Plankton Samples in Campbell River and Discovery Passage In Relation to Juvenile Chinook Diets

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Zooplankton sampling was carried out in the Campbell River estuary and Discovery Passage using Miller nets in 1983 and 1984. Five hundred sixty-four samples were collected from 9 stations over 33 sampling periods.

The estuarine zone macro zooplankton was dominated by cladocerans and calanoid copepods while calanoid copepods and copepod nauplii were predominant in the transition zone. The marine zone was dominated by calanoids and eggs. The micro zooplankton was dominated by calanoid copepods and copepod nauplii in all three zones.

The juvenile chinook salmon examined from the Campbell River area in 1983 and 1984 utilized four important food categories. Calanoids, amphipods, harpacticoids, and cladocerans were consumed by both the hatchery and wild chinook. The hatchery fish also ate cumacea while insects and decapod zoea were important in the wild chinook diets.

The Miller nets sampled the calanoids and cladocera effectively. Insects and epibenthos, such as amphipods, harpacticoids and cumacea, require other sampling methods.

RESUME

Brown, J. J., C. D. McAllister, and B. A. Kask. 1987. Plankton samples in Campbell River and Discovery Passage in relation to juvenile chinook diets. Can. MS Rep. Fish. Aquat. Sci. 1915: 35 p.

En 1983 et 1984, on a prélevé des échantillons de zooplancton dans l'estuaire de la rivière Campbell et dans le Discovery Passage en utilisant des filets Miller. On a recueilli cinq cent soixante-quatre échantillons provenant de 9 stations au cours de 33 périodes d'échantillonnage.

Le zooplancton macroscopique de la zone estuarienne était dominé par des cladocères des copépodes appartenant au groupe des calanoides alors qu'on retrouvait surtout des copépodes calanoides et des nauplius de copépodes dans la zone de transition. La zone marine était dominée par des calanoides et des oeufs. Dans les trois zones, le microzooplancton était dominé par des copépodes calanoides et des nauplius de copépodes.

Les jeunes saumons quinnats examinés provenant de la région de la rivière Campbell en 1983 et 1984 ont utilisé quatre catégories importantes de nourriture. Des calanoides, des amphipodes, des harpacticoides et des cladocères ont été consommés aussi bien par les saumons quinnats sauvages que d'élevage. Les poissons de piscifacture ont également consommé des cumacés alors que les insectes et des zoés de décapodes constituaient une partie importante du régime alimentaire des saumons quinnats.

Les filets Miller ont permis d'échantillonner efficacement les calanoides et les cladocères. Pour les insectes et l'épibenthos, comme les amphipodes, les harpacticoides et les cumacés, il faut utiliser d'autres méthodes d'échantillonnage.

INTRODUCTION

The Campbell River estuary (latitude 50°03' north and longitude 125°15' west) is located on the east coast of Vancouver Island, British Columbia. The Campbell River and its main tributary, the Quinsam River, provide the main freshwater discharge into the estuary. The estuary has been used for log handling for over 80 years and is also a rearing area for juvenile salmon (Bell and Thompson 1977). In 1982, British Columbia Forest Products constructed four intertidal islands to partially compensate for habitat lost by a new dry land log sort facility and a dredged log pond (Brownlee et al. 1984). A study was begun in 1982 to evaluate the effects of the estuarine rehabilitation on the survival of young salmon.

The distribution of juvenile salmonids was examined using beach seines (Brown et al. 1983, 1984a, b) and some fish were retained for length, weight and stomach analysis (Kotyk et al. 1985, 1986; Anderson and Galbraith 1984; Cross 1985). In addition, the near shore epibenthos was sampled using an epibenthic sled (Kask and Brown 1985) and the pelagic zooplankton was sampled with Miller nets (Miller 1961).

The sampling was carried out in three zones. The estuarine zone was defined as the intertidal area bounded by Tyee Spit. The transition zone included an area of Discovery Passage which is influenced by the Campbell River and the marine zone included the rest of Discovery Passage and Seymour Narrows.

Five hundred sixty-four zooplankton samples were collected. The raw counts, numbers m^{-3}, date, time, station, tide (height and type), temperature, salinity, and volume filtered may be found in Brown and Kask (1984, 1985).

The data is divided into 2 sets, the macro and micro zooplankton samples. The macro net had a mouth diameter of 11.3 cm and a 350 μ net while the micro net had a mouth diameter of 3.6 cm and a 100 μ net.

