish estuary. T. Johnson (pers. comm.) suggests that the summer tidal patterns at Squamish of low tides occurring during daylight hours, makes *Neomysis* more vulnerable to fish predators, especially on the ebbing part of the tidal cycle.

Dolly Varden were present throughout the year, but were not as abundant as cutthroat trout. Although both these species are reputed to be predators on juvenile salmon in freshwater (e.g. Ricker 1941), no cases of predation on salmon were observed in the present study. The absence of salmon fry predation was evident even in instances when Dolly Varden and chum salmon occurred in beach seines at the same time. There was a slightly higher proportion of fish in the diet of Dolly Varden, compared to cutthroat trout, but fish only represented a minor constitutent in the diet of both species. Andrusak and Northcote (1971), as well as Schutz and Northcote (1972), have compared the diet of cutthroat trout and Dolly Varden in B.C. lakes and discussed their results in light of Nilsson's (1963) theory of interactive segre segregation. The strong overlap in the diet of cutthroat trout and Dolly Varden (Fig. 23 and 24) provides circumstantial evidence for the absence of agonistic interactions between these two species when resident in the Squamish estuary.

Of the four salmon species in the Squamish system, estuarine residency is probably most significant for juvenile chum salmon. In the Nanaimo estuary some portions of the juvenile chum population can spend two weeks rearing on the mud flat environment (Healey et al. 1977). Based on the change in size of chum juveniles (Fig. 8), there is probably an extended residence period in the Squamish estuary as well. Chum are numerically the most abundant species - on one occasion (early June 1976) over 500 chum salmon were caught in one set of the beach seine at Station 3.1. The diet of chum salmon was more variable than that of coho and chinook salmon in the estuary - they exploited a diverse assemblage of food organisms not utilized to a great degree by the larger coho and chinook smolts. There were dietary shifts over time, and large prey items relative to the size of the juvenile chum predator (e.g. *Neomysis*) made up an increasing proportion of the diet (Fig. 13).

Numerically, the dominant species in the Squamish estuary fish community was probably the staghorn sculpin. Dunford (1975) has implicated this sculpin as an important predator on juvenile salmon. On several occasions during the present study, staghorn sculpins were observed preying on juvenile chum salmon in tidal creek enclosures. The importance of this predation is poorly understood. The autumnal increase in the catch-per-unit-effort of staghorn sculpins might have been due to one of a number of causes - e.g. immigration, reduced net avoidance, or an increase in activity. The change in behaviour may have significance for the timing of the downstream migration of chum salmon fry, if staghorn sculpins are indeed significant predators on the juveniles. Moyle (1977) has reviewed the literature on the importance of sculpin predation, as well as the circumstantial evidence for competitive relationships with salmonids in freshwater. The potential importance of sculpin-salmonid interactions provides a strong rational for an analysis of the function of staghorn sculpins in estuaries.

All the samples of coho salmon, except for one in July 1976, contained individuals which were classified as smolts. The large size of these fish (Fig. 9) relative to chum salmon probably indicates a substantial fresh water residency which precedes migration to the estuary. For an extended period (April to July), the mean size of coho juveniles in the estuary (Fig. 9) did not show any appreciable change. Juvenile chinook salmon showed a similar pattern (Fig. 10) - during the period May to July, there was apparently no change in the mean size of the fish. Reduced growth of juvenile chinook smolts, for 3 months in mid-summer, was reported by Reimers (1970) for both marked and unmarked juveniles in the Sixes River estuary, Oregon. Reimers postulated that the density of chinook juveniles in this estuary was sufficient to account for the mid-summer depression in growth which he inferred is mediated by a limited food supply. Furthermore, he hypothesized that the rearing capacity of the estuary increased during the summer due to an increased food abundance later in the summer, as well as a more complete utilization of the estuary by the chinook population. In the Nanaimo estuary, the apparent lack of growth in wild juvenile chinooks compared to a marked hatchery population was thought to be due to the recruitment of smaller fish into the estuary (Sibert 1975). Several other hypotheses, such as difference in residency time for early-run and late run juveniles could account for the observed mid-summer depression in growth and warrant consideration before decisions concerning estuarine development or salmonid enhancement are made.

Some degree of temporal segregation (Fig. 7 and 8) as well as differences in the feeding habits (Fig. 18 and 20) of juvenile coho and chinook salmon may serve to reduce competitive interactions between these two ecologically similar species. The freshwater life history of cohabiting coho and chinook juveniles in the Big Qualicum River, B.C., has been examined by Lister and Genoe (1970). They maintain that differences in spawning and emergence timing coupled with size-related differences in habitat selection serve to segregate the two species. Juvenile coho and chinook also show mutual agonistic behaviour in fresh water (Stein et al. 1973) which is thought to promote segregation. It is not known to what extent these behavioural interactions are important in estuaries.

QUANDARIES CONCERNING CHINOOK FRY

Juvenile chinook salmon captured in the present study had apparently spent a considerable period of time in fresh water before migrating to the estuary - no recently emerged fry were captured in beach seines. Goodman and Vroom (1972) also caught only larger (> 60-mm) chinooks in the Squamish estuary. In contrast, Dunford (1975) reports the occurrence of recently emerged chinook juveniles, about 40-mm in fork length, in the Fraser estuary, B.C., in April and May of 1973 and 1974. In the Cowichan River, B.C., most chinooks migrate as recently emerged fry, not more than 10% spending their first year in fresh water (Neave 1949). Most chinooks in the Big Qualicum River, B.C. spend two or three months in fresh water and migrate as 70-80-mm fingerlings (Lister and Genoe 1970). Further north, most chinook juveniles in the Taku River, Alaska, have a freshwater residency period of one year (Meehan and Siniff 1962). This pattern is consistent with Rich's (1925) suggestion of a latitudinal difference in the length of freshwater residency - population in higher latitudes generally reside longer in fresh water before migrating to the ocean. Variation within one river system is possible. Reimers and Loeffel (1967) have documented short-and long-term periods of residency for chinook populations in different tributaries of the Columbia River system. Five different migratory types of juvenile chinooks in the Sixes River, Oregon, have been classified (Reimers 1973). Although spring and fall runs of returning adults are common, adult chinooks can return to fresh water throughout the year. Evidence from an early marking study (Rich and Holmes 1928) shows that the timing of return to fresh water and the length of freshwater residency are heritable. Spring run chinooks are thought to produce progeny which have a long period of residency in fresh water. In contrast most fall run chinooks produce fry which migrate soon after hatching. The juvenile chinooks which occurred in the Squamish estuary were all substantially larger than the 40-mm '90-day fry' caught by Dunford (1975) in the Fraser estuary, and the Squamish system chinook show life history characteristics similar to more northern stocks. A large proportion of the population probably resides in freshwater for appreciable lengths of time before migrating to the estuary.

EFFECTS OF INDUSTRIAL DEVELOPMENT

The estuarine ecosystem has changed perceptibly since dyke construction in 1972. For example, a 'marine succession' of plants and invertebrates has occurred at the central delta front due to reduced freshwater flow and penetration of the salt wedge from Howe Sound into the central basin (Levings 1976). However, distribution of juvenile salmonids has apparently changed little since surveys of 1972. Our Station 3 corresponds exactly to Goodman and Vroom's (1972) Station 16. Beach seine catches and seasonal patterns of abundance of chum fry were similar at this station in 1976 compared to 1972 (Fig. 5 *vs* Fig. 30).

A. Argue (pers. comm.) suggests that the absence of chinook fry in the Squamish estuary in 1976 was due to a low 1975 spawning escapement coupled with poor egg/fry survival due to floods in the fall of 1975. An alternative hypothesis concerning the absence of chinook fry also relates to industrial disruption. Construction of training walls and dredging in the estuary has increased velocities in the Squamish River, and it is possible that small chinook fry were displaced to Howe Sound ("outer estuary") by these currents. Being unable to orient against prevailing currents and hence incapable of returning to the central basin, they would be missed by the sampling devices used in the present study. Thus, juvenile chinook fry might not possess the behavioural mechanisms shown by chum fry, which allows their migration into the productive areas of the central basin.

RECOMMENDED STUDIES

Many of the uncertainties dealing with residence time and utilization of the estuary by salmonids could be resolved with a coordinated freshwater (upstream) and estuarine sampling programme. Combined with a mark-recapture study similar to those carried out in other estuaries (e.g. Healey et al, 1977; Reimers 1970) useful information concerning the Squamish system salmon runs could be gained and is necessary to predict the effects of environmental change in the estuary. Experimental manipulation of the ecosystem, for example by regulating flow into the central basin via culverts, would also provide useful predictive information.

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REFERENCES

Anderson, T.W. 1958. Introduction to Multivariate Statistical Analysis. John Wiley & Sons, Inc., New York. 374 p.

Andrusak, H. and T.G. Northcote. 1971. Segregation between adult cutthroat trout (*Salmo clarki*) and Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes. J. Fish. Res. Board Can. 28: 1259-1268.

Dunford, W.E. 1975. Space and food utilization by salmonids in marsh habitats of the Fraser River estuary. M.Sc. Thesis. Dept. of Zoology. Univ. of B.C. 80 p.

Environment Canada. 1972. Effects of existing and proposed industrial develop- on the aquatic ecosystems of the Squamish estuary. Prepared for Fed. Prov. Task Force on the Squamish estuary Harbour Development. Fisheries and Marine Service, Vancouver, B.C. 38 p and appendices.

Giger, R.D. 1972. Ecology and management of coastal cutthroat trout in Oregon. Oregon State Game Comm. Fish. Res. Rep. No. 6. 61 p.

Goodman, D. and P.R. Vroom. 1972. Investigations into fish utilization of the inner estuary of the Squamish River. Env. Can. Tech. Rep. 1972-12. 52 p. Fisheries and Marine Service, Vancouver, B.C.

Healey, M.C., R.V. Schmidt, R.P. Jordan and R.M. Hungar. 1977. Young salmon in the Nanaimo area 1975: 1. Distribution and abundance. Fish. Res. Board Can. MS. Rep. 1369: 161 p.

Hoos, L.M. and C.L. Vold. 1975. The Squamish River estuary. Status of environmental knowledge to 1974. Env. Can. Spec.Estuary Ser. No. 2. 361 p.

Lee, P.J. 1971. Multivariate analysis for the fisheries biologist. Fish. Res. Board Can. Tech. Rept. 244: 182 p.

Levings, C.D. 1973. Intertidal benthos of the Squamish estuary. Fish. Res. Board Can. MS. Rept. 1218: 60 p.

1976. River diversion and intertidal benthos at the Squamish River delta, British Columbia. p. 193-202 *in* Skreslet, S., Leinebo, R, Matthews, J.B.L., and E. Sakshaus (Eds.). Fresh water on the Sea. Proc. Symp. Influence of Fresh Water Outflow on Biol. Processes in Fjords and Coastal Waters. 22-25 April 1974, Geilo, Norway. Assn. of Norwegian Oceanographers, Oslo, 1976. 246 pp.

Levy, D.A. 1977. The effects of experience on the acquisition of food by juvenile chum salmon, *Oncorhynchus keta*, in a tidal creek of the Squamish River estuary, B.C. M.Sc. Thesis. Dept. of Zoology, Univ. of B.C. 61 p.

Lister, D.B. and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. J. Fish. Res. Board Can. 27: 1215-1224.

McConnell, R.J. and G.R. Snyder. 1972. Key to field identification of anadromous juvenile salmonids in the Pacific Northwest. NOAA Tech. Rept. NMFS CIRC-366. 6 p.

Meehan, W.R. and D.B. Siniff. 1962. A study of the downstream migrations of anadromous fishes in the Taku River, Alaska. Trans. Am. Fish. Soc. 91: 399-407.

Moyle, P.B. 1977. In defense of sculpins. Fisheries (Publ. by Amer. Fish. Soc.) 2: 20-23.

Neave, F. 1949. Game fish populations of the Cowichan River. Fish. Res. Board Can. Bull. 84: 32 p.

Nilsson, N. 1963. Interaction between trout and char in Scandinavia. Trans. Am. Fish. Soc. 92: 276-285.

Reimers, P.E. 1970. Growth and abundance of juvenile fall chinook salmon in Sixes River Estuary 1969. Fish. Comm. Oregon Res. Div. Coastal Rivers Investigations. Information Rept. 70-4. 29 p.

1973. The length of residence of juvenile fall chinook salmon in the Sixes River, Oregon. Oregon Fish. Comm. Res. Rept. 4: 1-43.

Reimers, P.E. and R.E. Loeffel. 1967. The length of residence of juvenile fall chinook salmon in selected Columbia River tributaries. Oregon Fish. Comm. Res. Rept. 13: 5-19.

Rich, W.H. 1925. Growth and degree of maturity of chinook salmon in the ocean. U.S. Bur. Fish. Bull. 41 (Doc. 974): 15-90.

Rich, W.H. and H.B. Holmes. 1928. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. U.S. Bur. Fish. Bull. 44 (Doc. 1047): 215-264.

Ricker, W.E. 1941. The consumption of young sockeye salmon by predaceous fish. J. Fish. Res. Board Can. 5: 293-313.

Schutz, D.C. and T.G. Northcote. 1972. An experimental study of feeding behaviour and interaction of coastal cutthroat trout (*Salmo clarki clarki*) and Dolly Varden (*Salvelinus malma*). J. Fish. Res. Board Can. 29: 555-565.

Sibert, J. 1975. Residence of juvenile salmonids in the Nanaimo River estuary. Fish. Mar. Ser. Res. Dev. Tech. Rep. 537. 23 p.

Stein, R.A., P.E. Reimers and J.D. Hall. 1973. Social interaction between juvenile coho (*Oncorhynchus kisutch*) and fall chinook salmon (*O. tschawytscha*) in the Sixes River, Oregon. J. Fish. Res. Board Can. 29: 1737-1748.

Table 1. Secchi depth, temperature, and salinity measurements in the Squamish estuary during the period of sampling : Oct. 1975 - Sept. 1976.

DATE	STN	MAX SAMPLE (Z) METRES	TEMPERATURE °C SURF	TEMPERATURE °C MAX Z	SALINITY PPT SURF	SALINITY PPT MAX Z	SECCHI DEPTH METRES
30OCT75	1	3.0	7.2	10.5	11.0	27.3	2.63
30OCT75	2	3.0	7.6	10.3	13.1	26.9	1.95
30OCT75	3	2.0	7.6	9.5	11.8	23.0	1.61
27NOV75	1	3.0	7.8	8.4	27.1	28.9	GT Z*
27NOV75	2	2.5	7.3	8.0	27.5	28.3	GT Z
27NOV75	3	2.5	4.0	6.0	19.1	25.8	2.48
15DEC75	1	2.5	4.0	6.0	19.1	25.8	GT Z
15DEC75	2	2.5	5.0	6.0	22.3	25.6	GT Z
15DEC75	3	3.5	3.9	5.8	17.6	25.5	GT Z
29JAN76	1	2.5	6.2	7.1	18.5	26.3	GT Z
29JAN76	2	2.0	5.8	6.7	21.5	25.4	GT Z
29JAN76	3	3.0	5.8	6.7	17.0	25.5	GT Z
26FEB76	1	2.5	3.5	6.3	18.6	25.7	GT Z
26FEB76	2	2.5	5.3	6.0	24.0	25.7	GT Z
26FEB76	3	2.0	3.4	5.9	25.5	25.3	GT Z
12MAR76	1	1.5	5.5	6.3	21.8	27.7	GT Z
12MAR76	2	2.0	4.6	6.3	17.2	27.9	GT Z
12MAR76	3	2.5	5.1	6.4	19.2	27.2	GT Z
25MAR76	1	1.5	4.6	5.7	14.4	20.6	GT Z
25MAR76	2	2.0	4.2	6.1	11.0	20.9	GT Z
25MAR76	3	2.5	4.8	5.7	13.2	18.3	GT Z
22APR76	1	1.5	9.1	9.5	14.0	23.1	GT Z
22APR76	2	1.5	9.6	9.2	13.2	23.6	GT Z
22APR76	3	2.0	10.0	9.2	10.8	22.4	GT Z
25MAY76	1	2.5	7.2	8.2	1.9	3.3	1.90
25MAY76	2	2.5	7.6	7.9	2.9	2.9	1.95
25MAY76	3	3.5	7.8	11.3	2.6	4.8	1.85

*GREATER THAN THE MAXIMUM DEPTH

Table 1 (cont'd). Secchi depth, temperature, and salinity measurements in the Squamish estuary during the period of sampling : Oct.1975 - Sept.1976.

