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A Brief Investigation of Fish in the Surface Waters of the Somass River Estuary, Port Alberni, British Columbia

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December 1983

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1744

Government of Canada Fisheries and Oceans
Gouvernement du Canada Pêches et Océans

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Canadian Manuscript Report of Fisheries

and Aquatic Sciences No. 1744

December 1983

A BRIEF INVESTIGATION OF FISH IN THE SURFACE WATERS OF THE SOMASS RIVER ESTUARY, PORT ALBERNI, BRITISH COLUMBIA.

by

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Cat. No. Fs 97-4/1744 ISSN 0706-6473

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ABSTRACT

Birtwell, I.K., S. Nelles and R.M. Harbo. 1983. A brief investigation of fish in the surface waters of the Somass River estuary, Port Alberni, British Columbia. Can. MS Rep. Fish. Aquat. Sci. 1744: vi + 31 p.

During May, June and July 1975, sunken and floating gill nets were used to capture fish at six sites within the estuary of the Somass River on the west coast of Vancouver Island, British Columbia.

A total of 1427 fish were captured comprising 20 species. Significantly ($p < 0.05$) higher numbers of fish were caught within the less industrialized areas of the estuary and 79% of the catch was of three species: Pile perch *Rhacochilus vacca*, Pacific Staghorn sculpin *Leptocottus armatus*, and Shiner perch *Cymatogaster aggregata*. The horizontal distribution of fish captured in the estuary did not appear to be related to variations in temperature, pH, dissolved oxygen, salinity, oxidation-reduction potential and colour, values of which were not significantly different between the six sampling sites.

Floating gill nets (0.0 to 2.5 m) captured 16% (231) of the total fish catch. Salmonids comprised 32% (74) of the fish captured in this surface zone but only 1% (15) in the deeper waters (2.5 to 5.0 m). The higher numbers of salmonids in surface waters and their relative scarcity in the deeper waters was considered to be associated with the differences in certain water quality characteristics between the two water layers. Beneath the halocline, which was frequently within 4 m of the water surface, dissolved oxygen concentrations were depressed (a condition related to natural factors and the discharge of coloured effluent from the Port Alberni pulp mill) temperatures were lower, and salinities higher, than those in shallower waters.

The depressed concentrations of dissolved oxygen in the deeper waters of the Somass estuary were often at levels known to the stressful to salmonids. It was concluded that these conditions effectively reduced the habitat available to the salmon and restricted them to shallow surface waters.

Key Words: Somass River estuary, pulp mill effluent, dissolved oxygen depression, fish distribution.

RÉSUMÉ

Birtwell, I. K., S. Nelles and R. M. Harbo. 1983. A brief investigation of fish in the surface waters of the Somass River estuary, Port Alberni, British Columbia. Can. MS Rep. Fish. Aquat. Sci. No. 1744: vi + 31 p.

En mai, juin et juillet 1975, des filets maillants de surface et de fond ont été utilisés pour la capture de poissons à six endroits dans l'estuaire de la rivière Somass, sur la côte ouest de l'île Vancouver (Colombie-Britannique).

Au total, 1427 poissons appartenant à 20 espèces ont été capturés. Un nombre sensiblement plus élevé d'individus ($P < 0.05$) ont été pêchés dans les zones moins industrialisées de l'estuaire et les espèces suivantes constituaient 79% des prises: la perche de pilotis (*Rhacochilus vacca*), le chabot armé (*Leptocottus armatus*) et le perche-méné (*Cymatogaster aggregata*). La répartition horizontale des poissons capturés dans l'estuaire ne semblait pas reliée aux variations de la température, du pH, de l'oxygène dissous, de la salinité, du potentiel d'oxydoréduction et de la couleur car la valeur de ces facteurs ne variait pas de façon significative entre les six sites d'échantillonnage.

De la prise totale, 231 poissons (16%) ont été capturés à l'aide de filets maillants de surface (de 0.0 à 2.5 m). Des salmonidés composaient 32% (74 poissons) de la prise de surface mais seulement 1% (15 poissons) de la prise en profondeur. On croit que le nombre plus élevé de salmonidés dans les eaux superficielles et leur rareté relative dans les eaux profondes sont associés aux différences entre certaines caractéristiques qualitatives des deux zones aqueuses. Sous l'halocline, souvent présente à 4 mètres ou moins de la surface, les concentrations d'oxygène dissous (condition reliée à des facteurs naturels et au déversement d'effluents colorés de l'usine de pâte de Port Alberni) et les températures étaient inférieures à celles des eaux moins profondes, tandis que les salinités y étaient plus élevées.

Les concentrations moindres d'oxygène dissous dans les eaux profondes de l'estuaire de la Somass atteignaient souvent le niveau connu de stress pour les salmonidés. Les auteurs concluent que ces conditions réduisent effectivement l'habitat disponible pour le saumon et les restreignent aux eaux superficielles.

Mots-clés: estuaire de la rivière Somass, effluent d'usine de pâte, baisse du niveau d'oxygène dissous, répartition du poisson

INTRODUCTION

The estuary of the Somass River at the head of Alberni Inlet on the west coast of Vancouver Island, British Columbia (Fig 1) is used for a variety of urban and industrial activities Many of these activities have impinged upon fish habitat by physically encroaching upon intertidal areas and through the discharge of wastewaters. Summaries of these impacts and a review of ~ vironmental information have been provided by Morris and Leaney (1980) Notwithstanding these changes, large numbers of salmonids rear in, or migrate through, the Somass estuary each year. Because of the need to manage these important fishery resources, other aquatic organisms and their habitat, and to understand the effects of industrial activities upon them, a number of investigations have been carried out to provide pertinent information (Birtwell and Harbo 1980).

Large volumes of effluent (about 180 x 10^3 $m^3 \cdot d^{-1}$) from the Port Alberni pulp mill are discharged into the mouth of the Somass River. Prior to the operation of this pulp mill, Tully (1948) recorded dissolved oxygen levels close to air saturation in the upper water layers at the head of Alberni Inlet. Dissolved oxygen levels in, and just below the halocline were sometimes supersaturated, whilst in the deeper waters, dissolved oxygen levels fell to about 40% of air saturation. Since the pulp mill commenced operation and discharged its coloured effluent into the Somass River, dissolved oxygen depressions have occurred, most noticeably in the vicinity of the halocline which may lie within about 2-4 m of the water surface at the time of juvenile salmon migrations (Birtwell 1978). The proximity of the halocline to the water surface is dependent upon many factors, particularly the freshwater flow of the Somass River. Higher flows (typically in the autumn and winter) tend to move the halocline deeper in the water column. A minimum Somass River discharge of 27 $m^3 \cdot s^{-1}$ has been maintained since 1956 (Dept. Fish. Env. 1978) to benefit fishery resources and to assist in effluent dispersion and the maintainence of estuarine dissolved oxygen levels (Morris and Leaney 1980). Parker and Sibert (1973) and Sibert and Parker (1973) considered that the discharge of coloured pulp mill effluent affected the concentration of dissolved oxygen in the surface waters of the Somass estuary. They deduced that the humic stain of the effluent reduced photosynthetic activity of phytoplankton below the halocline. This, together with the oxygen demand of organic material and from heterotrophic organisms were factors which resulted in decreased dissolved oxygen concentrations within and below the halocline.