MATERIALS AND METHODS

Dual Miller nets were towed for 10 minutes at approximately 2 ms^{-1} with a 5 m inflatable boat. The nets were equipped with a flow meter to determine the volume filtered and the counts were converted to numbers m^{-3}. The nets sampled the surface meter of water except for station 372 which was sampled at 3-4 meters depth. The samples were preserved in 10% formalin and rose bengal. They were counted to major taxonomic group in the laboratory using a M5 dissecting microscope. When necessary, the sample was split using a Folsom plankton splitter and the results multiplied by the appropriate correction factor to give the total numbers in the samples. Organisms were identified as far as possible in the time available. One hundred each of the calanoids and harpacticoids were retained from each sample for future identification to species.

An analysis of variance of the amphipods and barnacle nauplii counts indicated no significant differences at the 95% level between the macro and micro samples. Concentrations of copepod nauplii in the micro samples were significantly higher in the transition and marine zones. This was an expected result because the copepod nauplii pass through the macro net while being retained by the micro net. This data indicates little avoidance of the micro net by the larger zooplankton while the small zooplankton pass through the macro net.

The surface temperature and salinity were measured using a Beckman RS-5 salinometer. The tide heights and type (ebb and flood) were calculated and recorded for the time of sampling, and are presented in Brown and Kask (1984, 1985).

RESULTS

ESTUARINE ZONE

Sampling Regime

The construction of the new islands within the estuary was designed to increase the shallow shoreline habitat. The islands were planted with marsh grass to increase organic inputs to food webs supporting young salmon. The construction and planting were completed in February 1982 (Brownlee et al. 1984) and fish utilization and monitoring by beach seining was begun in March 1982.

Beginning in February 1983 the zooplankton were sampled using dual miller nets. The zooplankton was sampled at 4 sites within the estuary on an approximately biweekly schedule. 130 samples were obtained in 1983 and 126 samples in 1984 from stations 1, 7, 15, and 371 (Fig. 1). Thirty samples were obtained from station 372 in 1983 and 28 in 1984 for a total of 314 samples in the estuarine zone from 4 sites over 32 sampling periods from February 23, 1983 to September 25, 1984 (Table 1). Station 15 was in the new islands while stations 7 and 1 were in established habitats. Stations 371 and 372 were samples from the dredged log pond at the surface and 3 to 4 m depth, respectively. The estuarine samples were collected at similar tide heights. Stations 1, 7, 15 and 371 were sampled at tide heights of 3.3, 3.2, 3.3 and 3.1 m (mean ± 0.1 SE) respectively (Table 2).

The salt wedge retreats from the main river channel at lower tides but is always present in the log basin and other deeper portions of the estuary (Al Ages, unpubl. data). Much of the estuary is alternately exposed to fresh, brackish, and saline water. The mean surface salinities at stations 1, 7, 15, and 371 ranged from 1.9 to 5.1°/₀₀ (Table 2). Station 372 was not included in the calculation of estuarine means because of its similarity with the transition and marine zone stations.

Zooplankton Abundance in the Estuarine Zone

The estuarine macro zooplankton were approximately 5 times more abundant in 1983 than in 1984. This decrease in 1984 was reflected in all zooplankton categories (Tables 5, 6) and represented a decrease in the large zooplankton available as fish food (85.4 ± 17.5 to 18.0 ± 5.5 m^{-3}, Table 3) from 1983.

The macro zooplankton showed a broad peak from March to August with low concentrations between September and February (Fig. 2) in both years. High catches were much more frequent in 1983. The peak was related to increased abundance of cladocera, calanoids, and unidentified eggs in both 1983 and 1984 (Table 7). The concentrations of cladocera in 1983 were 3-10 times higher than in 1984 at the 4 estuarine stations examined (Table 3).

The lowest total abundances of cladocerans and calanoids were found at station 371 in both 1983 and 1984 (Table 3). This was probably due to the poor exchange of surface water into the log pond area. Low harpacticoid concentrations may have resulted from the narrow intertidal area in this portion of the estuary.

The estuarine micro zooplankton was also more abundant in 1983 than in 1984. The total counts in 1984 for the estuarine mean were approximately 50% of the 1983 counts (437.6 ± 75.0 and 835.6 ± 156.4 respectively, Table 4). The decrease in zooplankton in 1984 was due to lower counts of unidentified eggs, copepod nauplii, cladocerans and calanoids (Table 5, 6).