DATE	STN	MAX SAMPLE (Z) METRES	TEMPERATURE °C SURF	TEMPERATURE °C MAX Z	SALINITY PPT SURF	SALINITY PPT MAX Z	SECCHI DEPTH METRES
22JUN76	1	1.0	13.5	13.5	2.0	2.1	0.71
22JUN76	2	0.5	13.5	13.5	1.9	1.9	0.88
22JUN76	3	1.0	14.1	14.2	1.9	2.3	0.86
19JUL76	1	3.0	11.4	10.5	1.7	1.9	0.84
19JUL76	2	1.5	12.6	12.3	1.7	1.7	0.81
19JUL76	3	3.0	11.5	11.0	1.8	2.1	0.95
23AUG76	1	2.5	9.8	10.9	3.0	8.1	0.99
23AUG76	3	3.0	12.1	12.0	3.2	3.7	0.95
21SEP76	1	3.0	9.8	11.0	12.2	23.2	0.74
21SEP76	3	4.0	11.2	11.8	11.1	19.7	1.07

Table 2. Occurrence of fish in the Squamish estuary: October 1975 - September 1976.

SAMPLING DATE		STAGHORN SCULPIN	STARRY FLOUNDER	CHUM SALMON	CHINOOK SALMON	COHO SALMON	PINK SALMON	SPINY DOGFISH	HERRING	SURF SMELT	CUTTHROAT TROUT	DOLLY VARDEN CHAR	PRICKLY SCULPIN	SHINER PERCH	THREESPINE STICKLEBACK	SNAKE PRICKLEBACK	EULACHON	SAND LANCE
30 Oct 75	seine[a]		+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
30 Oct 75	gill[b]	+	+	-	-	-	-	+	+	-	+	+	-	+	-	-	-	-
27 Nov 75	seine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27 Nov 75	gill	+	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
15 Dec 75	seine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15 Dec 75	gill	+	+	-	-	-	-	+	-	-	+	+	+	-	-	-	-	-
29 Jan 76	seine	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-	-
29 Jan 76	gill	+	+	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-
25 Feb 76	seine	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
25 Feb 76	gill	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
12 Mar 76	seine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12 Mar 76	gill	+	+	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-
25 Mar 76	seine	-	+	+	-	-	-	-	-	+	+	-	+	-	+	-	-	-
25 Mar 76	gill	+	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-
3 Apr 76	tc[c]	+	+	+	-	-	-	-	-	+	-	-	-	-	++	-	-	-
10 Apr 76	seine	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22 Apr 76	seine	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	-	+
22 Apr 76	gill	+	+	-	-	+	-	-	-	+	-	-	+	+	-	-	-	-
6 May 76	seine	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-
17 May 76	tc	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
25 May 76	seine	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25 May 76	gill	+	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-
9 Jun 76	seine	+	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-

[a] beach seine
[b] gill net
[c] tidal creek enclosure

Table 2 cont'd.

SAMPLING DATE		STAGHORN SCULPIN	STARRY FLOUNDER	CHUM SALMON	CHINOOK SALMON	COHO SALMON	PINK SALMON	SPINY DOGFISH	HERRING	SURF SMELT	CUTTHROAT TROUT	DOLLY VARDEN CHAR	PRICKLY SCULPIN	SHINER PERCH	THREESPINE STICKLEBACK	SNAKE PRICKLEBACK	EULACHON	SAND LANCE
21 Jun 76	seine	+	+	+	+	+	-	-	-	-	+	+	-	-	-	-	-	-
21 Jun 76	gill	+	+	-	-	+	-	-	+	+	+	+	+	-	-	+	-	-
27 Jun 76	seine	+	+	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-
1 Jul 76	tc	+	-	+	+	+	-	-	-	+	-	+	-	-	-	-	-	-
6 Jul 76	seine	-	-	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-
19 Jul 76	seine	-	-	+	+	+	-	-	-	-	+	+	-	-	-	-	-	-
19 Jul 76	gill	+	-	-	+	+	-	-	+	+	-	-	+	-	-	+	-	-
2 Aug 76	seine	+	+	-	+	+	-	-	+	+	+	+	-	-	-	-	-	-
23 Aug 76	seine	+	+	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-
23 Aug 76	gill	+	+	-	+	+	-	-	+	+	+	+	-	-	-	+	+	-
22 Sep 76	seine	+	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-
22 Sep 76	gill	+	+	-	+	+	-	-	+	+	+	-	-	+	-	-	-	-

Table 3. Day and night catch statistics for staghorn sculpin, dogfish, cutthroat trout and dolly varden in the Squamish estuary: Oct. 1975-Sept. 1976. Catch-per-unit-effort (CPUE) is expressed as number of fish caught per gill-net hour. Columns headed by T show total number per set.

DAY CATCH STATISTICS:

STN.	MESH inches	TIME hours	STAGHORN T	STAGHORN CPUE	DOGFISH T	DOGFISH CPUE	CUTTHROAT T	CUTTHROAT CPUE	DOLLY V. T	DOLLY V. CPUE	DAY	MO	YR
1	1.00	6.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	10	75
1	1.50	6.50	1.	0.15	1.	0.15	0.	0.0	0.	0.0	30	10	75
3	1.50	4.83	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	10	75
3	2.00	5.00	2.	0.40	0.	0.0	2.	0.40	2.	0.40	30	10	75
1	1.00	6.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
1	1.50	6.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
3	1.50	5.08	0.	0.0	0.	0.0	1.	0.20	2.	0.39	27	11	75
3	2.00	5.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
1	1.00	3.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
1	1.50	3.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
3	1.50	3.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
3	1.50	3.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
1	0.75	5.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
1	1.00	5.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
3	1.00	4.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
3	1.50	4.00	3.	0.75	0.	0.0	0.	0.0	0.	0.0	29	1	76
1	0.75	4.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
1	1.00	4.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
3	1.00	3.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
3	1.50	3.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
1	0.75	6.43	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
1	1.00	6.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	0.75	5.67	1.	0.18	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	1.50	5.67	1.	0.18	0.	0.0	0.	0.0	0.	0.0	13	3	76
1	0.75	7.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
1	1.00	7.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
3	0.75	6.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
3	1.00	6.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
1	0.75	7.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	1.00	7.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	2.00	7.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	0.75	5.83	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	1.00	5.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	1.50	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	2.00	5.66	1.	0.18	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	0.75	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	1.00	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	1.50	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	2.00	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	0.75	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	1.00	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	1.50	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	2.00	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	0.75	9.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76

Table 3. (Cont'd)

DAY CATCH STATISTICS

STN.	MESH inches	TIME hours	STAGHORN T	STAGHORN CPUE	DOGFISH T	DOGFISH CPUE	CUTTHROAT T	CUTTHROAT CPUE	DOLLY V. T	DOLLY V. CPUE	DAY	MO	YR
1	1.00	9.42	1.	0.11	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	1.50	9.42	1.	0.11	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	2.00	9.42	7.	0.74	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	0.75	8.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	1.00	8.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	1.50	8.33	7.	0.84	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	2.00	8.33	2.	0.24	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	0.75	5.67	1.	0.18	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	1.00	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	1.50	5.67	3.	0.53	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	0.75	5.42	1.	0.18	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	1.00	5.42	2.	0.37	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	1.50	5.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	2.00	5.42	1.	0.18	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	0.75	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	1.00	4.67	1.	0.21	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	1.50	4.67	8.	1.71	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	0.75	5.25	5.	0.95	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	1.00	5.25	2.	0.38	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	1.50	5.00	4.	0.80	4.	0.0	0.	0.0	0.	0.0	23	8	76
3	2.00	4.50	18	4.00	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	0.75	4.33	1.	0.23	0.	0.0	0.	0.0	0.	0.0	21	9	76
1	1.00	4.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
1	1.50	4.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	0.75	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	1.00	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	1.50	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	2.00	3.50	1.	0.29	0.	0.0	0.	0.0	0.	0.0	21	9	76

OVERNIGHT CATCH STATISTICS

1	1.00	16.50	12.	0.73	0.	0.0	0.	0.0	0.	0.0	16	11	75
1	1.50	16.50	10.	0.61	3.	0.18	0.	0.0	0.	0.0	16	11	75
3	1.50	18.50	4.	0.22	0.	0.0	2.	0.11	4.	0.22	16	11	75
1	1.50	15.75	5.	0.32	2.	0.13	0.	0.0	0.	0.0	30	1	76
3	1.00	17.25	50.	2.90	0.	0.0	0.	0.0	1.	0.06	30	1	76
1	0.75	16.50	8.	0.48	0.	0.0	0.	0.0	0.	0.0	27	2	76
1	1.00	16.00	27.	1.69	2.	0.13	0.	0.0	0.	0.0	27	2	76
3	1.00	17.58	4.	0.23	0.	0.0	0.	0.0	0.	0.0	27	2	76
1	1.00	16.25	13.	0.80	3.	0.18	0.	0.0	0.	0.0	13	3	76
1	0.75	16.75	0.	0.0	1.	0.06	0.	0.0	0.	0.0	13	3	76
3	0.75	19.00	1.	0.05	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	1.50	18.50	21.	1.14	0.	0.0	2.	0.11	2.	0.11	13	3	76
3	0.75	19.00	1.	0.05	0.	0.0	0.	0.0	0.	0.0	26	3	76
3	1.00	18.25	6.	0.33	0.	0.0	2.	0.11	1.	0.05	26	3	76

Table 3. (Cont'd)

OVERNIGHT CATCH STATISTICS

STN	MESH inches	TIME hours	STAGHORN T	STAGHORN CPUE	DOGFISH T	DOGFISH CPUE	CUTTHROAT T	CUTTHROAT CPUE	DOLLY V. T	DOLLY V. CPUE	DAY	MO	YR
1	0.75	15.50	1.	0.06	1.	0.06	0.	0.0	0.	0.0	26	3	76
1	1.00	15.50	15.	0.97	2.	0.13	0.	0.0	0.	0.0	26	3	76
3	0.75	16.17	1.	0.06	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	1.00	16.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	1.50	16.42	6.	0.37	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	2.00	16.66	6.	0.36	0.	0.0	0.	0.0	0.	0.0	23	4	76
1	0.75	15.17	1.	0.07	0.	0.0	0.	0.0	0.	0.0	23	4	76
1	1.00	15.17	4.	0.26	0.	0.0	0.	0.0	0.	0.0	23	4	76
1	2.00	14.25	40.	2.81	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	1.00	13.25	1.	0.08	0.	0.0	0.	0.0	0.	0.0	26	5	76
3	1.50	13.42	1.	0.07	0.	0.0	0.	0.0	0.	0.0	26	5	76
3	2.00	13.50	8.	0.59	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	1.00	13.17	6.	0.46	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	1.50	13.33	9.	0.68	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	2.00	13.50	35.	2.59	0.	0.0	0.	0.0	0.	0.0	26	5	76
3	0.75	13.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	0.75	13.08	1.	0.08	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	0.75	15.50	4.	0.26	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	1.00	15.50	6.	0.39	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	1.50	15.75	8.	0.51	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	2.00	15.92	51.	3.20	0.	0.0	0.	0.0	0.	0.0	22	6	76
3	0.75	10.08	2.	0.20	0.	0.0	0.	0.0	0.	0.0	22	6	76
3	1.00	10.08	8.	0.79	0.	0.0	0.	0.0	0.	0.0	22	6	76
3	1.50	10.50	34.	3.24	0.	0.0	1.	0.10	0.	0.0	22	6	76
3	2.00	10.50	22.	2.10	0.	0.0	0.	0.0	1.	0.10	22	6	76
1	0.75	15.08	10.	0.66	0.	0.0	0.	0.0	0.	0.0	20	7	76
1	1.00	15.25	15.	0.98	0.	0.0	0.	0.0	0.	0.0	20	7	76
1	1.50	15.58	13.	0.83	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	0.75	17.42	19.	1.09	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	1.00	17.08	16.	0.94	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	1.50	16.83	52.	3.09	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	2.00	16.08	26	1.62	0.	0.0	0.	0.0	0.	0.0	20	7	76
1	0.75	16.00	4.	0.25	0.	0.0	0.	0.0	0.	0.0	24	8	76
1	1.00	16.25	22.	1.35	0.	0.0	0.	0.0	0.	0.0	24	8	76
1	1.50	17.25	57.	3.30	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	0.75	14.00	3.	0.21	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	1.00	14.00	12.	0.86	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	1.50	15.00	49.	3.27	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	2.00	12.00	62.	5.17	0.	0.0	0.	0.0	0.	0.0	24	8	76
1	0.75	18.17	7.	0.39	0.	0.0	0.	0.0	0.	0.0	22	9	76
1	1.00	18.17	26.	1.43	0.	0.0	0.	0.0	0.	0.0	22	9	76
1	1.50	18.17	52.	2.86	0.	0.0	0.	0.0	0.	0.0	22	9	76
3	0.75	17.25	14.	0.81	0.	0.0	0.	0.0	0.	0.0	22	9	76
3	1.00	17.25	17.	0.99	0.	0.0	0.	0.0	0.	0.0	22	9	76
3	1.50	16.50	49.	2.97	0.	0.0	0.	0.0	0.	0.0	22	9.	76
3	2.00	16.00	60.	3.75	0.	0.0	0.	0.0	0.	0.0	22	9.	76

Table 4. Day and night catch statistics for herring, salmon smolts(combined coho and chinook), surf smelt, and snake prickleback in the Squamish estuary: Oct. 1975-Sept.1976. Catch-per-unit-effort (CPUE) is expressed as number of fish caught per gill-net hour. Columns headed by T show total number per set.

DAY CATCH STATISTICS:

STN	MESH inches	TIME hours	HERRING T	HERRING CPUE	SMOLTS T	SMOLTS CPUE	SMELT T	SMELT CPUE	PRICKLEBACK T	PRICKLEBACK CPUE	DAY	MO	YR
1	1.00	6.42	1.	0.16	1.	0.16	0.	0.0	0.	0.0	30	10	75
1	1.50	6.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	10	75
3	1.50	4.83	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	10	75
3	2.00	5.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	10	75
1	1.00	6.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
1	1.50	6.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
3	1.50	5.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
3	2.00	5.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	11	75
1	1.00	3.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
1	1.50	3.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
3	1.50	3.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
3	1.50	3.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	15	12	75
1	0.75	5.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
1	1.00	5.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
3	1.00	4.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
3	1.50	4.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	29	1	76
1	0.75	4.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
1	1.00	4.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
3	1.00	3.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
3	1.50	3.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	2	76
1	0.75	6.43	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
1	1.00	6.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	0.75	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	1.50	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
1	0.75	7.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
1	1.00	7.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
3	0.75	6.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
3	1.00	6.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	3	76
1	0.75	7.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	1.00	7.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	2.00	7.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	0.75	5.83	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	1.00	5.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	1.50	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
3	2.00	5.66	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	4	76
1	0.75	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	1.00	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	1.50	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
1	2.00	5.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	0.75	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	1.00	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	1.50	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76
3	2.00	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	25	5	76

Table 4. (Cont'd)

DAY CATCH STATISTICS:

STN	MESH inches	TIME hours	HERRING T	HERRING CPUE	SMOLTS T	SMOLTS CPUE	SMELT T	SMELT CPUE	PRICKLEBACK T	PRICKLEBACK CPUE	DAY	MO	YR
1	0.75	9.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	1.00	9.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	1.50	9.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	2.00	9.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	0.75	8.33	0.	0.0	0.	0.0	0.	0.12	1.	0.0	21	6	76
3	1.00	8.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	1.50	8.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
3	2.00	8.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	6	76
1	0.75	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	1.00	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	1.50	5.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	0.75	5.42	1.	0.18	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	1.00	5.42	1.	0.18	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	1.50	5.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
3	2.00	5.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	19	7	76
1	0.75	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	1.00	4.67	1.	0.21	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	1.50	4.67	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	0.75	5.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	1.00	5.25	1.	0.19	0.	0.0	0.	0.0	0.	0.0	23	8	76
3	1.50	5.00	0.	0.0	1.	0.20	0.	0.0	0.	0.0	23	8	76
3	2.00	4.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	8	76
1	0.75	4.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
1	1.00	4.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
1	1.50	4.33	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	0.75	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	1.00	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	1.50	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76
3	2.00	3.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	21	9	76

OVERNIGHT CATCH STATISTICS:

STN	MESH	TIME	HERRING T	HERRING CPUE	SMOLTS T	SMOLTS CPUE	SMELT T	SMELT CPUE	PRICKLEBACK T	PRICKLEBACK CPUE	DAY	MO	YR
1	1.00	16.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	16	11	75
1	1.50	16.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	16	11	75
3	1.50	18.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	16	11	75
1	1.50	15.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	1	76
3	1.00	17.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	30	1	76
1	0.75	16.50	1.	0.06	0.	0.0	0.	0.0	0.	0.0	27	2	76
1	1.00	16.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	2	76
3	1.00	17.58	0.	0.0	0.	0.0	0.	0.0	0.	0.0	27	2	76
1	1.00	16.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
1	0.75	16.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	0.75	19.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76
3	1.50	18.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	13	3	76