We considered that the vertical changes in dissolved oxygen concentration, the presence of pulp mill effluent and other wastewaters and a variety of water use activities may affect fish use of the Somass estuary. A number of investigations were carried out to examine these concerns, and this report describes a brief study of the horrizontal and vertical distribution of fish in relation to some of the prevailing environmental variables. This report is intended to supplement others on fish distribution and abundance (Birtwell 1978, Birtwell and Harbo 1980) fish survival within in-situ bioassay experiments (in preparation), and the diet of fish in relation to benthic organisms (Birtwell et al. 1983).

MATERIALS AND METHODS

LOCATION OF SAMPLING SITES

Figure 1 indicates the approximate location of the six sites at which gill nets were set. Site 1 was closest to the pulp mill outfall, site 2 was located opposite the main Somass River channel, at the head of Alberni Inlet, site 3 was adjacent to a wharf, sites 4 and 6 were proximal to log booming areas and site 5 was close to Stamp Point next to a log storage area.

FISH CAPTURE AND TREATMENT

Floating and sunken gill nets were used to capture fish at each sampling site. The floating net fished the surface to 2.5 m depth and the sunken net from 2.5 to 5.0 m. Each gill net comprised 5 panels (mesh sizes 19, 25, 38, 51 and 63 mm), 7.8 m in length. Fishing was carried out on May 20-22, June 18-20 and July 14-17, 1975 at each site (site 5 was not sampled in July). The nets (one floating, one sunken per site) were set at high slack tide (mean height 3.3 m) in the evening and retrieved the following day after approximately 12 h. The captured fish were identified, enumerated and samples were retained for length and weight determination. Total length was recorded for Pacific staghorn sculpin (Leptocottus armatus), speckled sanddab (Citharichthys stigmaeus), ratfish (Hydrolagus colliei), brown Irish lord (Hemilepidotus spinosus), sand sole (Psettichthys melanostictus), Pacific cod (Gadus macrocephalus), lingcod (Ophiodon elongatus), while 'fork length' was measured for the other species that were captured.

WATER QUALITY

At the beginning and end of each gill net set at each site and on each sampling occasion, a multiprobe sensing unit (Hydrolab Model 6-D, Texas Instruments) was used to determine temperature, conductivity, dissolved oxygen, pH and oxidation-reduction potential (ORP) at the surface, 2.5 and 5.0 m depths.

Dissolved oxygen, conductivity, and ORP were occasionally determined at the joint Department of Fisheries and Oceans and Department of Environment laboratories (West Vancouver, B.C.) on samples collected by standard techniques. The methods used for these analyses (and that for colour determination using the platinum cobalt method) were those stated by the American Public Health Association (1975).

STATISTICAL TREATMENT

Analysis of Variance (ANOVA) was used to determine if significant differences occurred in the water quality characteristics between the six sites in each of the water layers we examined (0.0 to 2.5 m and 2.5 to 5.0 m). In addition an unpaired "t" test ($p < 0.05$) was performed to determine if there was a significant difference in values of dissolved oxygen, temperature, salinity, pH and ORP between water layers, for each site and over the entire study area (sites combined).

ANOVA and Duncan's Multiple Range Test were used to determine significant differences ($p < 0.05$) in fish catches; between sites at each depth (0.0 to 2.5 m and 2.5 to 5.0 m); between sites with depths combined, (0.0 to 5.0 m) and between depths, sites combined, (0.0 to 2.5 m and 2.5 to 5.0 m). The following data groupings were used in these analyses: total number of fish, numbers of salmonids, numbers of non-salmonids and of individual species. All fish catch data were transformed ($\sqrt{x + 0.5}$) prior to analyses.

RESULTS

HORIZONTAL DISTRIBUTION

Water quality

Table 1 lists the mean values of water quality variables recorded in the two water layers at the six sampling sites, Table 2 lists the data on a monthly basis and Table 3 summarizes the information for the study period.

0.0 to 2.5 m water layer

Results of ANOVA revealed that there was not a significant difference ($p < 0.05$) between the six sampling locations with respect to dissolved oxygen, salinity, temperature, pH, ORP and colour.

Mean dissolved oxygen levels were high (90% of air saturation) during May and June but declined slightly in July to 80% of air saturation.

Temperatures increased during the three month period while salinity and pH remained relatively constant (Table 2).

2.5 to 5.0 m water layer

Differences between sites were not statistically significant with respect to the measured water quality variables. In this water layer, dissolved oxygen levels and temperatures were generally lower while salinities were higher and more variable than those recorded in the surface layer. Values of pH and ORP were similar to those recorded in the shallower water. Colour values ranged from 5 to 20 units and were seemingly related to the depth of the halocline, colour values greater than 5 generally being found above this very marked vertical salinity gradient.

The depth of the thermocline and halocline changed between the monthly sampling occasions. In May, they were located between about 2.5 m and 5.0 m depths, in June from 4.0 to 8.0 m and in July from 3.0 to 6.0 m. As a result, warmer water layers of lower salinity and higher dissolved oxygen levels, were deeper in the water column in June. In contrast, during May and July, salinities were much higher and dissolved oxygen levels much lower within the 2.5-5.0 m water layer.

Fish

During this brief investigation 1427 fish were captured of which 231 were taken in the 0.0 to 2.5 m water layer and 1196 from the 2.5 to 5.0 m layer. Twenty species of fish were caught, 14 species were taken from the uppermost water layer and 19 species from the deeper layer (see Tables 4 and 5). Ninety-five percent of the total catch in the deeper waters was from four species: pile perch *Rhacochilus vacca*, Pacific staghorn scuplin *Leptocottus armatus*, shiner perch *Cymatogaster aggregata* and Pacific herring *Clupea harengus pallasi*. In the shallower water layer seven species made up 90% of the catch. These were *R. vacca*, *L. armatus*, *C. aggregata* and *C. harengus pallasi*, coho salmon *Oncorhynchus kisutch*, chinook salmon *O. tshawytscha*, and sockeye salmon *O. nerka*.

Fish were captured at all the sampling sites except site 5 on the western shoreline, adjacent to a log storage area. While the absence of fish may well be important, the chosen statistical treatment (whereby catch data were transformed so that there was no "zero catch") tended to mask the significance of this finding. The significant results of ANOVA and Duncan's Multiple Range Test applied to the fish catch data are presented in Table 6.

In the upper water layer the Pacific hake, *Merluccius productus* was the only species of fish that ocurred in significantly different numbers between sampling sites. Four fish were caught at site 6 about 2.75 km from the pulp mill outfall and adjacent to a log storage area.

Within the deeper waters (2.5 to 5.0 m) the fish catch (total numbers and numbers of non-salmonid species) at site 4, on the west side of the estuary, was greater than that at the other sampling sites. However, catches at site 2 were similar to those at site 4 and also to sites 1, 3, and 6 which comprised another homogeneous data set (Table 6).