The micro zooplankton showed patterns of concentration similar to those of the macro zooplankton (Fig. 2). The main peaks in 1983 were related to abundances of copepod nauplii, unidentified eggs, calanoids, and cladocera (Table 7), as was the case in 1984 except that harpacticoids replaced unidentified eggs. The abundance of freshwater cladoceran concentrations in the micro net was similar in 1983 and 1984 (136.5 ± 42.0 and 94.0 ± 27.0 m^{-3}). The micro zooplankton abundance in the estuary was an order of magnitude larger than the macro zooplankton concentrations.

Estuarine Zone Station Comparisons

Correlation coefficients were determined between stations for total abundance, cladoceran, and calanoid abundance for the macro and micro samples. The copepod nauplii were compared between stations for the micro samples only.

The concentration of total zooplankton m^{-3} for stations 1, 7, 15 and 371 all had correlation coefficients of $r \geq 0.55$ ($P<0.01$). This suggests that macro zooplankton concentrations tend to fluctuate in unison over the surface of the estuary. This is supported by the cladocera counts in the macro samples which also correlated well over the estuary with $r \geq 0.60$ ($P<0.01$).

Counts of calanoids from macro nets at station 371 correlated with those at 1, 7, and 15 with $r \geq 0.56$ ($P<0.01$). Station 15 also correlated well with stations 1 and 7 at $P<0.05$. The only non-significant r value was between stations 1 and 7 for the calanoids taken in the macro nets.

Total micro zooplankton correlated between stations 7 and 15 with r=0.58 and between 1 and 15 with r=0.45 ($P<0.01$ and 0.05 respectively). Stations 15 with 7, and 1 with 371 correlated ($P<0.01$) for both the micro calanoid and copepod nauplii concentrations. Copepod nauplii at station 15 also correlated with station 1 with r=0.45 ($P<0.05$).

The cladoceran data from micro nets correlated at r=0.36 and 0.40 for station 15 versus 371 and 7 ($P<0.05$). All other estuarine station combinations correlated with a significance of ($P<0.01$).

The correlation coefficients for total zooplankton and cladocera concentrations in the macro and micro samples imply a fairly uniform surface layer dominated by freshwater spread evenly throughout the estuary. The calanoid and copepod nauplii counts, which were very important in the micro zooplankton samples (Table 8), showed little consistency in distribution throughout the estuary. The most consistent similarities occurred between stations 7 and 15, and 1 with 371. This was an expected relationship due to station locations and known current flows (Fig. 1).

Vertical Distribution of Zooplankton in the Log Pond

The dredged log basin has a mean depth 3 m below zero tide and maintains a permanent salt wedge on all tides. The natural gravel slopes of 3:1 or less have been replaced with a dredged slope of 1.5:1, stabilized with rip rap (Brownlee et al. 1984). The entire littoral zone within the log basin consists of rip rap of size class 61 cm or less which was necessary to counteract erosion from tug boat activity. Stations 371 (0 m sample depth) and 372 (3 m sample depth) were located within the dredged log basin area.

The total macro zooplankton concentrations were higher at 3 m than 0 m (106.2 ± 29.3 and 20.2 ± 6.3 respectively, Table 3) and was indicative of the zooplankton in the intruding salt wedge (Table 3, 4). The macro calanoid abundance at 3 m was similar to the transition stations and indicate the influence of marine water at depth in the log pond. The micro net catches at 3 m were also similar to the transition and marine stations (Table 4). The micro net calanoid catches at depth in the log pond were an order of magnitude higher than at surface estuarine stations and were similar to those in the transition and marine zones. The salinity at 3 m, at the time of sampling, ranged between 22.6 and 30.5‰ (Table 2). Due to the nature of station 372, the results were not used to calculate the estuarine means.

Juvenile Chinook Diets in the Estuarine Zone

One hundred forty-six hatchery and 123 wild juvenile chinook were examined for stomach contents in 1983 from the Campbell River estuary (M. Kotyk, unpub. data) (Table 9). Cladocera and calanoids were important in the diet of both the hatchery and wild chinook. The hatchery fish also consumed cumacea and harpacticoids while insects and benthic amphipods were important to the wild chinook (Table 7). Eogammarus sp., Corophium sp., and unidentified Gammarids comprised 96.2% of the amphipods consumed by the wild chinook.