Table 4. (Cont'd)

OVERNIGHT CATCH STATISTICS:

STN	MESH inches	TIME hours	HERRING T	HERRING CPUE	SMOLTS T	SMOLTS CPUE	SMELT T	SMELT CPUE	PRICKLEBACK T	PRICKLEBACK CPUE	DAY	MO	YR
3	0.75	19.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	3	76
3	1.00	18.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	3	76
1	0.75	15.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	3	76
1	1.00	15.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	3	76
3	0.75	16.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	1.00	16.08	0.	0.0	0.	0.0	1.	0.06	0.	0.0	23	4	76
3	1.50	16.42	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	2.00	16.66	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
1	0.75	15.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
1	1.00	15.17	0.	0.0	0.	0.0	2.	0.13	0.	0.0	23	4	76
1	2.00	14.25	0.	0.0	0.	0.0	0.	0.0	0.	0.0	23	4	76
3	1.00	13.25	0.	0.0	5.	0.38	4.	0.30	0.	0.0	26	5	76
3	1.50	13.42	1.	0.07	0.	0.0	0.	0.0	0.	0.0	26	5	76
3	2.00	13.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	1.00	13.17	0.	0.0	11.	0.84	0.	0.0	0.	0.0	26	5	76
1	1.50	13.33	0.	0.0	1.	0.08	0.	0.0	0.	0.0	26	5	76
1	2.00	13.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	5	76
3	0.75	13.00	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	0.75	13.08	0.	0.0	0.	0.0	0.	0.0	0.	0.0	26	5	76
1	0.75	15.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	1.00	15.50	0.	0.0	1.	0.06	0.	0.0	4.	0.26	22	6	76
1	1.50	15.75	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	2.00	15.92	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	6	76
3	0.75	10.08	5.	0.50	1.	0.10	0.	0.0	0.	0.0	22	6	76
3	1.00	10.08	4.	0.40	1.	0.10	0.	0.0	0.	0.0	22	6	76
3	1.50	10.50	1.	0.10	0.	0.0	0.	0.0	0.	0.0	22	6	76
3	2.00	10.50	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	6	76
1	0.75	15.08	0.	0.0	0.	0.0	1.	0.07	0.	0.0	20	7	76
1	1.00	15.25	0.	0.0	0.	0.0	0.	0.0	2.	0.03	20	7	76
1	1.50	15.58	0.	0.0	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	0.75	17.42	1.	0.06	0.	0.0	0.	0.0	0.	0.0	20	7	76
3	1.00	17.08	0.	0.0	5.	0.29	0.	0.0	0.	0.0	20	7	76
3	1.50	16.83	0.	0.0	1.	0.06	0.	0.0	0.	0.0	20	7	76
3	2.00	16.08	0.	0.0	0.	0.0	0.	0.0	0.0	0.0	20	7	76
1	0.75	16.00	0.	0.0	0.	0.0	1.	0.06	0.	0.0	24	8	76
1	1.00	16.25	1.	0.06	0.	0.0	2.	0.12	1.	0.06	24	8	76
1	1.50	17.25	2.	0.12	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	0.75	14.00	1.	0.07	0.	0.0	0.	0.0	0.	0.0	24	8	76
3	1.00	14.00	13.	0.93	2.	0.14	0.	0.0	0.	0.0	24	8	76
3	1.50	15.00	57.	3.80	1.	0.07	0.	0.0	0.	0.0	24	8	76
3	2.00	12.00	3.	0.25	0.	0.0	0.	0.0	0.	0.0	24	8	76
1	0.75	18.17	0.	0.0	0.	0.0	0.	0.0	0.	0.0	22	9	76
1	1.00	18.17	0.	0.0	0.	0.0	2.	0.11	0.	0.0	22	9	76
1	1.50	18.17	13.	0.72	1.	0.06	0.	0.0	0.	0.0	22	9	76
3	0.75	17.25	0.	0.0	2.	0.12	0.	0.0	0.	0.0	22	9	76
3	1.00	17.25	15.	0.87	1.	0.06	0.	0.0	0.	0.0	22	9	76
3	1.50	16.50	58.	3.52	0.	0.0	0.	0.0	0.	0.0	22	9	76
3	2.00	16.00	1.	0.06	0.	0.0	0.	0.0	0.	0.0	22	9	76

Table 5. Statistical test of successive canonical roots - Squamish estuary gill net catch data.

CANONICAL ROOTS	CHI SQUARE VALUE	DEGREES OF FREEDOM	SIGNIFICANCE LEVEL
1 - 0.739	185.382	56	P< 0.01
2 - 0.494	87.432	42	P< 0.01
3 - 0.426	52.742	30	P< 0.01
4 - 0.391	27.910	20	NS
5 - 0.181	7.337	12	NS
6 - 0.144	3.206	6	NS
7 - 0.072	0.644	2	NS

Table 6. Canonical variates for Squamish estuary fish catch records.

CANONICAL ROOT	1	2	3	4	5	6	7
SURFACE TEMPERATURE	-0.01	0.87	-0.13	-0.35	0.82	-0.45	-1.02
SURFACE SALINITY	0.16	-0.11	-0.19	-0.54	1.05	-1.28	0.55
SECCHI DEPTH	-0.23	0.20	0.49	-0.33	-0.44	0.51	-1.68
STATION LOCATION	-0.03	-0.61	-0.65	0.43	-0.18	0.12	-0.29
MESH SIZE	0.36	0.03	-0.38	-0.78	-0.23	0.32	0.12
SET TIME	0.48	-1.40	-0.21	0.32	1.53	2.08	0.04
TIME OF DAY	-0.47	-1.26	-0.46	0.15	1.52	2.15	0.23
STAGHORN SCULPIN CATCH	0.87	0.33	-0.24	-0.30	-0.04	0.33	-0.25
DOGFISH CATCH	0.27	-0.28	0.80	-0.32	-0.05	-0.31	0.11
CUTTHROAT TROUT CATCH	0.12	-0.44	-0.05	0.05	-0.22	0.90	1.28
DOLLY VARDEN CHAR CATCH	0.13	-0.29	-0.22	-0.11	-0.09	-0.89	-1.02
HERRING CATCH	-0.04	-0.14	-0.21	0.31	0.41	-0.91	0.29
SALMON SMOLT CATCH	0.13	0.24	0.14	0.45	-0.82	-0.19	0.09
SURF SMELT CATCH	0.28	-0.48	0.20	0.61	0.34	0.24	-0.35
PRICKLEBACK CATCH	0.17	0.36	0.29	0.24	0.34	0.03	0.33

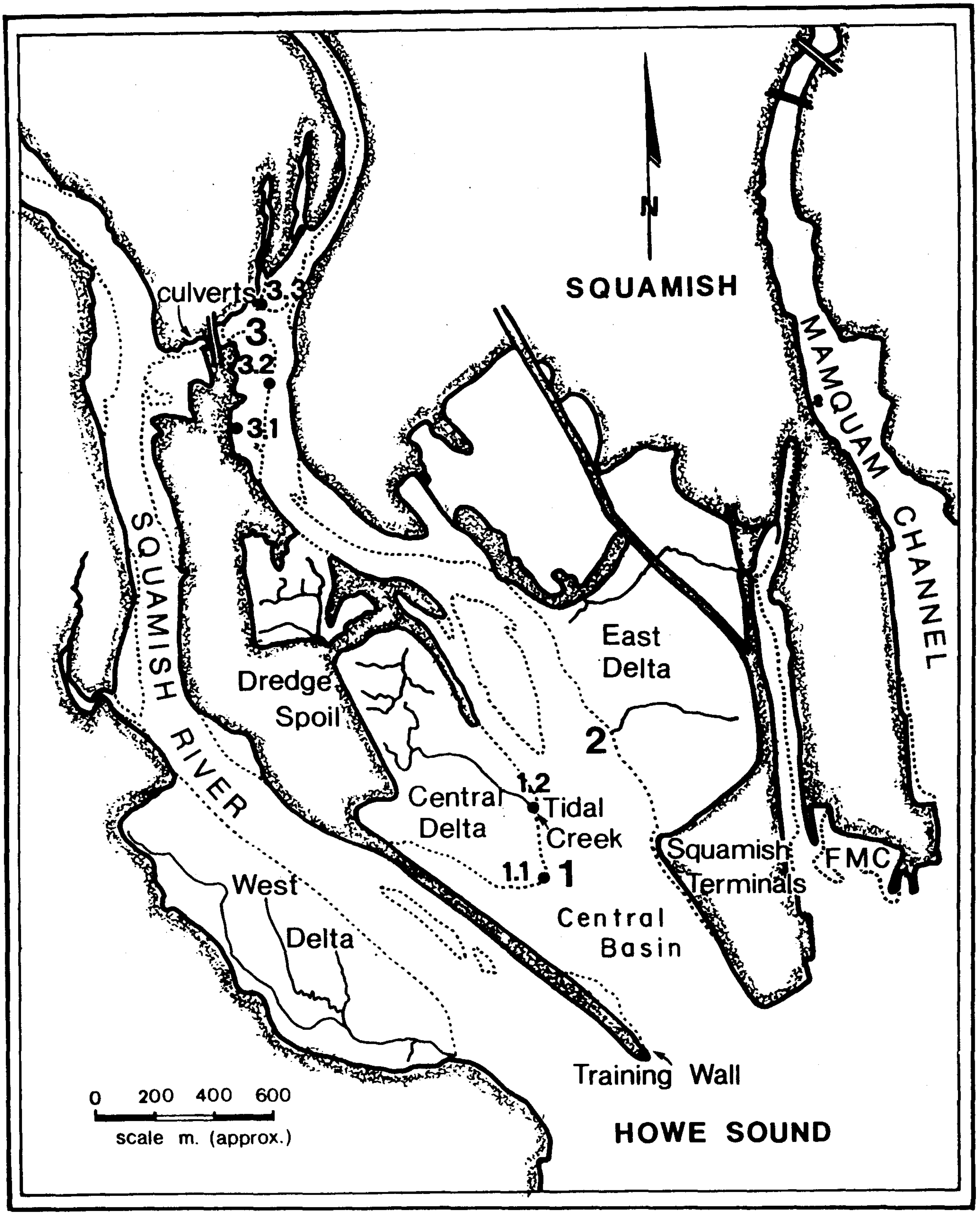


Fig. 1. Location of the study area showing major physical features and sampling stations.

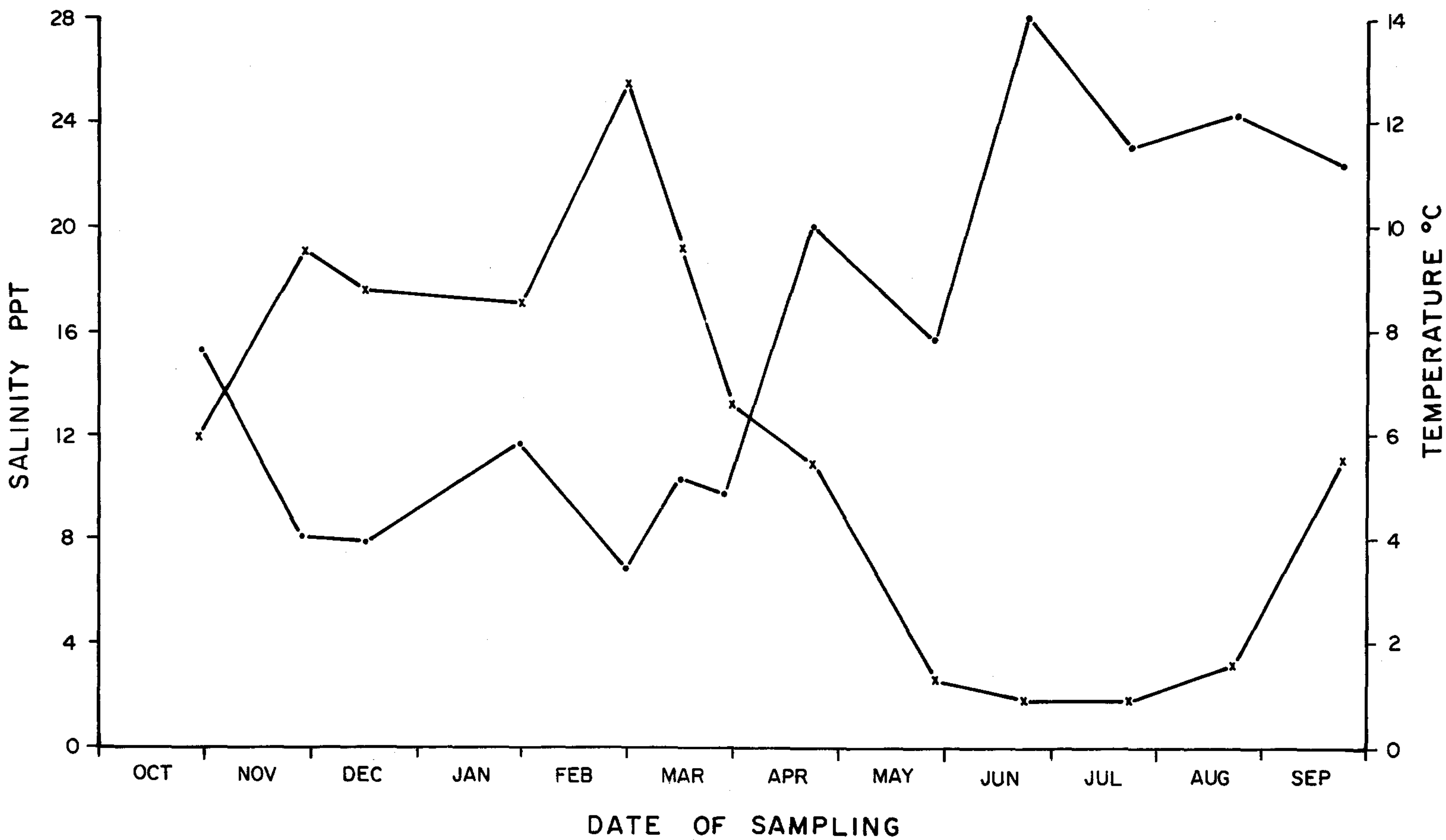


Fig. 2. Monthly surface salinity (x) and temperature (.) values at Station 3 in the Squamish estuary, October 1975 to September 1976.

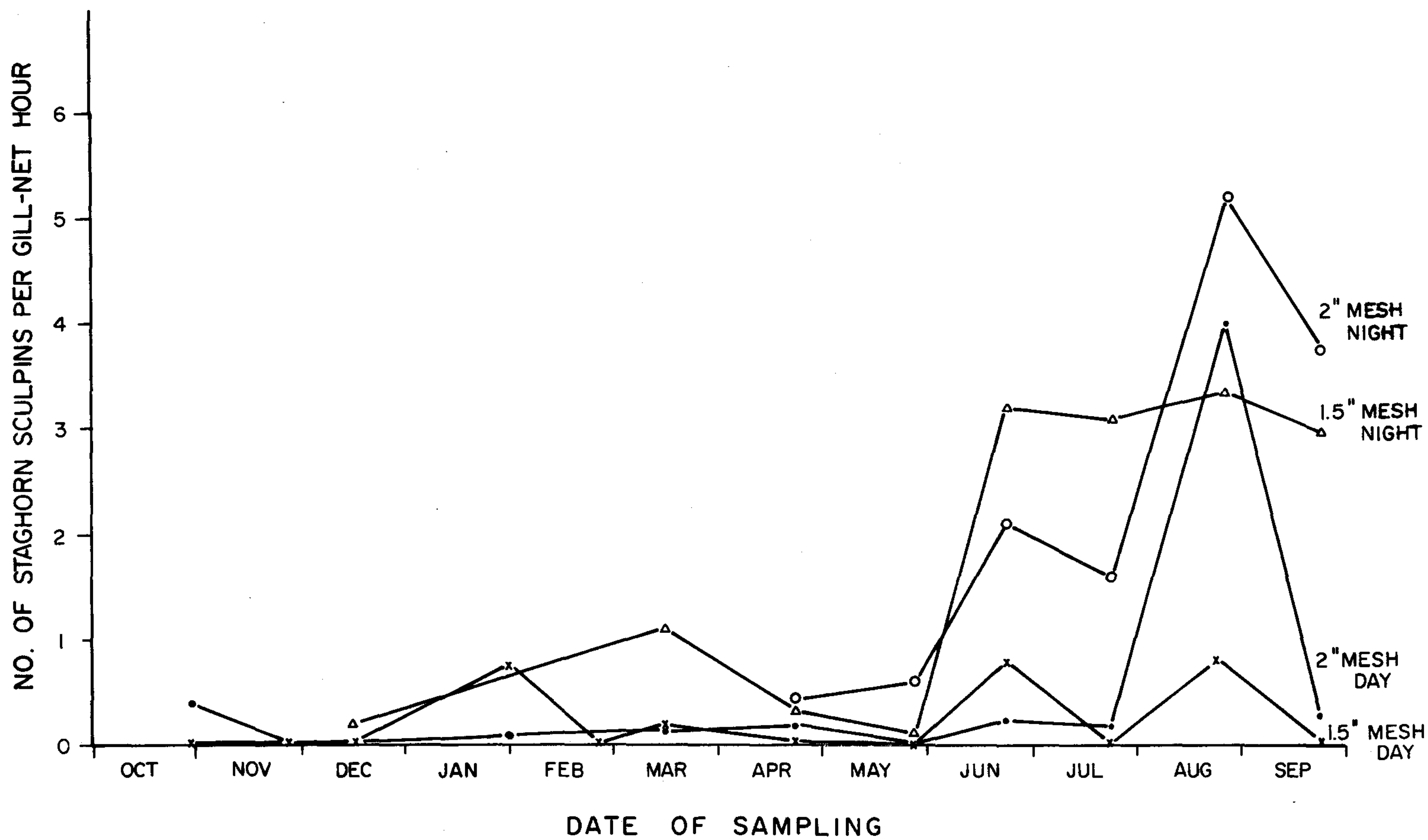


Fig. 3. Relative catch-per-unit-effort of staghorn sculpins (*Leptocottus armatus*) at Station 3 in the Squamish estuary, October 1975 to September 1976.