When the fish catch data for both water layers were combined, the differences in the catches of salmonids, between sites, were not significant. However, a significantly ($p < 0.05$) greater total number (752) of fish (52.7% of the total catch) occurred at site 4 on the west side of the estuary. The total number of non-salmonids captured was significantly higher at site 4, but the catches at site 2 were similar to those at site 4 and those at sites 1, 3 and 6 which formed another homogeneous data set (Table 6).

When consideration was given to particular species only catches of herring, *Clupea harengus pallasi* and Pacific hake, *Merluccius productus*, were significantly different between the six sampling sites. Herring were in greater numbers at site 4 where 78 were caught, and Pacific hake were only captured at site 6.

VERTICAL DISTRIBUTION

Water quality

An unpaired "t" test was performed to determine if there was a significant difference ($p < 0.05$) in the characteristics of the 0.0 to 2.5 m and 2.5 to 5.0 m water layers. As shown in Table 7 there were significantly higher temperatures and concentrations of dissolved oxygen in the surface waters, whereas salinities in the surface layer were significantly lower than those in the deeper waters.

An unpaired "t" test was also carried out to determine if significant differences ($p < 0.05$) in the measured variables occurred between depths at each site. Significant results were obtained for dissolved oxygen and salinity. At site 2, directly opposite the mouth of the Somass River, dissolved oxygen concentrations were significantly higher and less variable in the surface layer (8.6 ± 0.6 $mg \cdot L^{-1}$) than in the deeper water layer (5.8 ± 2.7 $mg \cdot L^{-1}$). Sites 1, 2 and 3 proximal to the main current of the Somass River, had significantly lower salinities in the surface water layer (range 0.4 to 2.7‰, Table 1), when compared with salinities in the 2.5 to 5.0 m layer (range 1.5 to 25.6‰, Table 1).

Fish

The total number of salmonids that were captured was significantly higher in the surface (74) than in the deeper water layer (15) as shown in Table 8. The salmonid catch was predominantly of juvenile chinook and coho, with respective mean lengths and weights of 17.5 ± 6.7 cm ($n = 19$) and 52.4 ± 62.4 g ($n = 6$); 13.0 ± 3.5 cm ($n = 38$) and 29.3 ± 43.9 g ($n = 38$). Steelhead trout (*Salmo gairdneri*) and cutthroat trout (*S. clarki*) were also captured.

Sockeye salmon (*O. nerka*) were only caught in the surface water layer. Most of these fish were adults three to four years of age (2 years of freshwater residence), and presumed to be on their spawning migration.

Catches of salmonids were greatest during May when 48 were taken from the 0.0 to 2.5 m layer followed by catches of eight and 18 in June and July respectively. The remainder of the salmonid catch (15 salmon chinook and coho) was taken at site 4 (2.5 to 5.0 m) and on one sampling occasion.

Walleye pollock, *Theragra chalcogramma*, were caught in significantly greater numbers in the surface water layer.

At site 6, there was a significant difference between the number of pile perch, *Rhacochilus vacca*, caught in the two water layers; six were caught in the surface layer but none in the deeper waters.

Overall significantly greater total numbers of fish were captured in the 2.5 to 5.0 m zone (see Tables 6 and 8).

Analysis of the catches of fish between depths at each site, revealed significant results for site 4 where higher numbers of fish, particularly non-salmonids, were captured in the 2.5 to 5.0 m water layer (Table 6).

WEIGHT-LENGTH RELATIONSHIPS

The results of weight-length regression analyses are given in Table 9, for certain fish species. The linear relationship between total length (sculpins, ratfish) or fork length (salmonids, herring, perch) and standard length for each species was not determined. Accordingly, the results of these regression analyses may not be strictly comparable with those for the same species in studies where regression analyses were undertaken using standard length measurements.

DISCUSSION

Despite the brevity of this survey, the results, in general, provide information on the presence of fish in the highly stratified Somass estuary. Significant differences in some of the measured water variables between the sampling sites, related, for example, to the discharge of pulp mill effluent from the Port Alberni pulp mill and the flow of fresh water from the Somass River was anticipated. But, the results of ANOVA and Duncan's Multiple Range Test did not reveal such differences. However, a marked difference in the values of certain variables between surface (0.0 to 2.5 m), and deeper waters (2.5 to 5.0 m) was identified and it is this aspect of the Somass estuary which most probably influenced the distribution of fish in the water column.

Although a total of 20 species of fish were captured by the gill nets during this investigation only 12 species were captured by beach seines set in the intertidal zone of the Somass estuary during the same sampling period (unpublished data). The numerically dominant fish in the catches were quite different, perhaps as much a reflection on the selectivity of the methods used for capture as upon the habitats occupied by particular species. During the beach seining programme juvenile chinook salmon (*O. tshawytscha*) comprised 57% of the catch (Birtwell 1978) whereas in the gill net study pile perch (*R. vacca*) was the dominant species (33%).

HORIZONTAL DISTRIBUTION

Site 4 yielded 52% of the total fish catch and when combined with the catches at site 2, 85.2% of the total catch was accounted for. Four species, Pacific herring *Clupea harengus pallasi*, Pacific staghorn sculpin *Leptocottus armatus*, shiner perch *Cymatogaster aggregata*, and pile perch *Rhacochilus vacca* were the numerically dominant species. In view of the dominance of *L. armatus*, *C. aggregata* and *R. vacca* in the fish catches, attention has been focussed upon them in the succeeding sections.

Sixty percent of the Pacific staghorn sculpins that were captured, were taken at site 2 in the centre of the estuary adjacent to a bay with soft sediment. Another 30% were captured on the west side of the estuary (site 4) close to a log handling area, but none were captured at site 5, a location quite removed from many industrial activities (but over relatively deep water).

Adult staghorn sculpins are known to frequent bays and the deeper waters of estuaries, while the juveniles occur in shallow low salinity waters (Jones 1962; Tasto 1975). They are typically benthic sedentary fish which occupy a variety of habitats (eel grass beds, sandy and muddy substrates, etc). These fish are reported to be continual and opportunistic feeders, consuming such epibenthic and benthic invertebrates as shrimp, crab, amphipods and polychaetes, and fish species such as anchovy, smelt, goby and herring (Jones 1962; Tasto 1975).

Some of the smaller staghorn sculpins captured in the intertidal area of the Somass estuary (unpublished information) were found to have consumed mostly amphipods at three sites on the western side of the estuary. In contrast, at a site on the industrialized eastern shore, adjacent to the government wharf, insects were the predominant component of their diet (amphipods were not prevalent).

Pile perch Rhacochilus vacca, was the most abundant of the two perch species. Eighty-nine percent of the total catch came from sites 2 and 4 within the less industrialized parts of the Somass estuary. It is noteworthy that 90% of the total catch of shiner perch Cymatogaster aggregata came from site 4, perhaps indicating that the habitat preferences and community associations of this perch species were similar to those of R. vacca, at the time of sampling.

Pile perch and shiner perch like Pacific staghorn sculpin are found in bays and estuaries. Both perch species inhabit shallow sandy bottom areas, eel grass beds and waters adjacent to docks and pilings. Their presence in these habitats is greatest during the summer months when mating and parturition occur (Gordon 1965; Wares 1971).

Both pile and shiner perch are considered to be opportunistic benthic feeders, utilizing crabs, mussels, barnacles, algae and zooplankton (Gordon 1965).

Fish catches were markedly different between sampling sites on the eastern and western sides of the Somass estuary. Pacific staghorn sculpins, pile perch and shiner perch were not caught at site 3; an unexpected result considering the variety of habitats these species utilize, and the presence of staghorn sculpins in the intertidal area near this site (unpublished data). Similarly the absence of fish at site 5 cannot be related to the water quality conditions at this site which were generally comparable with those at the sites where fish were captured.

Despite the adaptability of the sculpins and perch to changes in habitat and water quality, they were captured in larger numbers on the less developed western side of the Somass estuary. This may reflect a habitat preference rather than a response to subtle variations in water quality conditions.

VERTICAL DISTRIBUTION

Water quality variations and fish presence

Salmonids

The vertical distribution of salmonids appeared to be closely related to vertical differences in water quality.

In general the surface water layers were comprised of relatively warm water with high dissolved oxygen levels and lower salinities ($\bar{x}$ = 16.4°C, 85% of air saturation; 1.7‰ salinity). These waters also served as a diluent for pulpmill effluent. The deeper waters were generally cooler, more saline, and with lower levels of dissolved oxygen ($\bar{x}$ = 14.9°C; 70% air saturation; 9.4‰ salinity) However, due to the position of the halocline in June (at 6.0 to 8.0 m) warmer, low salinity waters with relatively higher levels of dissolved oxygen extended to depths below 5.0 m.

The vertical changes in water quality most probably affected the vertical distribution of certain fish, particularly those which are stenothermal or stenohaline. Accordingly it was expected that those fish would predominate in catches in areas below or above the halocline in the Somass estuary.

Chinook and coho salmon were more abundant above the halocline. Brett (1952) stated that the ultimate upper lethal temperature for Pacific salmon was between 23.8 and 25.1°C but that they preferred temperatures between 12 and 14°C. If this were the case for those fish we captured in the Somass estuary they would probably not be adversely affected by the temperatures they encountered (refer to Table 3).

In addition, the salinity range which those salmonids encountered would probably have been tolerated, particularly by, for example, juvenile chinook, which rapidly acclimate to salinity (Hoar 1976) and possess a strong tolerance to high salinities (Weisbart 1968) and by adult sockeye salmon which were presumed to be returning to fresh water.

On the assumption that both temperature and salinity variations in the 0.0 to 5.0 m water layer were acceptable to salmonids, it may be inferred, that other variables, such as dissolved oxygen singly, or in combination with other variables could have influenced the vertical distribution of these fish.

Davis (1975) developed dissolved oxygen criteria to protect fish populations:

> Level A provides for a high degree of safety and permits little depression of dissolved oxygen from full saturation.
> Level B is where some degree of risk to a portion of a fish population exists - especially if the oxygen minimum is prolonged beyond a few hours.
> Level C is where a large portion of a given fish population or community may be affected, and should be applied only where the fish populations are judged hardy or of marginal significance or economic importance.

For a mixed population of anadromous and marine species of fish (based on a salinity of 28% and temperatures from 0 to 25°C) the respective levels are: A, 9.0 $mg \cdot L^{-1}$ (100% of air saturation) B, 6.5 $mg \cdot L^{-1}$(80 to 95% of air saturation) and C, 4.0 $mg \cdot L^{1}$, 55 to 60% of air saturation).

According to this classification system the dissolved oxygen levels encountered by fish at 0.0 to 2.5 m depth during our study were between levels B and A. At 2.5 to 5.0 m depths, the average dissolved oxygen concentrations ranged from just above level C for sites 1, 2, 3, 4 and 6 to just above level B for site 5. Consequently, a greater threat to the survival of salmonids existed in the deeper water layers where the dissolved oxygen levels were well below level B. The surface water layer where the majority of salmonids were captured had dissolved oxygen concentrations at level B or greater and perhaps provided a less stressful environment for the growth and development of juvenile salmonids prior to their seaward migration; and for returning adults.

Supporting information is provided by the results of in-situ experiments with natural and hatchery reared juvenile chinook salmon (Birtwell 1978; Birtwell and Harbo 1980). A significant avoidance of the deeper waters occurred and it was determined that reduced levels of dissolved oxygen below 4 m depth were most probably responsible for the absence of fish.

Five times more salmonids were found in the surface zone (0.0 to 2.5m) despite the presence of pulp mill effluent admixed with the warmer lower salinity surface waters. Their presence in these surface waters could be related to higher levels of dissolved oxygen in this layer, but more likely the scarcity of it in the deeper waters. There was a substantial difference in the ranges of dissolved oxygen levels between the two depths.They were from 65 to 95% of air saturation in the surface waters and 25 to 95% of air saturation in the 2.5 to 5.0 m water layer (Table 3). The only occasion when juvenile coho and chinook were captured in the 2.5 to 5.0 m zone was during May when the level of dissolved oxygen was about 70% of air saturation, and 90% of air saturation in surface waters.

Other fish species

Non-salmonids were more abundant in the deeper waters (2.5 to 5.0 m). The majority (50%) of the total fish catch at this depth were adults of three species; Pacific staghorn sculpin, shiner perch and pile perch, which have been reported to occupy deeper high salinity waters before and after reproduction (Jones 1962; Tasto 1975; Gordon 1965). As well as being able to utilize various habitats these three species are considered to be quite tolerant of changes in dissolved oxygen, salinity and temperature (Carpelan 1961; Jones 1962; Bane and Robinson 1970; Wares 1971). Such abilities and behavioural features may explain their relative distribution between the water layers we sampled.

PACIFIC STAGHORN SCULPIN

Ninety percent of all the Pacific staghorn sculpins were caught at sites 2 and 4 on the less industrialized western side of the Somass estuary and 95% of these fish taken in the 2.5 to 5.0 m water layer (e.g. of the 209 sculpins taken at site 2, 200 were caught in the 2.5 to 5.0 m depth range and, similarly, 104 of 106 sculpins captured at site 4 came from the deeper water layer).

An age/length frequency classification developed by Jones (1962) indicates that these fish were one to four years of age.

Jones (1962) examined the salinity tolerances of the various life stages of L. armatus and found that as these fish mature their ability to tolerate low salinity waters decreases. Eggs can tolerate salinities from 17.6 to 26.4‰ while larval survival is optimal in salinities ranging from 10.2 to 17.6‰. Juveniles have the greatest range of salinity tolerance (2.0 to 34.3‰) however, maximum survival occurs at 10.2‰. After spending 3 to 6 weeks in low salinity waters the juveniles move into deeper more saline waters due to a decreased ability to tolerate low salinities.