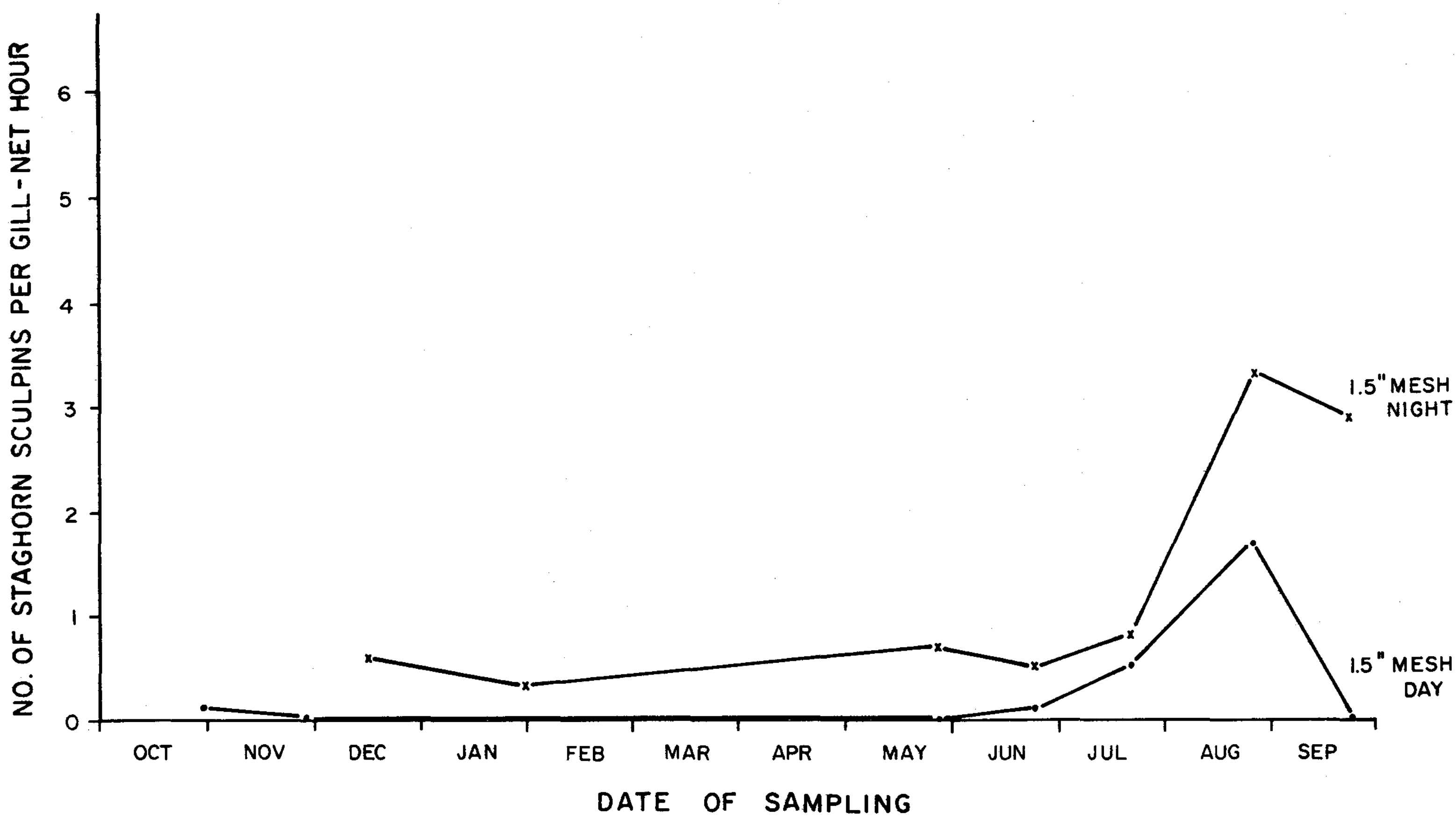


Fig. 4. Relative catch-per-unit-effort of staghorn sculpins (*L. armatus*) at Station 1 in the Squamish estuary, October 1975 to September 1976.

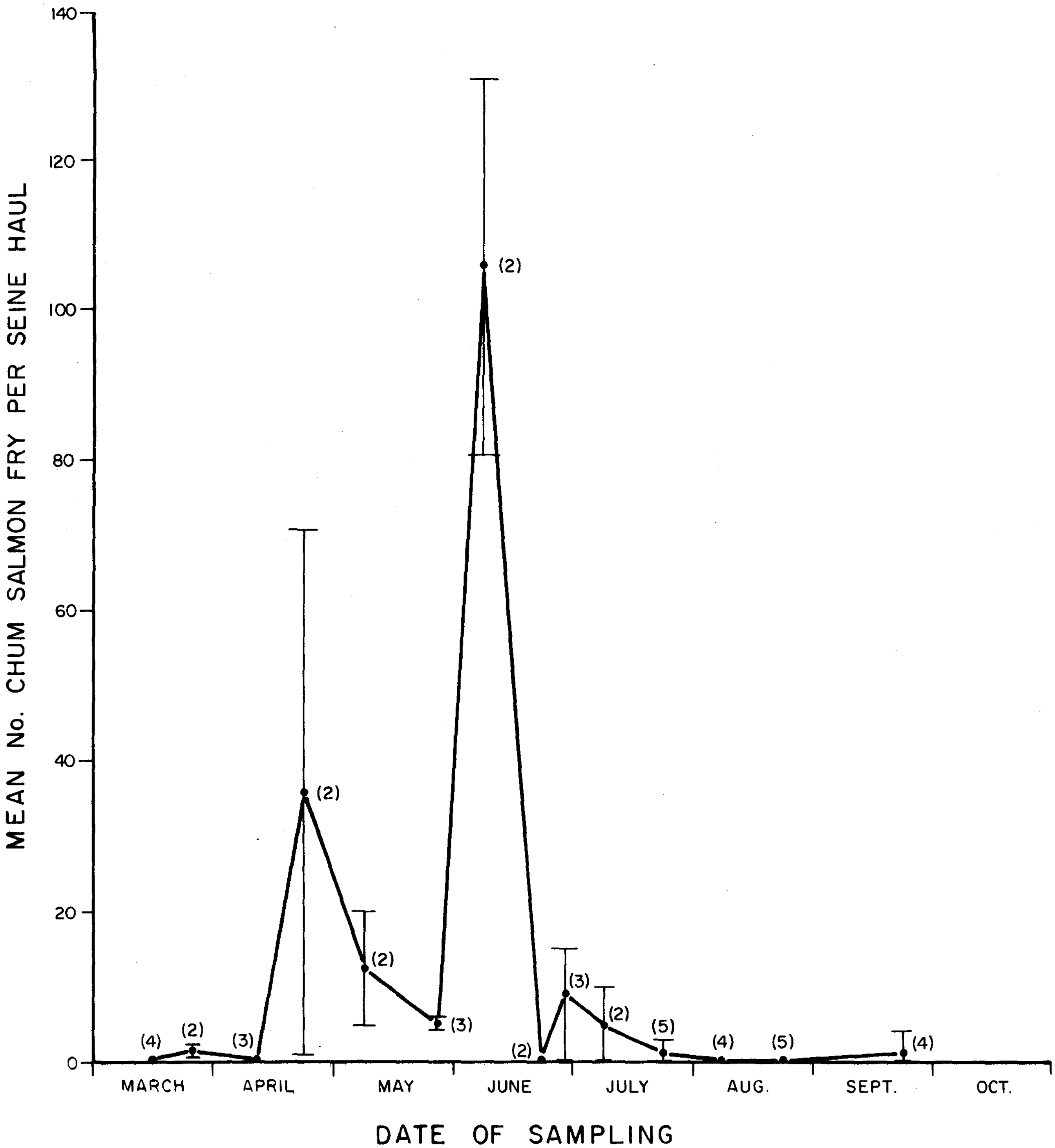


Fig. 5. Number of juvenile chum salmon per beach seine haul at Station 3 in the Squamish estuary, 1976. Mean and range, as well as the number of replicate seines (in brackets) are shown.

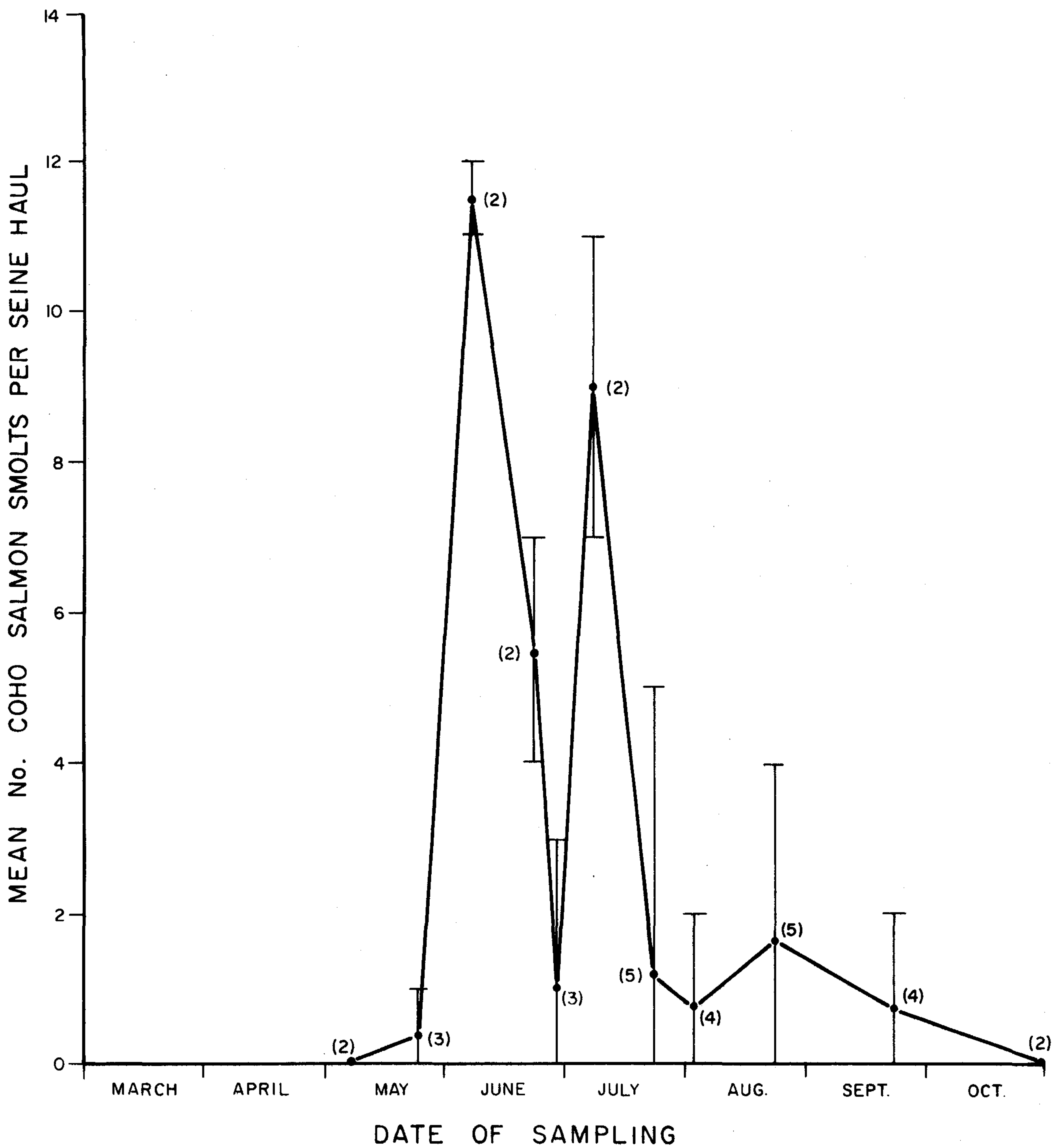


Fig. 6. Number of juvenile coho salmon per beach seine haul at Station 3 in the Squamish estuary, 1976. Mean and range, as well as the number of replicate seines (in brackets) are shown.

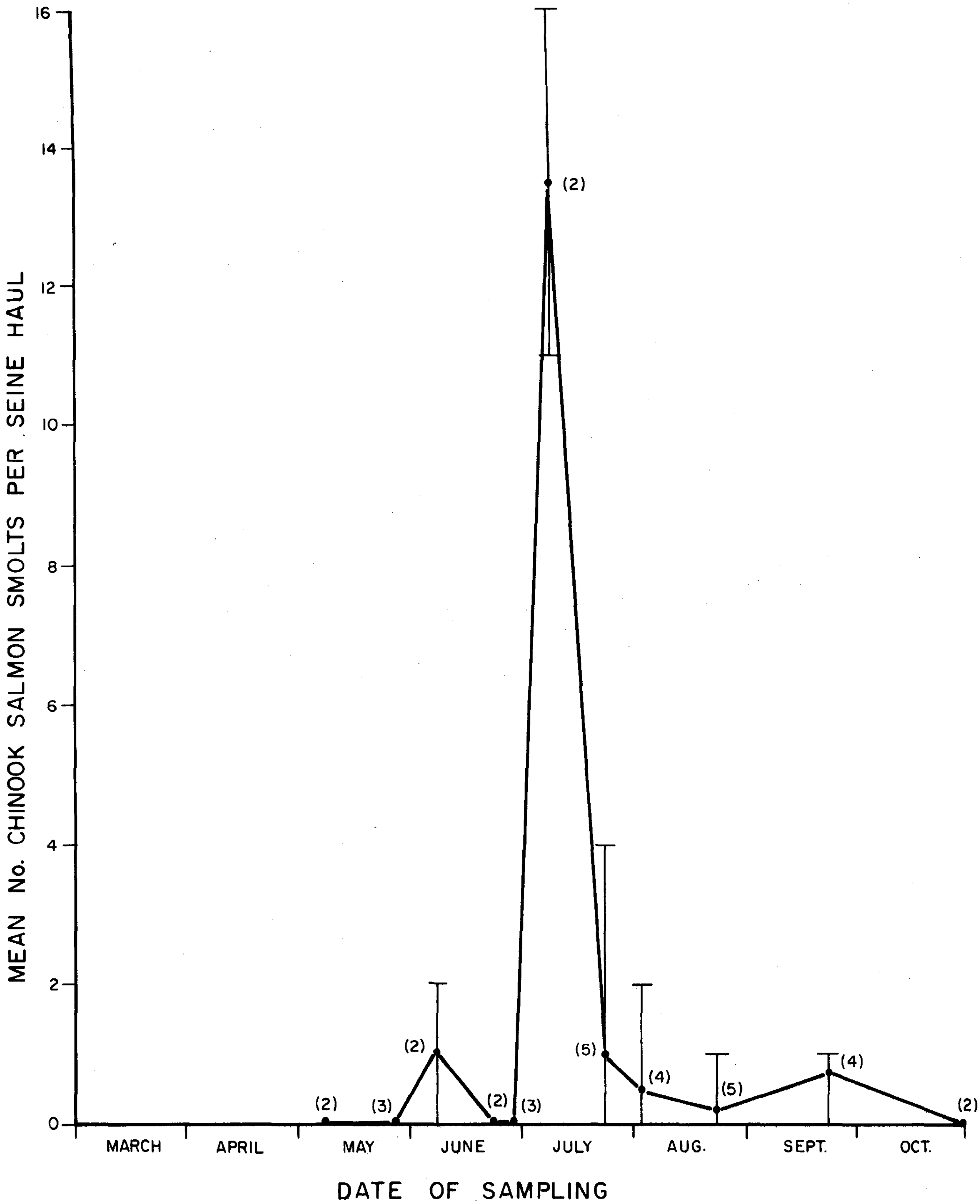


Fig. 7. Number of juvenile chinook salmon per beach seine haul at Station 3 in the Squamish estuary, 1976. Mean and range, as well as the number of replicate seines (in brackets) are shown.