The Pacific staghorn sculpins captured in the gill nets were mainly sexually mature adults as deduced from the age/length classification. On those occasions when these fish were captured in the 2.5 to 5.0 m water layer, at sites 2 and 4, salinities ranged between 2.3 and 13.3‰. Temperatures ranged from 11.0 to 18.2°C while dissolved oxygen levels ranged from 60 to 95% of air saturation. In the "inner" estuary of the Fraser River (within and around Deas Slough), Pacific staghorn sculpins were captured in salinities ranging from <0.1 to 6.8‰, temperatures from 1.4 to 20.2°C and dissolved oxygen concentrations between 8.9 and 14.0 $mg \cdot L^{-1}$, 90 and 120% of air saturation respectively (unpublished data).The largest and oldest staghorn sculpin (age 5+) was captured in November close to Deas Slough in a salinity of 2‰, a result which would not have been expected according to Jone's findings for Californian populations, but one which is consistent with the observations in the Somass estuary.

The reproductive behaviour of this species does not clearly account for its observed distribution solely within the 2.5 to 5.0 m water layer in the study area. However, it may account for the temporal trend in numbers of this species captured in the gill nets and beach seines. Adult Pacific staghorn sculpins occurred in substantially larger numbers in gill nets set during June (254) than in May (70) and July (22). Similarly catches of this species in the intertidal area of the Somass estuary were also highest in June. The increase in numbers of adults and juveniles at this time probably signified the reproductive period. These fish generally lay their egg masses in the deeper waters of bays. After a ten day incubation period the eggs hatch and the emergent larvae are carried by water movements to the nearshore estuarine waters. The juveniles remain in these areas for up to six weeks before they move into deeper, more saline, waters. The decline in numbers of juvenile L. armatus in beach seine catches in July (unpublished information), perhaps reflected this age-related movement into deeper "offshore" waters.

SHINER PERCH

The majority of shiner perch were captured at site 4 and all but one of the 285 fish caught at this location were in the 2.5 to 5.0 m water layer. Similarly at site 6, the total catch of 23 shiner perch was from the same water layer. The prevelance of C. aggregata at these depths may well be associated with the physiological characteristics and reproductive behaviour of the species.

Bane and Robinson (1970) described shiner perch as being euryhaline and eurythermal. Odenweller (1975), gives a temperature tolerance range of 4 to 21°C for the species. From the occurrence of C. aggregata in a coastal lagoon in southern California, it appears that this species can survive in waters of low dissolved oxygen (approximately 5 $mg \cdot L^{-1}$) with high temperatures, and salinities greater than normal seawater (Carpelan 1961). Temperature, salinity and dissolved oxygen values recorded at the time of their capture in the Somass estuary tend to support these reports on the eurythermal and euryhaline capacities of these fish. When 97% of the total number of shiner perch were captured from site 4, dissolved oxygen levels were 60 and 85% air of saturation, salinities were 13.3 and 2.8‰ and temperatures 11.0 and 16.2°C. The shiner perch captured by beach seine in the intertidal zone of the Somass estuary were in low salinity waters (0.2 to 4.5‰) dissolved oxygen levels were high, with a minimum of 75% and a maximum of 105% of air saturation, and temperatures ranged from 15.0 to 22.5°C (unpublished information).

The breeding season for shiner perch extends from April to July. Sperm are "stored" in the females' oviduct for approximately six months. Once the eggs have matured, fertilization occurs initiating a six to eight month gestation period. Live young are born during June and July of the following year (Bane and Robinson 1970).

The lengths of 27% of the total gill net catch of C. aggregata were recorded. All of these fish were at least three years of age based on the length-age categories given by Gordon (1965) and Wilson and Millemann (1969). As females are sexually mature by age 2, and males sooner (Hubbs 1921; Bane and Robinson 1970) it is probable that the shiner perch we captured in the gill nets were sexually mature.

At Keates Island, B.C., Gordon (1965) followed the movements of adult shiner perch prior to, during and after parturition, by means of underwater observations and the use of gill nets. Adult male shiner perch inhabited waters of 2.5 to 6.0 m depth a few weeks prior to parturition. Approximately three days before giving birth, female perch also moved into shallow waters. While parturition was occurring schools of adult perch were observed in waters as shallow as 1.5 m. After this time, adults moved offshore into deeper waters (10 to 34 m) until mid-October at which time they moved out of the study area. It is important to note that prior to and during parturition, adult shiner perch were not feeding.

In the Somass estuary the greatest catches of shiner perch were in May and June when 168 and 131 fish were caught in each month respectively. These catches may have been indicative of the movement of adults into nearshore areas prior to parturition. By July, a dramatic drop in the catch of this species was observed and only 18 were captured. A trend consistent with the expected movement of adults to deeper waters following parturition.

An examination of shiner perch catch data obtained during surveys of the intertidal areas of the Somass estuary (unpublished data) indicates that parturition probably occurred during the months of June and July. While catches of shiner perch were decreasing from May through July in the gill nets the numbers of perch were increasing in the beach seines set in the shallow intertidal area. During May and June, the majority of the perch taken by beach seines were adults whose mean length and weight ranged from 105.0 mm and 26.9 g in May to 117 mm and 32.5 g in June. Late in June and throughout July, smaller perch were captured with mean lengths and weights ranging from 39.0 mm and 1.0 g to 57.0 mm and 3.1 g. According to Gordon's (1965) findings these smaller fish were most probably underyearlings, indicating that parturition had probably taken place in the study area as early as June.

PILE PERCH

Pile perch exhibited a similar vertical distribution to the Pacific staghorn sculpin and shiner perch. The greatest numbers of Rhacochilus vacca were obtained at sites 2 and 4. Of the approximately 425 specimens captured at these sites, about 400 were caught in the nets which fished the 2.5 to 5.0 m zone.

Pile perch like shiner perch, appear to be eurythermal and euryhaline. As indicated by the distribution of pile perch in Yaquina Bay, Oregon (Wares 1971) this species is able to reside in both oceanic environments with stable temperatures and high salinities and also in areas influenced by fresh waters. In the present study, pile perch were captured in a range of salinities, (from a minimum of 1.3 to a maximum of 16.4‰), temperatures (from 10.0 to 19.0°C) and dissolved oxygen levels (from 75 to 90% of air saturation).

There is little information on the reproductive behaviour of R. vacca, but like C. aggregata it is viviparous. The results of this study, provide no information on the timing of parturition in pile perch or upon temporal trends which could be associated with reproductive behaviour.

It is apparent that the vertical distribution of the numerically dominant fish species (Pacific staghorn sculpin L. armatus, pile perch R. vacca and shiner perch C. aggregata) in the Somass estuary is probably related to numerous factors. As all three species are known to tolerate a wide range of salinities and temperatures, it does not appear that variations in these factors within the Somass estuary at the time of capture significantly affected their vertical distribution. All three species are known to use a variety of habitats and consume a wide range of food organisms (Jones 1962; Gordon 1965; Odenweller 1975; Tasto 1975). They appear to be quite adaptable but it is possible, however, that some conditions in the surface water layers were less acceptable to these fish species than those in the 2.5 to 5.0 m water strata where the higher numbers were captured.