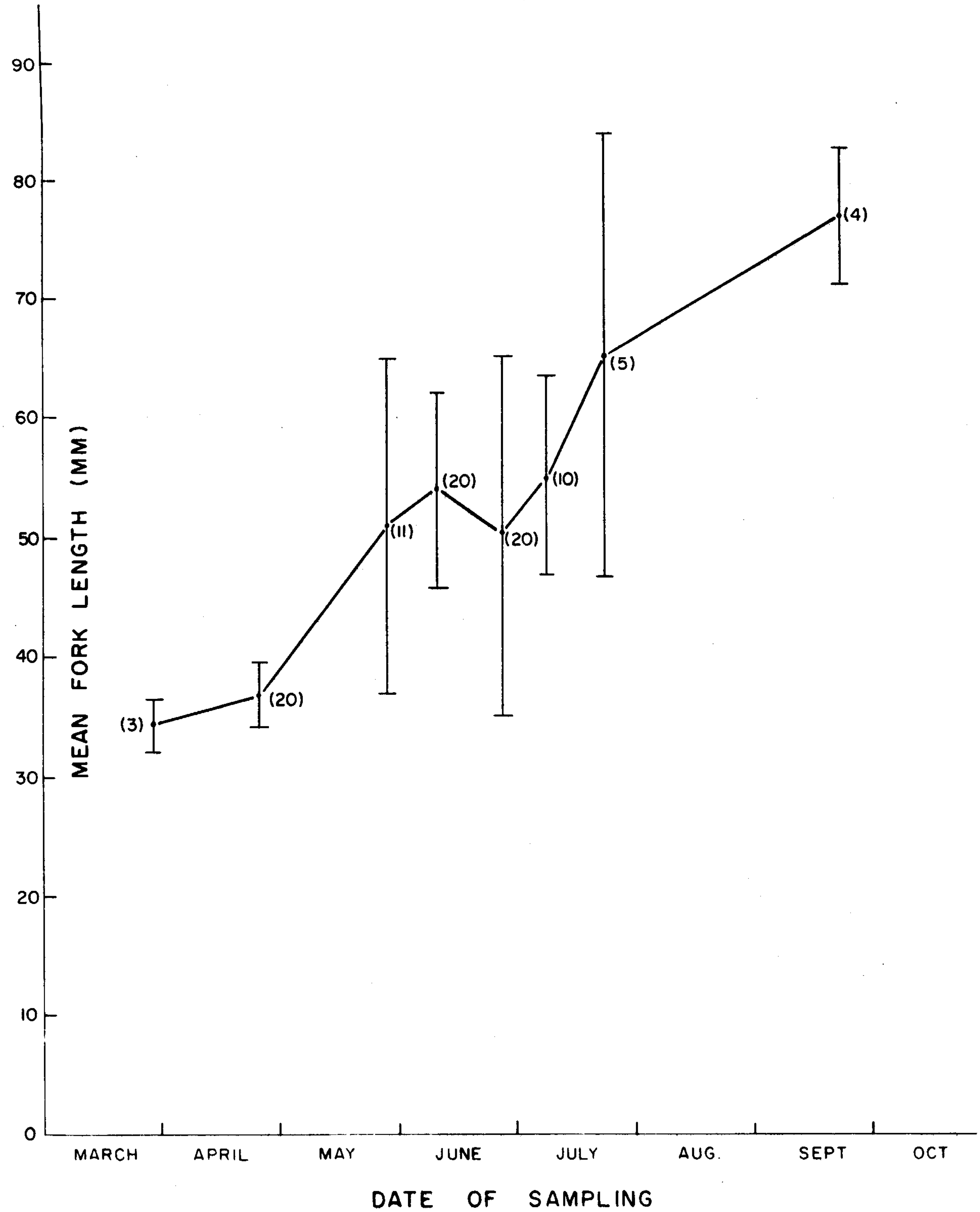


Fig. 8. Mean fork length of juvenile chum salmon at Station 3 in the Squamish estuary, 1976. 95% confidence limits are indicated as bars, and the number of fish measured is indicated in brackets.

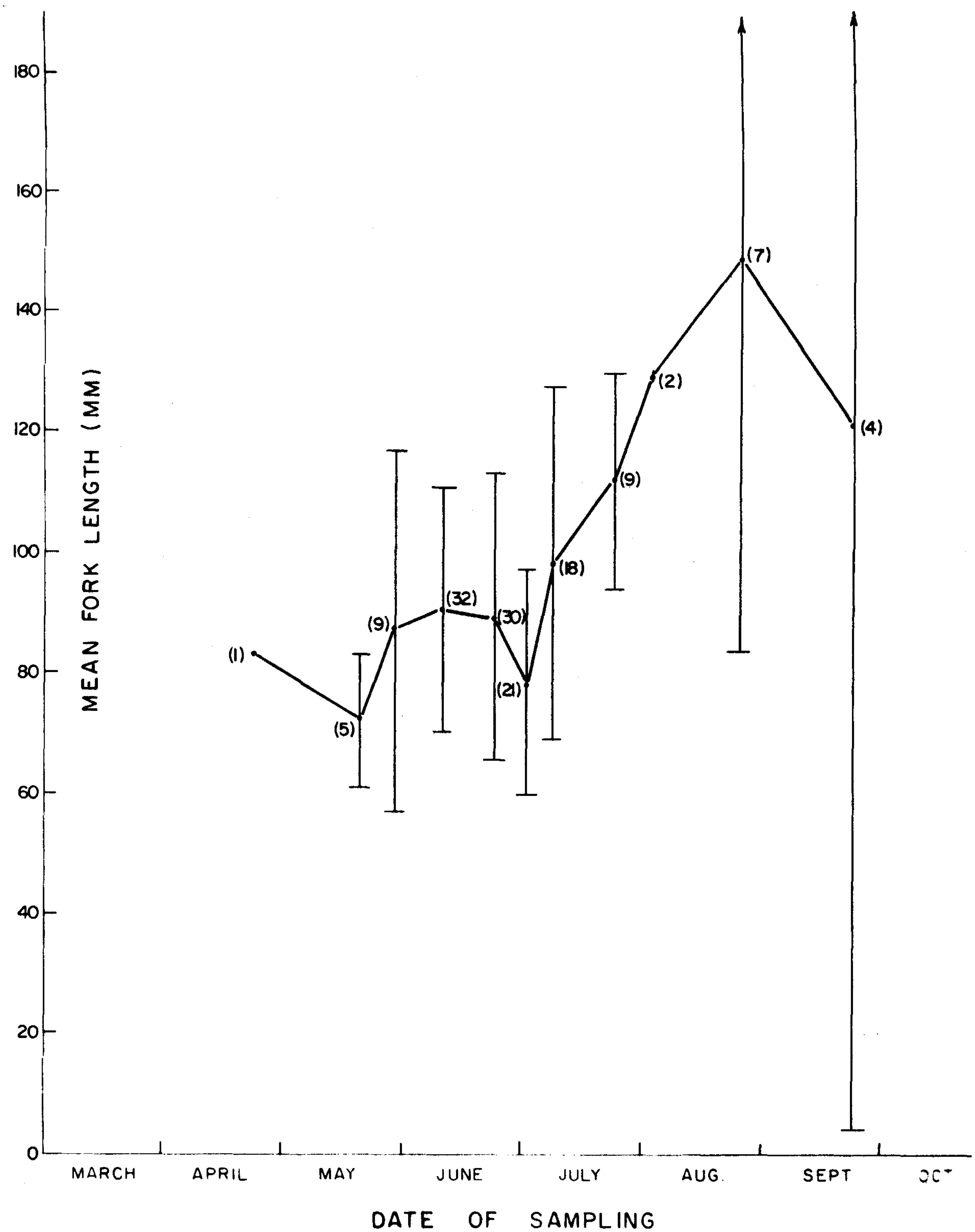


Fig. 9. Mean fork length of juvenile coho salmon in the Squamish estuary, 1976. 95% confidence limits are indicated as bars, and the number of fish measured is indicated in brackets.

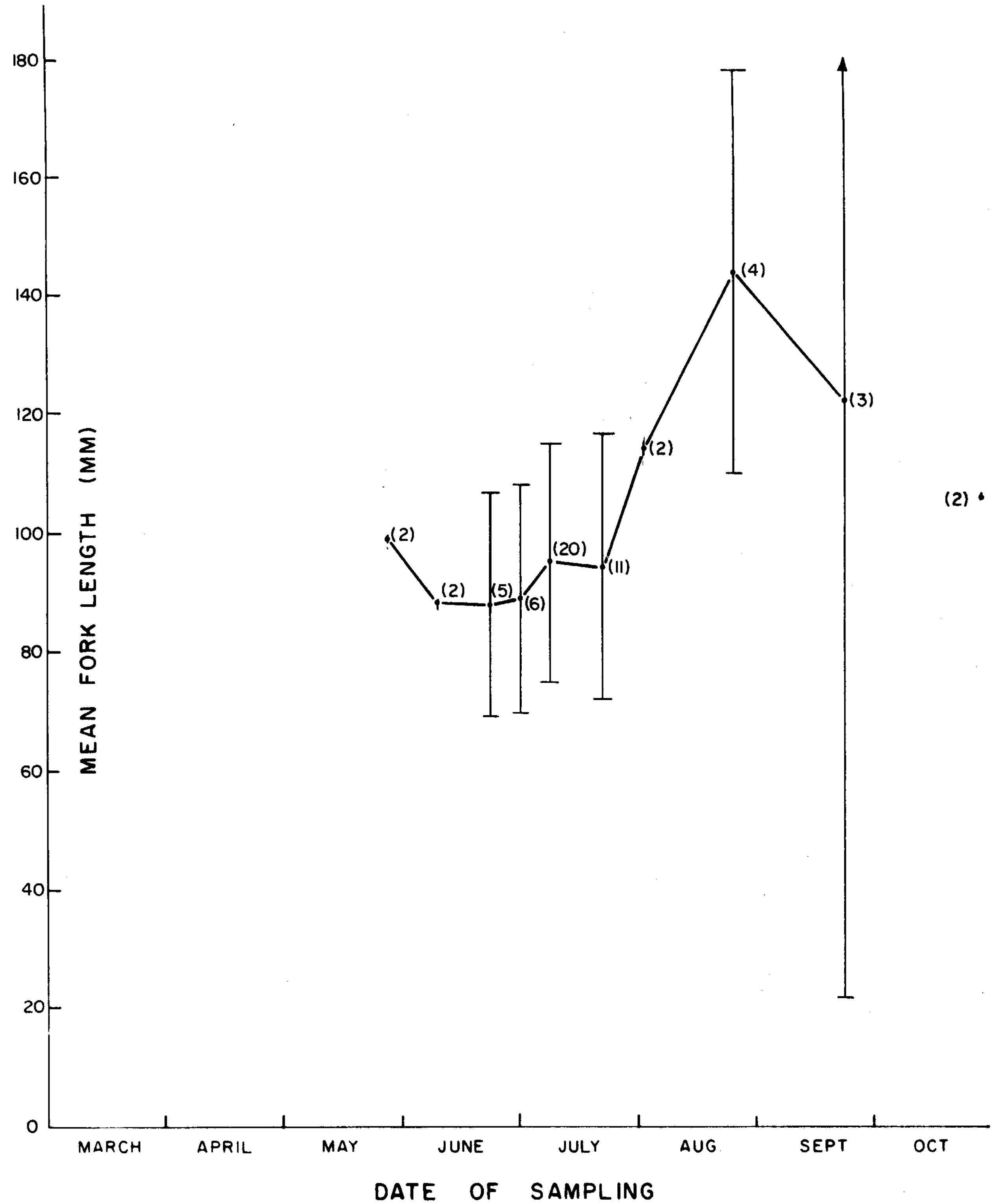


Fig. 10. Mean fork length of juvenile chinook salmon in the Squamish estuary, 1976. 95% confidence limits are indicated as bars, and the number of fish measured is indicated in brackets. The October sample was obtained in 1975.

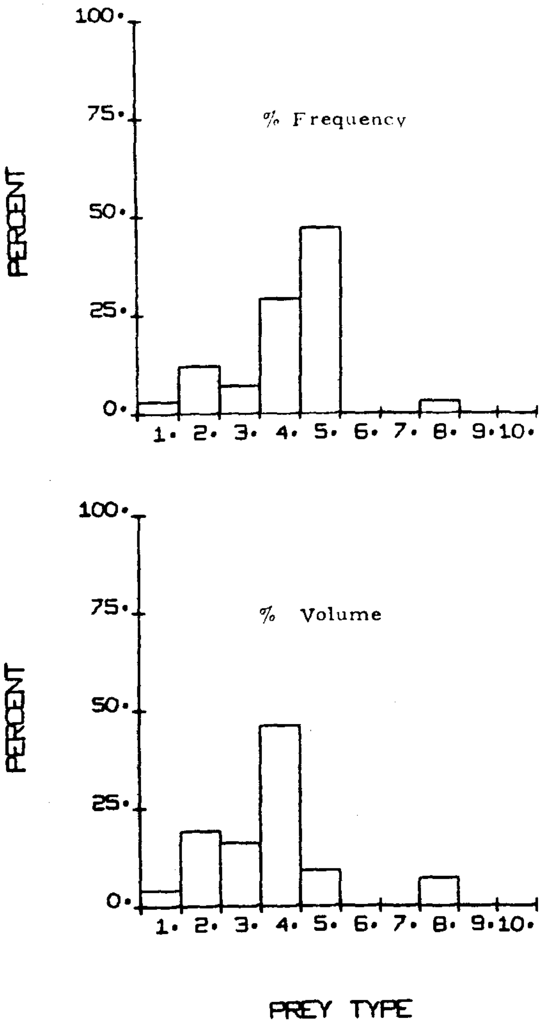


Fig. 11. Diet of juvenile chum salmon at Station 3.2 in the Squamish estuary on April 23, 1976. Data from 19 fish [mean length 37 mm (SD = 2.2); mean weight 0.39 g (SD = 0.07)].

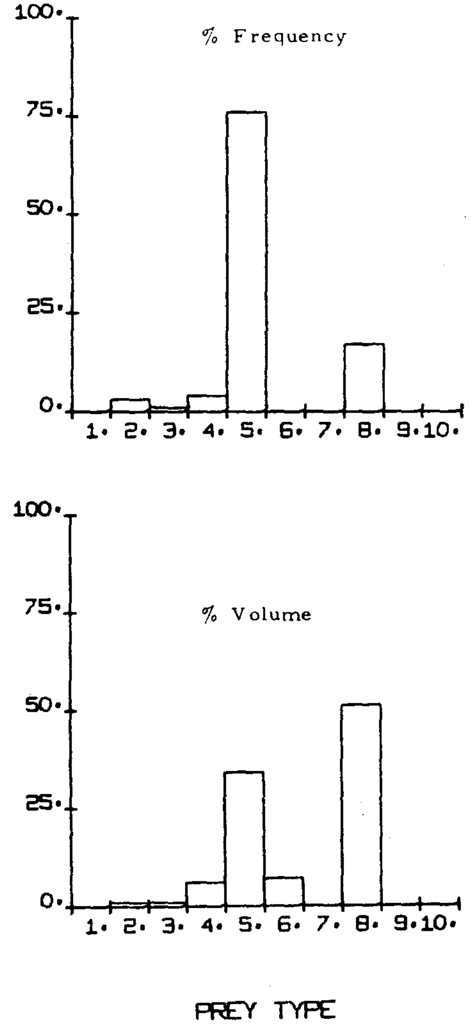


Fig. 12. Diet of juvenile chum salmon at Station 1.1 in the Squamish estuary on May 6, 1976. Data from 14 fish [mean length 41 mm (SD = 3.7); mean weight 0.58 g (SD = 0.18)].

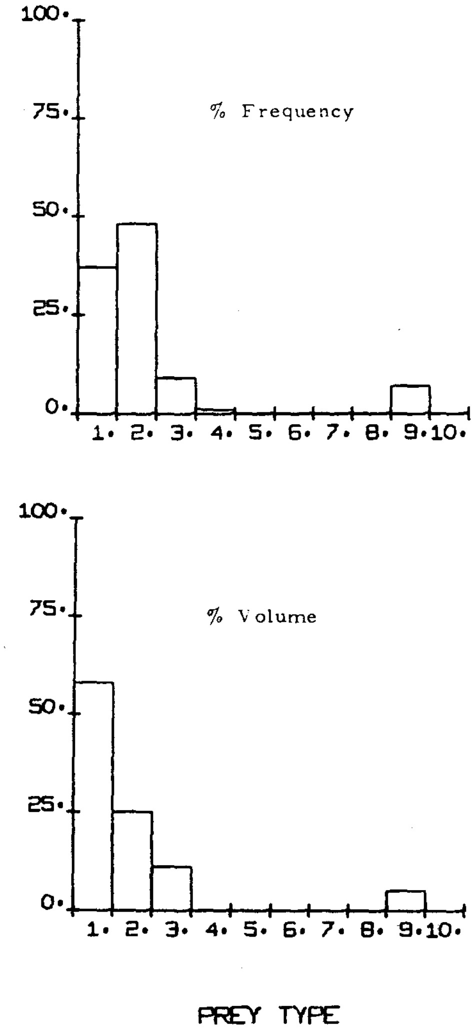
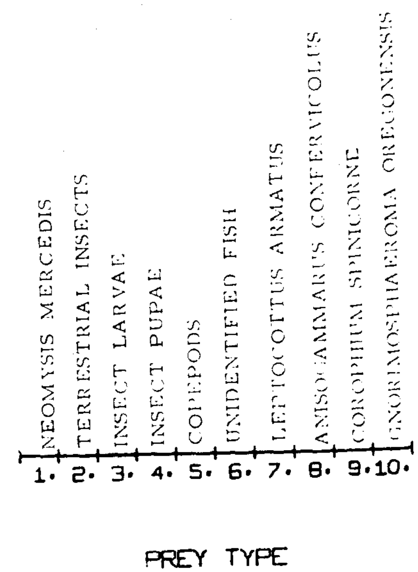


Fig. 13. Diet of juvenile chum salmon at Station 3.1 in the Squamish estuary on June 27, 1976. Data from 15 fish [mean length 48 mm (SD = 2.2); mean weight 1.15 g (SD = 0.57)].



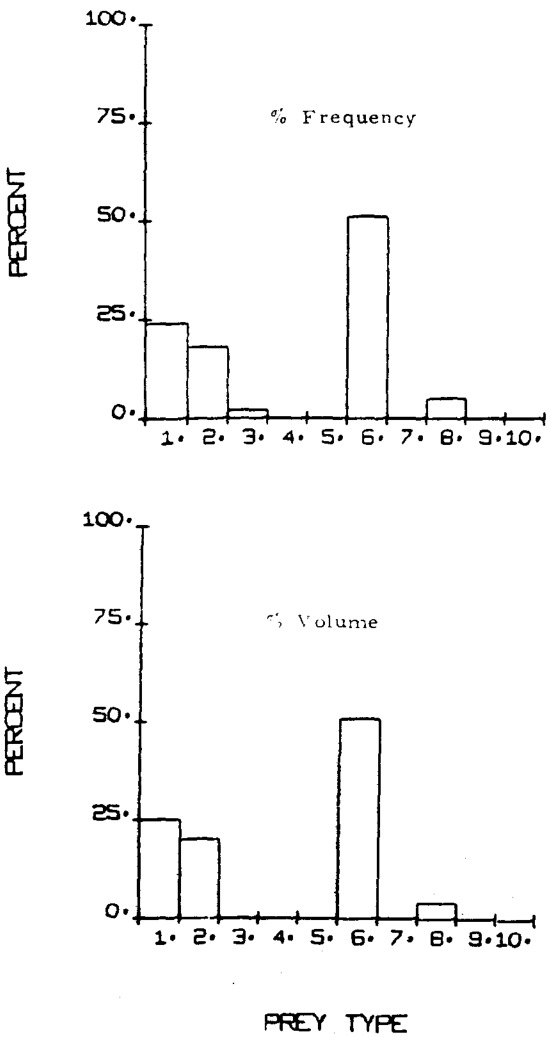


Fig. 14. Diet of juvenile coho salmon from a tidal creek (adjacent to Station 1.2) at the Squamish estuary (May 17,1976). Data from 5 fish [mean length 73 mm (SD 6.3); mean weight 4.96 g (SD = 1.19)].

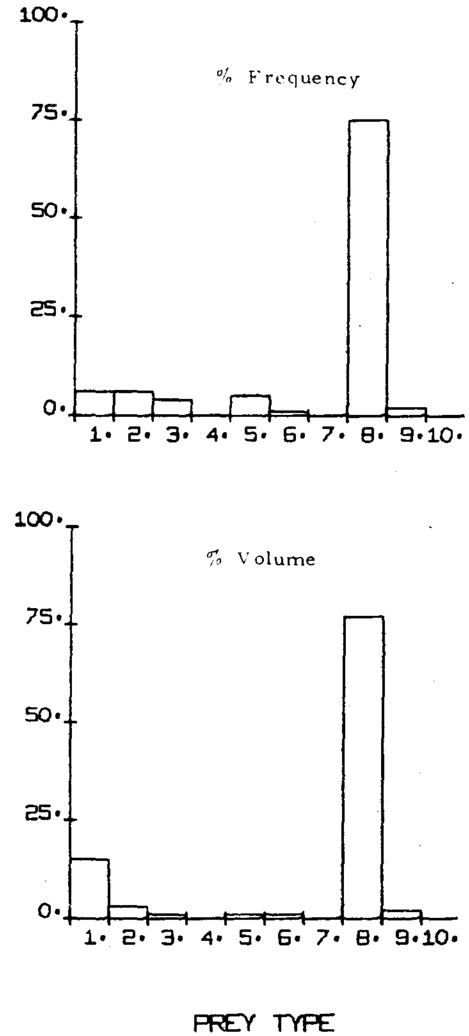


Fig. 15. Diet of juvenile coho salmon from a tidal creek (adjacent to Station 1.2) at the Squamish estuary (June 8,1976). Data from 9 fish [mean length 84 mm (SD = 10.7); mean weight 7.50 g (SD = 2.5)].

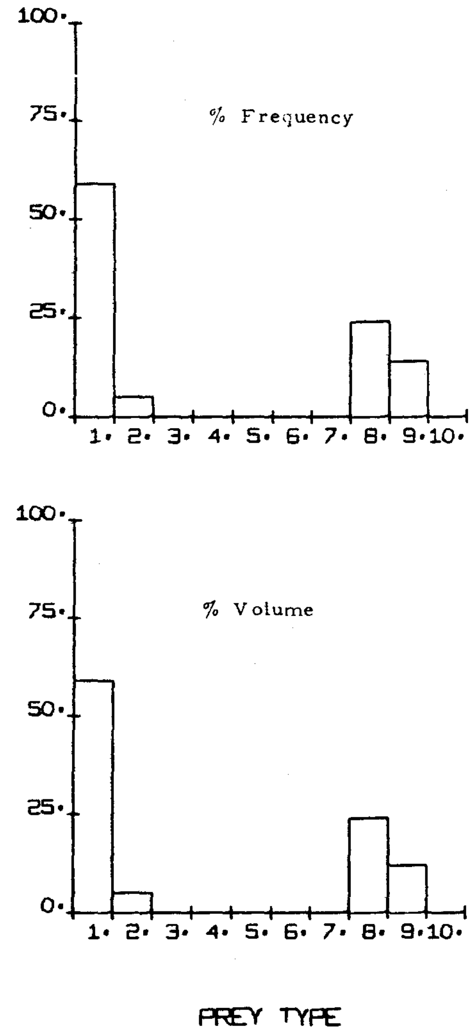
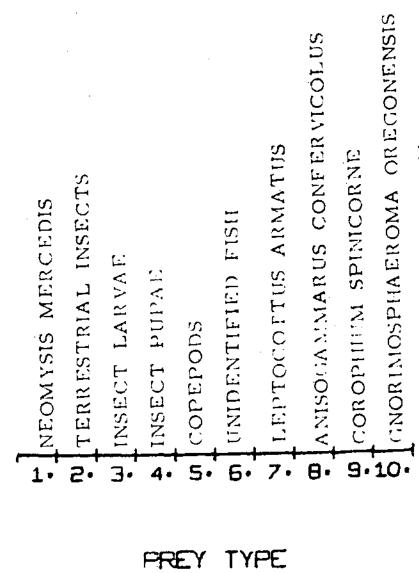


Fig. 16. Diet of juvenile coho salmon at Station 3.1 in the Squamish estuary on June 9, 1976. Data from 11 fish [mean length 90 mm (SD = 9.3); mean weight 9.40 g (SD = 3.6)]



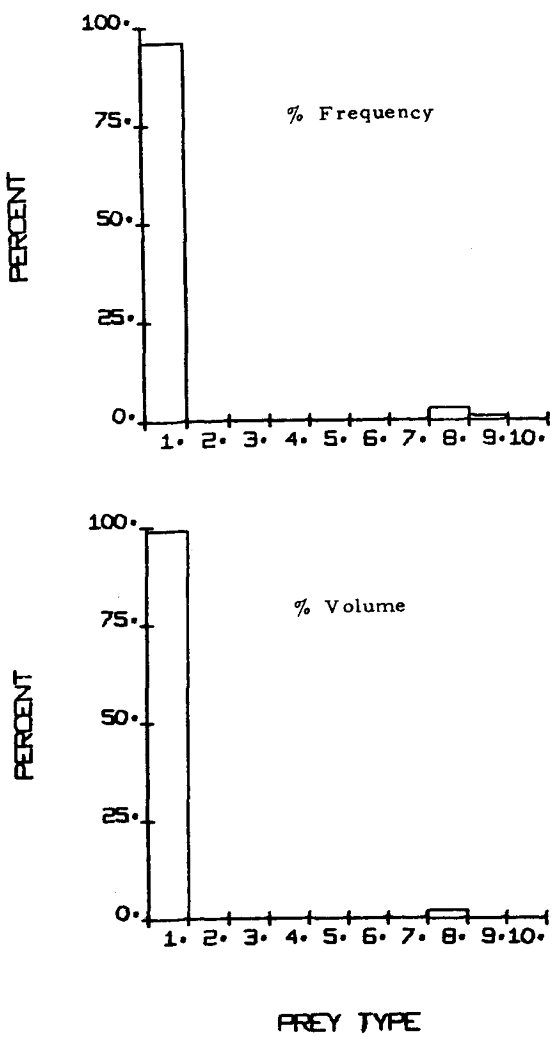


Fig. 17. Diet of juvenile coho salmon at Station 3.3 in the Squamish estuary on June 9, 1976. Data from 10 fish [mean length 98 mm (SD = 6.2); mean weight 12.1 g (SD = 2.3)].

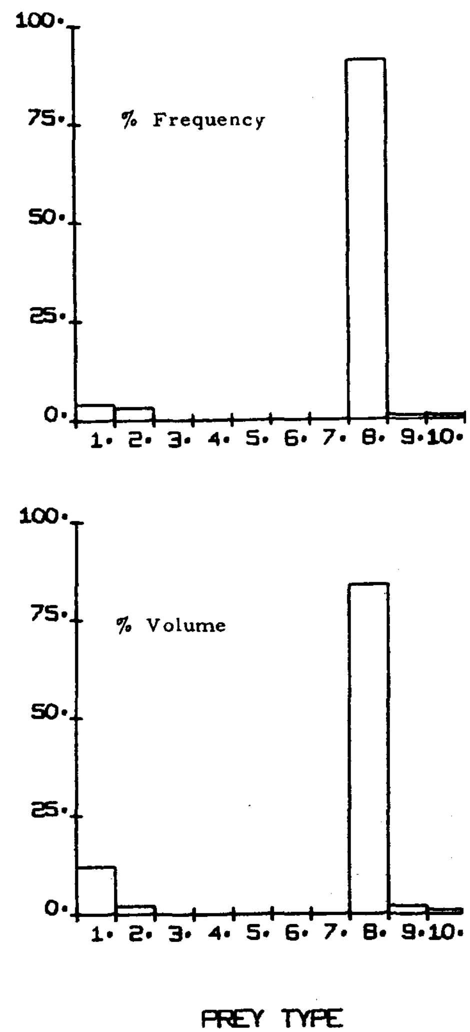


Fig. 18 . Diet of juvenile coho salmon at Station 1.2 in the Squamish estuary on June 21, 1976. Data from 8 fish [mean length 90 mm (SD = 5.8); mean weight 9.70 g (SD = 1.8)].

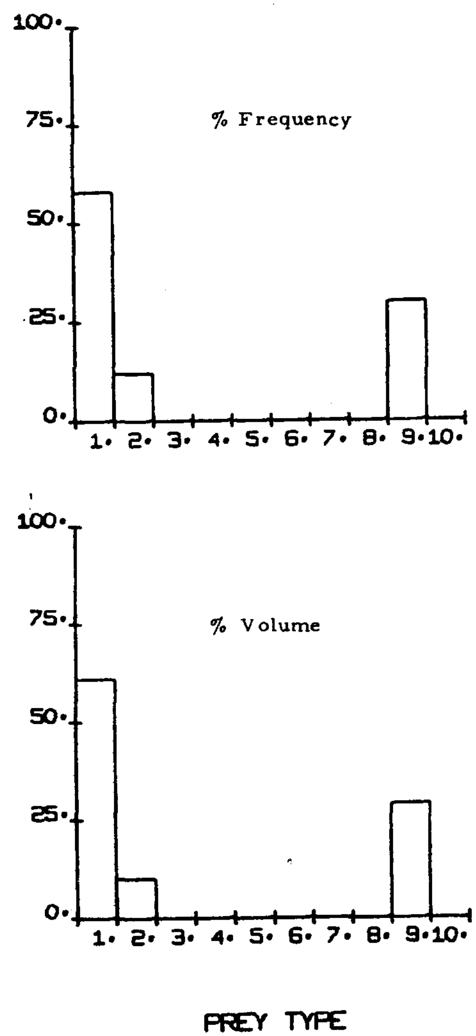
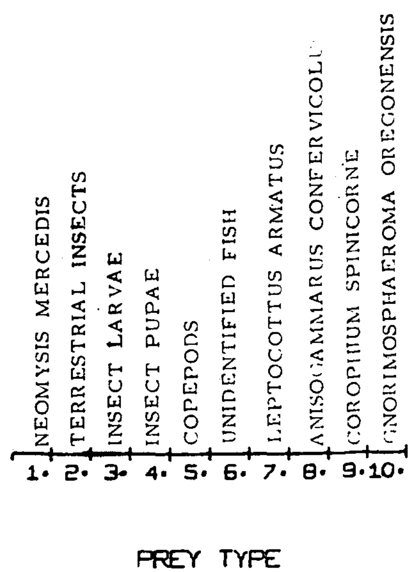


Fig. 19 . Diet of juvenile coho salmon at Station 3.3 in the Squamish estuary on June 21, 1976. Data from 6 fish [mean length 93 mm (SD = 9.3); mean weight 10.70 g (SD = 3.8)].



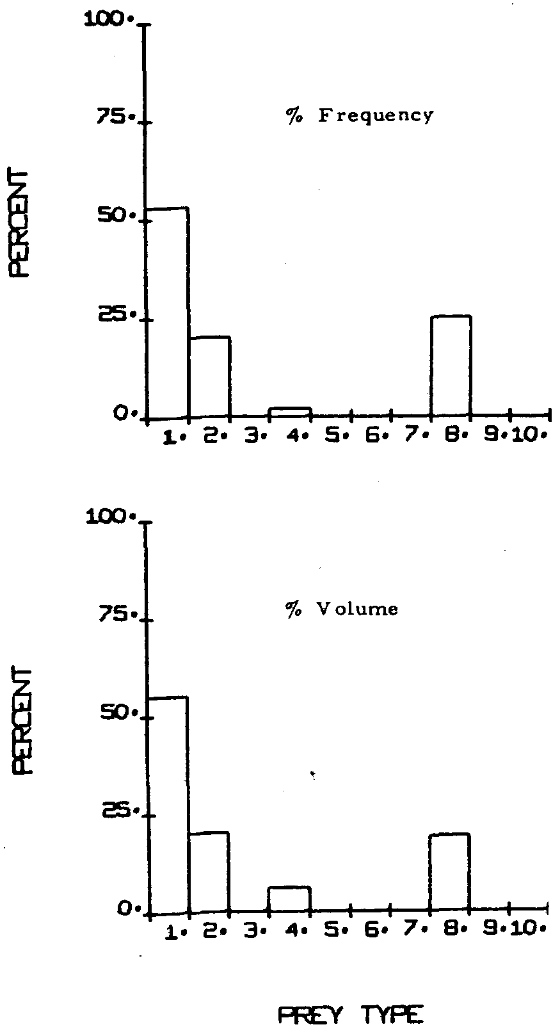


Fig. 20. Diet of juvenile chinook salmon at Station 1.2 in the Squamish estuary on June 21, 1976. Data from 5 fish [mean length 88 mm (SD = 9.4); mean weight 8.60 g (SD = 2.7)].