With respect to salmon, the catch data and results of in-situ experimentation (Birtwell and Harbo 1980) strongly support the opinion that the deeper waters of the Somass estuary are generally unsuitable for these fish. In particular, reduced levels of dissolved oxygen most probably prevented their full utilization of the water column.

ACKNOWLEDGMENTS

The assistance of G. Carlson, A. Cowan, and R. Taylor during the field work and the constructive comments on the manuscript by M.D. Nassichuk is appreciated. Mr. D. Jeffries performed the statistical analysis. Mrs. D. Price and G. McLaren typed the manuscript.

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Table 1. Mean values (±SD) of water quality variables at six sites within the estuary of the Somass River obtained during the capture of fish with gill nets set between May and July 1975.

		Dissolved oxygen			
	depth (m)	0.0 - 2.5		2.5 - 5.0	
Site		$mg \cdot L^{-1}$	% air satn.	$mg \cdot L^{-1}$	% air satn.
1	$\bar{x}$ ±SD	7.8±1.3	80±10	6.2±2.0	65±20
	(n)	(4)	(4)	(4)	(4)
	range	6.2-9.1	65-95	4.2-9.0	45-90
2	$\bar{x}$ ±SD	8.6±0.6	90± 5	5.8±2.7	60±30
	(n)	(5)	(5)	(5)	(5)
	range	7.9-9.2	80-95	2.4-9.1	25-95
3	$\bar{x}$ ±SD	8.3±0.9	85± 5	6.7±2.1	70±20
	(n)	(5)	(5)	(5)	(5)
	range	7.2-9.3	75-95	3.9-8.8	45-90
4	$\bar{x}$ ±SD	8.4±0.7	85± 5	6.9±1.8	70±15
	(n)	(5)	(5)	(5)	(5)
	range	7.7-9.1	80-95	4.5-8.7	45-90
5	$\bar{x}$ ±SD	8.7±0	90± 5	6.8±2.4	80±10
	(n)	(2)	(2)	(2)	(2)
	range	8.7	90-95	5.1-8.5	75-90
6	$\bar{x}$ ±SD	8.1±1.0	85±10	6.5±2.8	65±30
	(n)	(4)	(4)	(4)	(4)
	range	6.8-9.0	75-90	2.8-8.8	25-90

Table 1. (cont)

Site	Depth (m)	Temperature (°C) 0.0-2.5	Temperature (°C) 2.5-5.0	Salinity (‰) 0.0-2.5	Salinity (‰) 2.5-5.0
1	$\bar{x}$ ±SD	17.3±2.3	16.1±2.5	1.4±0.3	7.9±4.8
	(n)	(4)	(4)	(5)	(5)
	range	14.4-19.3	12.6-18.6	1.1-1.9	1.5-12.8
2	$\bar{x}$ ±SD	16.8±1.6	14.4±2.0	1.3±0.9	11.4±8.9
	(n)	(5)	(5)	(6)	(6)
	range	14.5-18.4	12.1-16.5	0.4-2.7	1.5-25.6
3	$\bar{x}$ ±SD	17.0±1.8	15.8±2.0	1.7±0.9	9.2±6.9
	(n)	(5)	(5)	(6)	(6)
	range	15.3-19.0	13.0-18.5	0.5-2.7	1.8-16.4
4	$\bar{x}$ ±SD	16.1±2.2	15.0±2.6	1.5±0.6	6.6±5.4
	(n)	(6)	(6)	(5)	(5)
	range	12.0-17.9	11.0-18.2	0.9-2.3	2.4-13.3
5	$\bar{x}$ ±SD	15.0±2.6	13.4±2.7	3.0±1.0	10.4±9.3
	(n)	(3)	(3)	(3)	(2)
	range	12.0-16.8	10.8-16.1	2.1-4.0	3.8-17.0
6.	$\bar{x}$ ±SD	16.1±2.4	14.5±3.1	2.2±0.5	11.2±9.8
	(n)	(5)	(5)	(5)	(5)
	range	12.0-18.2	10.4-17.6	1.4-2.6	2.9-25.8

Table 1. (cont)

Site	Depth (m)	pH 0.0-2.5	pH 2.5-5.0	ORP (meV) 0.0-2.5	ORP (meV) 2.5-5.0
1	$\bar{x}$ ±SD	7.4±0.2	7.4±0.1	+265±27	+274±34
	(n)	(5)	(5)	(3)	(3)
	range	7.2-7.7	7.2-7.5	+240-+294	+249-+313
2	$\bar{x}$ ±SD	7.4±0.2	7.2±0.1	+312±71	+338±85
	(n)	(6)	(6)	(4)	(4)
	range	7.2-7.6	7.3-7.5	+245-+387	+260-+419
3	$\bar{x}$ ±SD	7.4±0.1	7.4±0.2	+273±33	+288±33
	(n)	(6)	(6)	(4)	(4)
	range	7.4-7.5	7.3-7.6	+246-+320	+260-+335
4	$\bar{x}$ ±SD	7.4±0.1	7.4±0.2	+299±58	±314±66
	(n)	(5)	(6)	(4)	(4)
	range	7.3-7.6	7.1-7.6	+240-+259	+240-+384
5	$\bar{x}$ ±SD	7.4±0.1	7.5±0.2	+280±56	+280±67
	(n)	(3)	(3)	(1)	(1)
	range	7.2-7.4	7.4-7.7	-	-
6.	$\bar{x}$ ±SD	7.4±0.1	7.4±0.1	+320±56	+332±67
	(n)	(5)	(5)	(4)	(4)
	range	7.3-7.5	7.3-7.6	+270-+382	+270-+407

Table 2. Mean values (±SD) of water quality variables determined in May, June and July 1975 within the estuary of the Somass River.

Month	Depth (m)	n	Dissolved oxygen $mg \cdot L^{-1}$	Dissolved oxygen % air satn.	Range min-max ($mg \cdot L^{-1}$)	Min-max % air satn.
May	0.0-2.5	5	8.6±0.4	90±5	8.2-9.2	90-95
	2.5-5.0	5	5.7±0.4	70±5	5.1-6.1	65-75
June	0.0-2.5	10	9.0±0.2	90±5	8.7-9.2	85-95
	2.5-5.0	10	8.7±0.3	90±5	7.9-9.1	80-95
July	0.0-2.5	10	7.4±0.6	80±5	6.2-8.0	65-85
	2.5-5.5	10	4.7±1.5	50±15	2.4-7.2	25-70

Month	Depth (m)	n	Temperature (°C)	Range min - max
May	0.0-2.5	8	14.0±1.7	12.0-16.1
	2.5-5.0	8	12.0±1.1	10.4-13.2
June	0.0-2.5	10	16.4±0.4	16.0-17.2
	2.5-5.0	10	16.2±0.2	16.0-16.5
July	0.0-2.5	10	18.4±0.6	17.4-19.3
	2.5-5.0	10	15.9±2.5	11.9-18.6