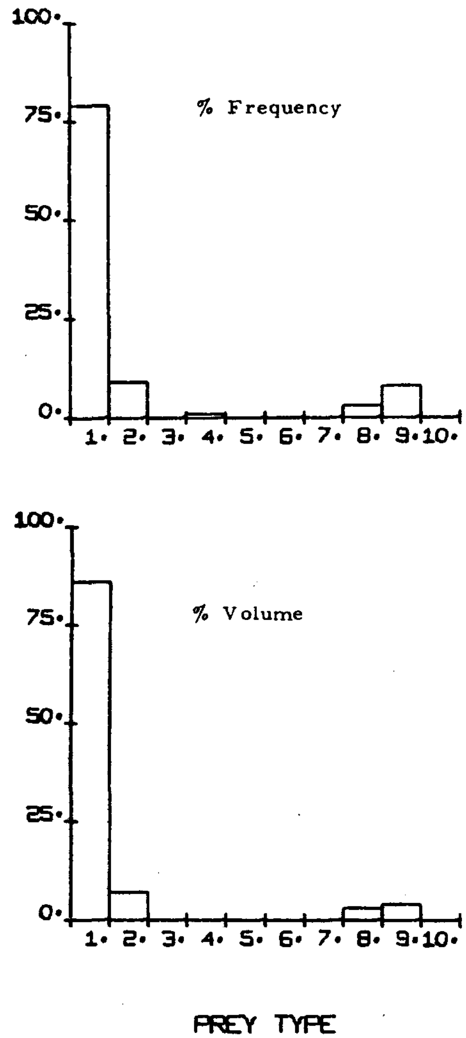


Fig. 21. Diet of juvenile chinook salmon at Station 3.3 in the Squamish estuary on July 6, 1976. Data from 16 fish [mean length 93 mm (SD = 6.3); mean weight 10.60 g (SD = 3.2)]

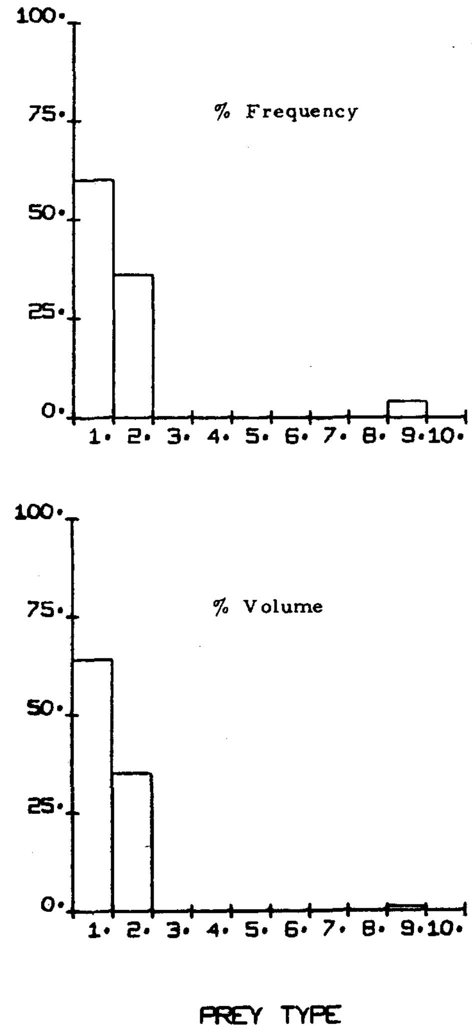
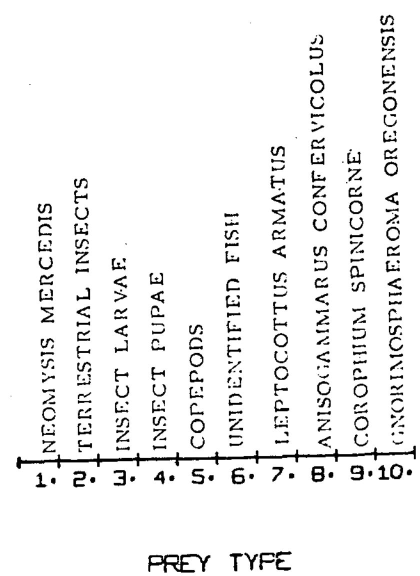


Fig. 22. Diet of juvenile chinook salmon at Station 3.1 in the Squamish estuary on July 19, 1976. Data from 4 fish [mean length 95 mm (SD = 11.7); mean weight 12.60 g (SD = 3.5)]



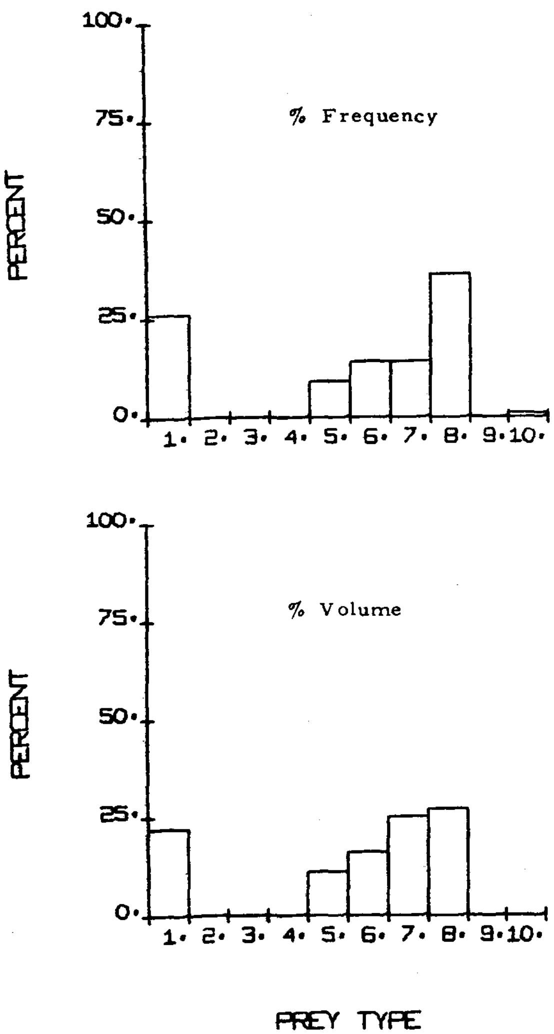


Fig. 23. Diet of dolly varden char in the Squamish estuary (mainly from Station 3) during the period October 1975 to September 1976. Data from 18 fish [mean length 31.4 cm (SD = 5.6); mean weight 265 g (SD = 240)]

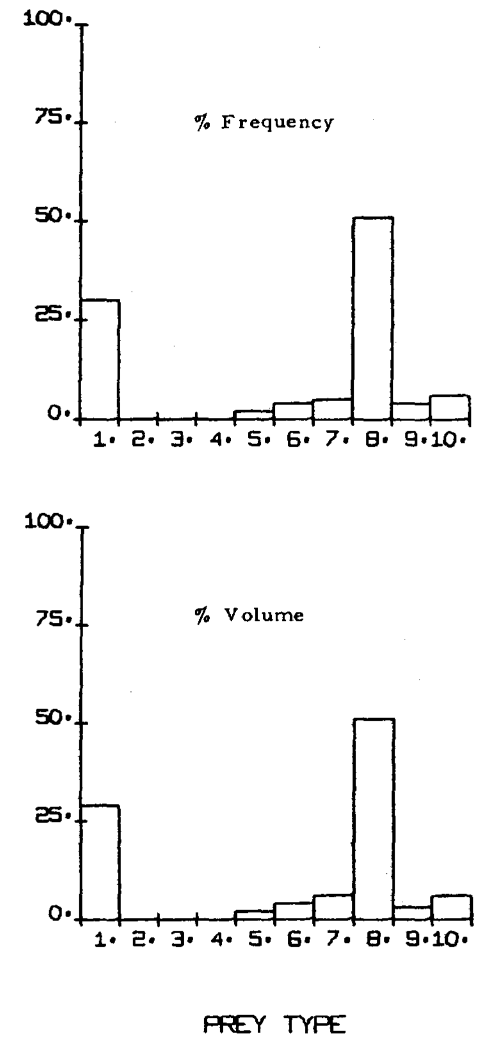


Fig. 24. Diet of cutthroat trout in the Squamish estuary (mainly from Station 3) during the period October 1975 to September 1976. Data from 14 fish [mean length 20.4 cm (SD = 3.6); mean weight 110 g (SD = 49.5)].

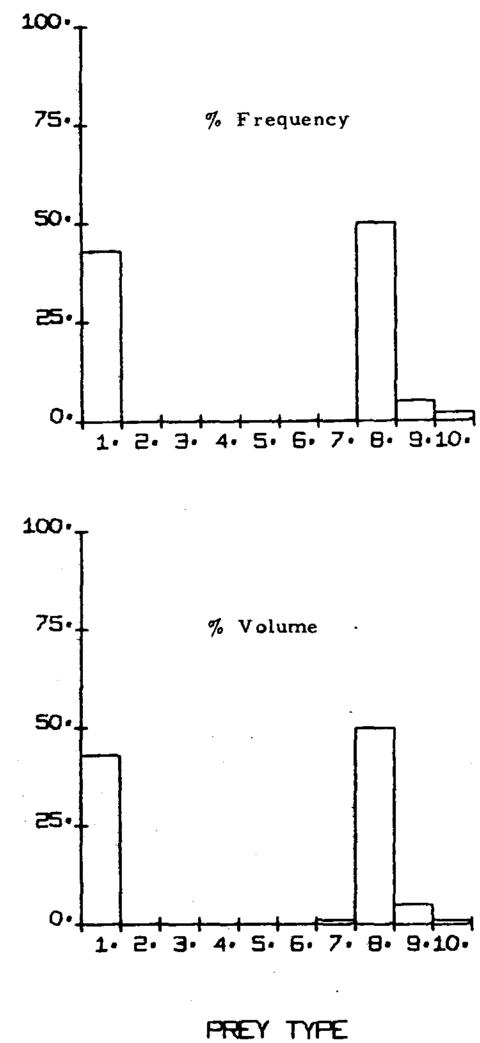
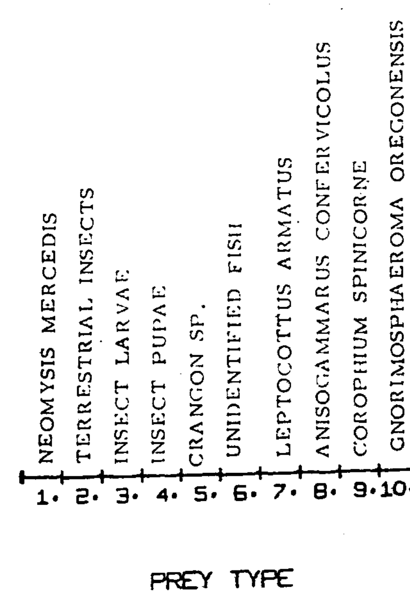


Fig. 25. Diet of cutthroat trout less than 25 cm in fork length in the Squamish estuary (mainly from Station 3) during the period October 1975 to September 1976. Data from 14 fish [mean length 20.4 cm (SD = 3.6): mean weight 110 g (SD = 49.5)].



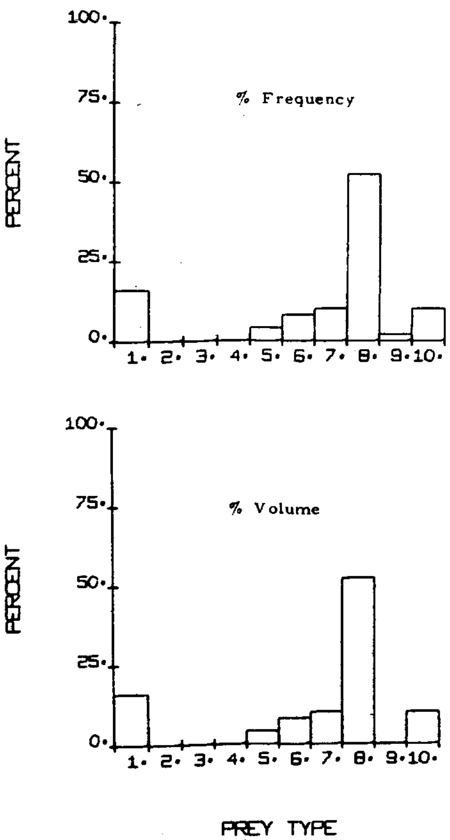


Fig. 26. Diet of cutthroat trout greater than 24 cm in fork length in the Squamish estuary (mainly from Station 3) during the period October 1975 to September 1976. Data from 14 fish [mean length 31.5 cm (SD = 7.2); mean weight 420 g (SD = 256)].

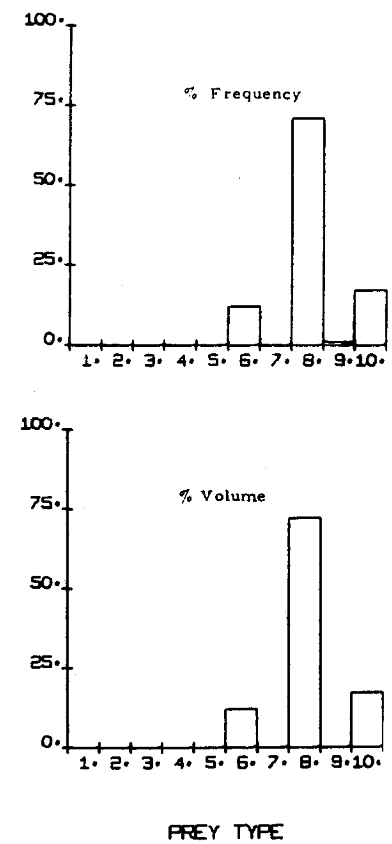


Fig. 27. Diet of cutthroat trout in the Squamish estuary (mainly from Station 3) during the period October 1975 to January 1976. Data from 9 fish [mean length 28.8 cm (SD = 6.2); mean weight 327 g (SD = 231)].

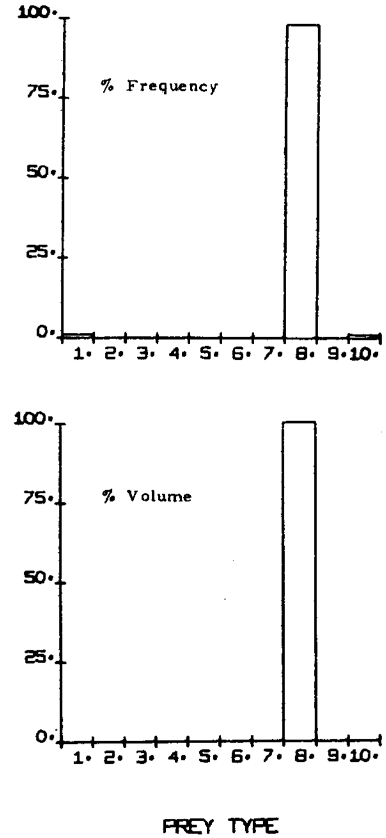


Fig. 28. Diet of cutthroat trout in the Squamish estuary (mainly from Station 3) during the period February 1976 to May 1976. Data from 7 fish [mean length 25.1 cm (SD = 1.8); mean weight 327 g (SD = 232)].

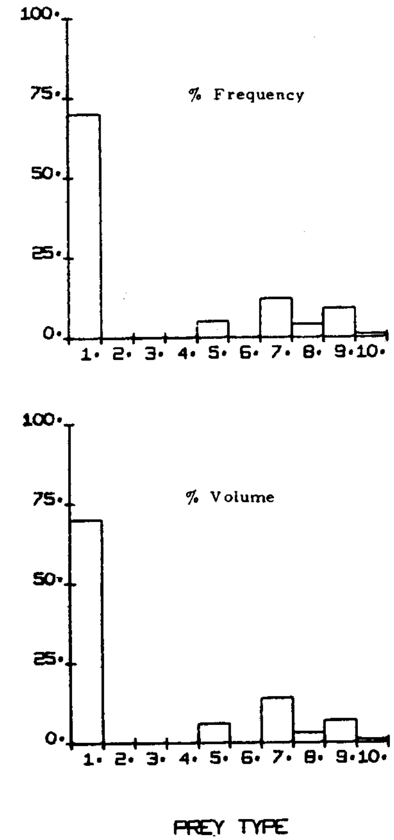
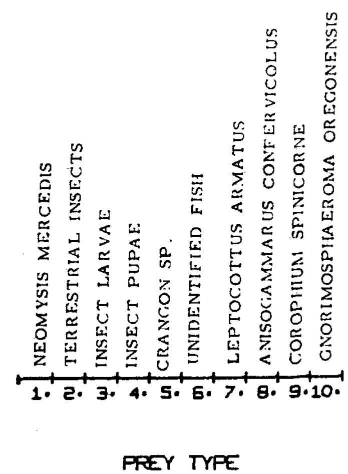


Fig. 29. Diet of cutthroat trout in the Squamish estuary (mainly from Station 3) during the period June 1976 to September 1976. Data from 12 fish [mean length 24.3 cm (SD = 12); mean weight 252 g (SD = 310)].



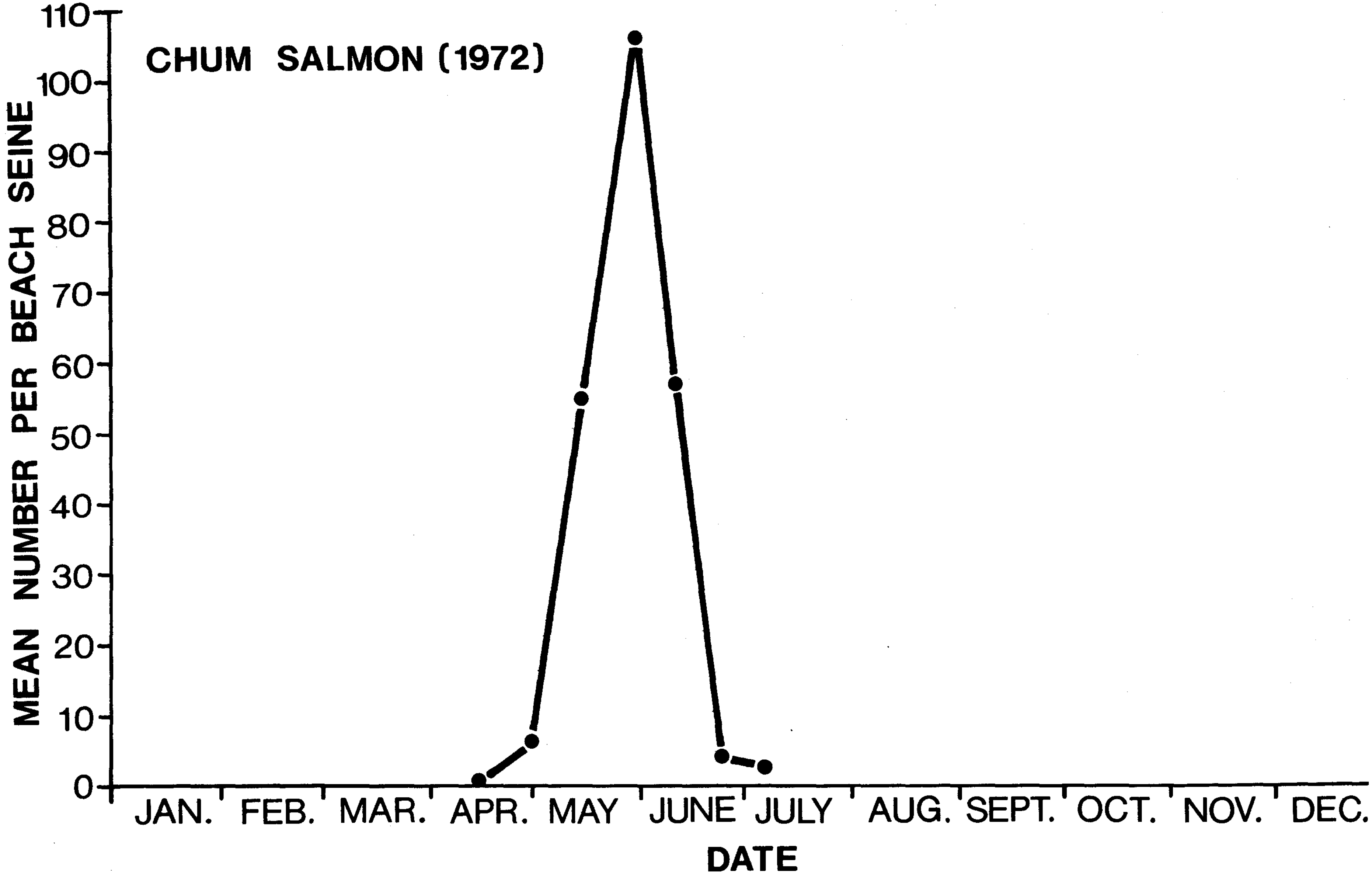
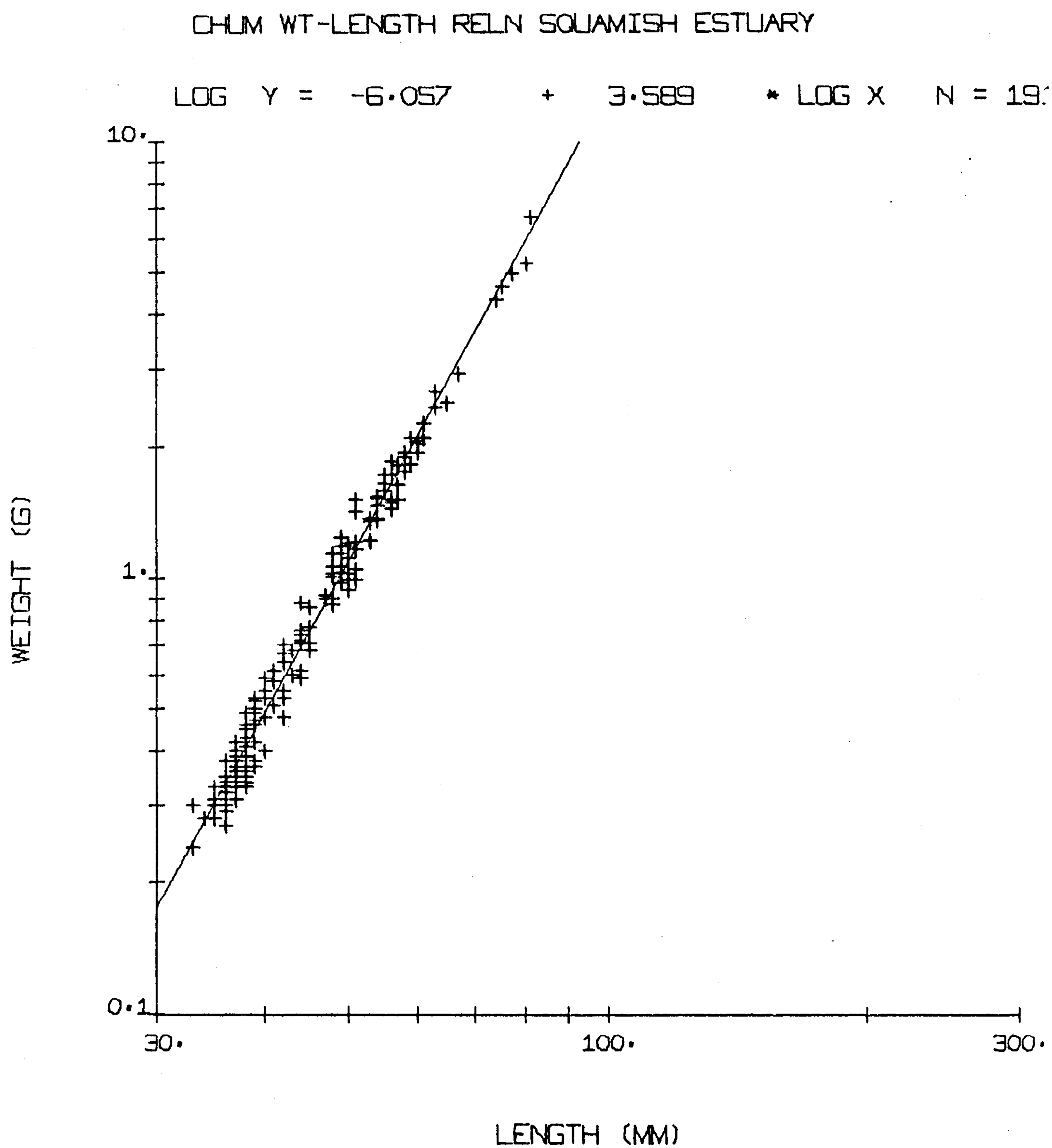
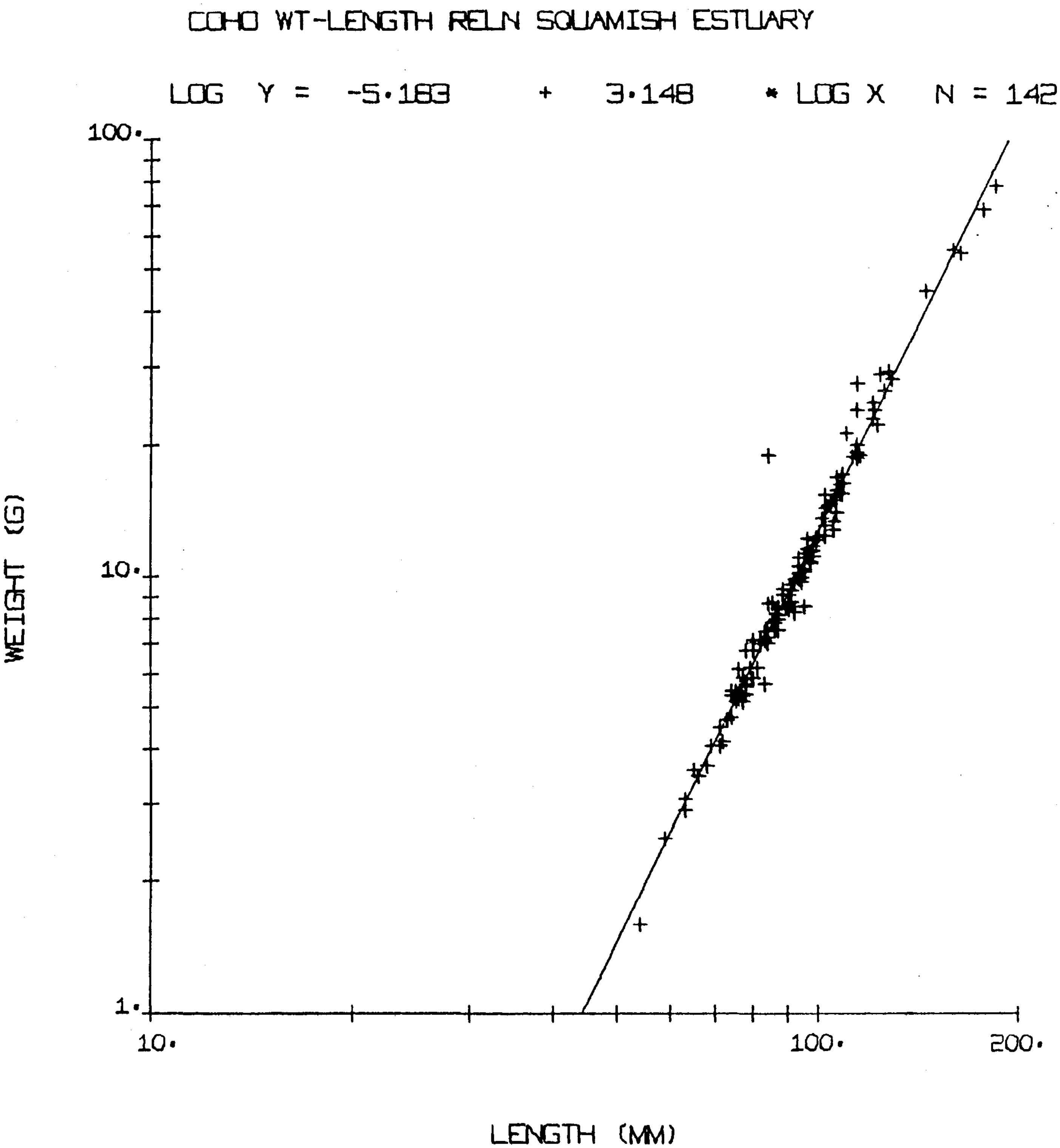


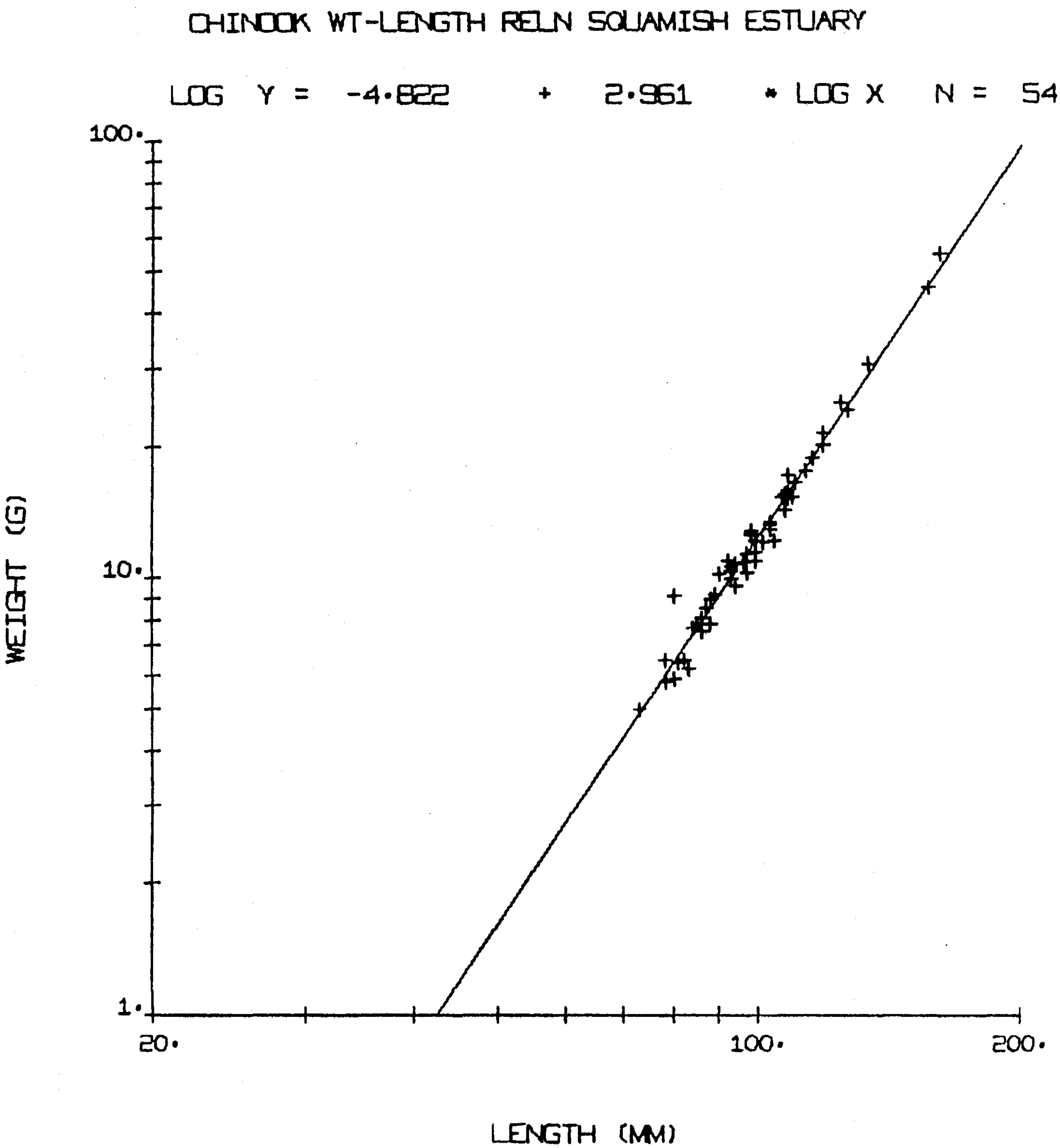
Fig. 30. Number of juvenile chum salmon per beach seine haul in Station 3 in the Squamish estuary, 1972 (data from Goodman and Vroom, 1972; their station BS16).



Appendix Fig. 1. Relationship between fork length and "blotted" wet weight for juvenile chum salmon in the Squamish estuary.



Appendix Fig. 2. Relationship between fork length and "blotted" wet weight for juvenile coho salmon in the Squamish estuary.



Appendix Fig. 3. Relationship between fork length and "blotted" wet weight for juvenile chinook salmon in the Squamish estuary.