Month	Depth (m)	n	Salinity (‰)	Range min - max
May	0.0-2.5	10	2.4±0.8	1.2-4.0
	2.5-5.0	9	14.1±2.5	9.8-17.0
June	0.0-2.5	10	1.5±0.7	0.4-2.6
	2.5-5.0	10	2.6±0.8	1.5-3.8
July	0.0-2.5	10	1.3±0.6	0.7-2.6
	2.5-5.0	10	12.0±8.3	2.4-25.6

Month	Depth (m)	n	pH	Range min - max
May	0.0-2.5	10	7.4±0.1	7.2-7.5
	2.5-5.0	9	7.5±0.1	7.4-7.5
June	0.0-2.5	10	7.4±0.1	7.2-7.7
	2.5-5.0	10	7.4±0.1	7.3-7.5
July	0.0-2.5	10	7.5±0.1	7.3-7.6
	2.5-5.0	10	7.3±0.1	7.2-7.5

Table 2. (cont'd)

Month	Depth (m)	n	ORP (meV)	Range min max
May			no data	
June	0.0-2.5	10	+258±15	+240-+280
	2.5-5.0	10	+267±14	+240-+280
July	0.0-2.5	10	+331±46	+261-+387
	2.5-5.0	10	+352±55	+261-+419

Table 3. Mean values (±SD) of water quality variables derived from combined data from six sampling sites in the estuary of the Somas River, May, June and July 1975.

Variable		Depth (m)	mean ±SD	n	Range
Dissolved	($mg \cdot L^{-1}$)	0.0-2.5	8.3±0.9	25	6.2-9.3
Oxygen	(% air satn.)		85±10	25	65-95
	($mg \cdot L^{-1}$)	2.5-5.0	6.5±2.1	25	6.4-9.1
	(% air satn.)		70±20	25	25-95
Temperature (°C)		0.0-2.5	16.4±2.0	28	12.0-19.3
		2.5-5.0	14.9±2.4	28	10.4-18.6
Salinity (‰)		0.0-2.5	1.7±0.8	30	0.4-4.0
		2.5-5.0	9.4±7.1	29	1.5-25.8
pH		0.0-2.5	7.4±0.1	30	7.2-7.7
		2.5-5.0	7.4±0.1	29	7.1-7.7
ORP (meV)		0.0-2.5	+295±50	20	+240-+387
		2.5-5.0	+310±59	20	+240-+419

Table 4. List of fish captured by gill nets set at six sites and two depths in the Somass estuary during May, June and July 1975.

Site	1		2		3		4		5		6	
Depth (m)	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0
Pile perch *Rhacochilus vacca*	46	-	22	200*	-	-	-	203	-	-	-	6
Pacific Staghorn sculpin *Leptocottus armatus*	1	26	9	200*	-	-	2	104	-	-	6	-
Shiner perch *Cymatogaster aggregata*	-	-	9	-	-	-	1	284	-	-	-	23
Pacific herring *Clupea harengus pallasi*	-	11	2	-	-	-	38	76	-	-	3	1
Coho salmon *Oncorhynchus kisutch*	8	-	11	-	1	-	16	9	-	-	4	-
Ratfish *Hydrolagus colliei*	-	27	-	-	-	3	-	2	-	-	4	2
Chinook salmon *Oncorhynchus tshawytscha*	1	-	8	-	-	-	6	6	-	-	-	-
Sockeye salmon *Oncorhynchus nerka*	4	-	2	-	1	-	1	-	-	-	5	-
Black rockfish *Sebastes melanops*	-	-	-	-	7	1	-	-	-	-	-	2
Pacific hake *Merluccius productus*	-	-	-	-	-	-	-	-	-	-	4	-

Table 4. (con't)

Site	1		2		3		4		5		6	
Depth (m)	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0
Rainbow trout Salmo gairdneri	-	-	-	-	-	-	-	-	-	-	3	-
Cutthroat trout Salmo clarki	-	-	2	-	1	-	-	-	-	-	-	
Pacific cod Gadus macrocephalus	-	-	-	-	-	-	-	1	-	-	2	-
Walleye pollock Theragra chalcogramma	-	-	-	-	-	1	-	1	-	-	-	1
Bocaccio Sebastes paucispinis	-	-	-	-	-	2	-	-	-	-	-	-
Brown Irish lord Hemilepidotus spinosus	1	-	-	-	-	-	-	-	-	-	-	-
Lingcod Ophiodon elongatus	-	-	-	-	-	-	-	-	-	-		1
Northern sculpin Icelinus borealis	-	-	-	-	-	-	-	1	-	-	-	-
Sand sole Psettichthys melanostictus	-	-	-	-	-	-	-	1	-	-	-	-

Table 4. (cont)

Site	1		2		3		4		5		6	
Depth (m)	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0	0.0-2.5	2.5-5.0
Speckled sanddab <u>Citharichthys</u> <u>stigmaeus</u>	-	-	-	-	-	-	-	-	-	-	-	1
Total	61	64	65	400*	10	7	64	688	no catch		31	37
Number of species	6	3	8	2	4	4	6	11	zero		8	8
% of catch (by depth)	4.3	4.5	4.5	28.0	0.7	0.5	4.5	48.2	zero		2.2	2.6
% of catch at site	8.8		32.5		1.2		52.7		zero		4.8	
Total number of species	8		8		6		12		zero		14	

* estimate

Table 5. Ranked abundance of fish captured by gill nets in two water strata (0.0 to 2.5 m; 2.5 - 5.0 m) May, June and July 1975, in the Somass estuary.

Species	0.0-2.5 m	2.5-5.0 m	0.0-5.0 m	% total
catch				
Pile perch *Rhacochilus vacca*	68	409	477	33
Pacific staghorn sculpin *Leptocottus armatus*	18	330	348	24
Shiner perch *Cymatogaster aggregata*	10	307	317	22
Pacific herring *Clupea harengus pallasi*	43	88	131	9
Coho salmon *Oncorhynchus kisutch*	40	9	49	3.4
Ratfish *Hydrolagus colliei*	4	34	38	2.7
Chinook salmon *Oncorhynchus tshawytscha*	15	6	21	1.5
Sockeye salmon *Oncorhynchus nerka*	13	-	13	0.9
Black rockfish *Sebastes melanops*	7	3	10	0.7
Pacific hake *Merluccius productus*	4	-	4	0.3
Rainbow trout *Salmo gairdneri*	3	-	3	0.2
Cutthroat trout *Salmo clarki*	3	-	3	0.2
Pacific cod *Gadus macrocephalus*	2	1	3	0.2
Walleye pollock *Theragra chalcogramma*	-	3	3	0.2

Table 5. (con't)

Species	0.0-2.5 m	2.5-5.0 m	0.0-5.0 m	% total
Bocaccio *Sebastes paucispinis*	-	2	2	0.1
Brown Irish lord *Hemilepidotus spinosus*	1	-	1	<0.1
Lingcod *Ophiodon elongatus*	-	1	1	<0.1
Northern sculpin *Icelinus borealis*	-	1	1	<0.1
Sand sole *Psettichthys melanostictus*	-	1	1	<0.1
Speckled sanddab *Citharichthys stigmaeus*	-	1	1	<0.1
Total	231	1196	1427	100
% of total catch	16.0	84.0	100	

Table 6. Significant results of ANOVA and Duncan's Multiple Range Test ($p < 0.05$) applied to fish catch data, between sampling sites and between depths.

Data set	Between sites: Depths combined	Between sites: 0.0 m - 2.5 m	Between sites: 2.5 m - 5.0 m	Between depths: Sites Combined	1	2	3	4	5	6
Total number of fish	(5,3,1,6)-(3,1,6,2)-(4)		(5,3,6,1,2)-(2,4)	+				+		
Salmonids				+						
Total number of non-salmonids	(5,3,1,6,2,)-(2,4)		(5,3,6,1,2)-(2,4)	+				+		
Herring (*Clupea harengus pallasi*)	(5,3,2,6,1)-(4)									
Pacific Hake (*Merluccius productus*	(5,4,3,2,1)-(6)	(5,4,3,2,1)-(6)								
Pile perch (*Rhacochilus vacca*)										+
Walleye pollock (*Theragra chalcogramma*)				+						
Sockeye salmon (*Oncorhynchus nerka*)				+						

+ indicates a significant difference between 0-2.5 m and 2.5-5.0 m.
( ) indicate homogeneous data sets.

Table 7. A comparative analysis of water quality data between 0.0-2.5 m and 2.5-5.0 m water depths for individual sites, and for combined data sets.

Variable	Sites combined	Sites 1	2	3	4	5	6
Dissolved oxygen ($mg \cdot L^{-1}$)	+						
(% air satn.)	+		+				
Temperature (°C)	+						
Salinity (‰)	+	+	+	+			

+ indicates significant results ($p < 0.05$).

Table 8. Salmonid and non-salmonid catches in gill nets set in the estuary of the Somass River, May - July 1975.

Depth (m)	Number of salmonids	%	Number of non-salmonids	%	Total number of fish
0.0-2.5	74	32	157	68	231
2.5-5.0	15	1	1143	99	1158
0.0-5.0	89	6	1300	94	1389

Table 9. Weight-length relationships for seven species of fish captured by gill nets between May and July 1975 in the Somass estuary.

Species	n	Coefficient (R^2)	$W = aL^b$ a	b
Chinook salmon (*Oncorhynchus tshawytscha*)	6	0.9360	0.024	2.722
Coho salmon (*Oncorhynchus kisutch*)	38	0.9595	0.017	2.806
Pacific Staghorn sculpin (*Leptocottus armatus*)	91	0.9335	0.009	3.147
Herring (*Clupea harengus pallasi*)	60	0.9431	0.017	2.773
Pile perch (*Rhacochilus vacca*)	58	0.9047	0.033	2.815
Shiner perch (*Cymatogaster aggregata*)	114	0.8350	0.019	3.035
Ratfish (*Hydrolagus colliei*)	15	0.9256	0.001	3.368

W - weight, L - length. a,b - constants

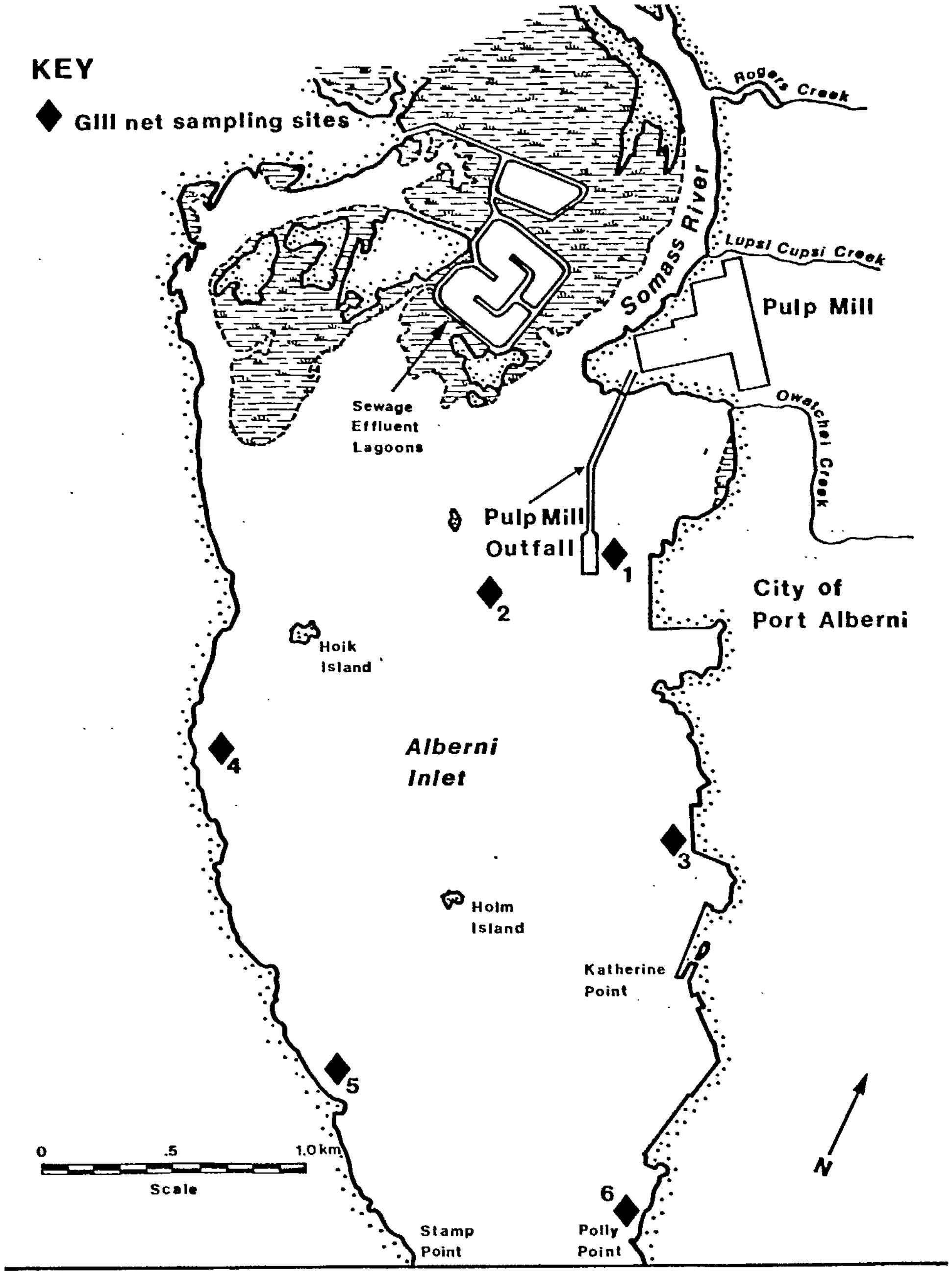

Fig. 1. The location of gill net sampling sites in the estuary of the Somass River.