Sixty-seven hatchery and 94 wild juvenile chinook were examined for stomach contents from April to August 1984 (Table 9; Cross 1985). Cladocerans were important in the diet of both the wild and hatchery fish. The hatchery fish also consumed calanoids in large numbers while amphipods (mainly Corophium sp. and Gammarus sp.) were equally important to both the hatchery and wild chinook.

Cladocera, calanoids, and benthic amphipods were in the top 4 food groups consumed by both the hatchery and wild chinook in both 1983 and 1984. This indicates that the hatchery and wild chinook share similar food items within the Campbell River estuary but consume them in different proportions.

The Miller nets did sample some of the main food groups (calanoids, cladocera and amphipods) consumed by the juvenile chinook in the estuary in 1983 and 1984 (Table 7). Insects consumed by the wild chinook in 1983 and 1984 and by the 1984 hatchery chinook were poorly sampled by the Miller nets. The amphipods would be better sampled by the use of quadrats or an epibenthic sled while the pelagic zooplankton appeared effectively sampled.

TRANSITION ZONE

Sampling Regime

Station 20 has complex currents with a large intertidal gravel beach. Station 34 has freshwater outflow at high tide. Both stations have subtidal eelgrass beds. Station 21 is influenced the least by the freshwater from the Campbell River while being adjacent to a large intertidal flat with moderate tidal currents.

Stations 20 and 34 (Fig. 1, 3; Table 1) were sampled from March 15, 1983 to September 25, 1984 producing 118 samples of zooplankton. Station 21 (Fig. 3) was sampled from March 8, 1984 to September 25, 1984 producing 28 samples (Table 1). A total of 146 zooplankton samples were collected from the 3 stations. The transition and estuary samples were collected at similar tide heights (Table 2). Stations 20 and 34 had a mean of 3.0 ± 0.2 and 3.4 ± 0.1 m respectively, while station 21 had a mean of 2.5 ± 0.2 m. The minimum surface temperature for the transition zone was 4.4°C while the maximum surface temperature was 15.9°C. These were both recorded from station 34. The mean surface salinities for stations 20, 21, and 34 were 29.3 ± 0.4, 29.2 ± 0.4, and 5.4 ± 0.9 respectively (Table 2).

Zooplankton Concentrations in the Transition Zone

Macro zooplankton samples from the transition zone displayed a summer peak, decreasing from September to a winter low (Fig. 4). The micro zooplankton samples show a similar pattern (Fig. 4). The mean abundance for the macro net was 247.4 ± 65.5 organisms m^{-3} compared to the micro net at 4429.3 ± 637.3 m^{-3} (Tables 3, 4). The March 29, 1983 sample at station 34 was taken during strong winds and the macro miller net touched the rocks on shore, catching a large number of barnacles. This in turn saturated the sample with barnacle nauplii and eggs. These two categories in the macro sample were not similarily represented in the micro net, and were removed from further calculations.

The 1983 transition macro zooplankton were the most complex of all three zones. The main categories which composed the peaks were calanoids, cladocera, unidentified eggs, and amphipods which made up only 57.2% of the 1983 counts (Table 7). The 1984 peaks were composed mainly of calanoids, copepod nauplii and gastropod eggs. Nematodes, which ranked fourth in importance in the averages, (Table 7) were present only once in high numbers in any of the plankton samples. This occurred on June 21, 1984 at station 34 and the nematodes were not similarly represented in the micro net which sampled concurrently. These counts are probably due to sampling error in which the bottom macro net inadvertently touched the bottom or passed through eel grass and should be ignored.

The 1983 micro zooplankton peaks in the transition zone (Fig. 4) were composed of calanoids, copepod nauplii, unidentified eggs and cladocera which made up 80.1% of the total counts. The main categories in the 1984 peaks were copepod nauplii, calanoids, barnacle nauplii and unidentified eggs making up 87.1% of the catches. The between year variations were minimal, except for the low cladocera counts in 1984 (Table 4) but no significant differences were noted (t test, dF=27).

Transition Zone Station Comparisons

Total zooplankton concentrations, calanoid, cladocera, and harpacticoid concentrations were used to calculate correlation coefficients between stations for the macro and micro transition zone zooplankton results. The copepod nauplii were examined for the micro net only. The harpacticoid counts produced no significant correlation coefficients between any of the transition zone stations.

Total abundance data correlate at r=0.52 and 0.91 for the micro zooplankton between station 34 versus 20 and 21 respectively ($P<0.01$). The total abundance of macro samples correlated only between station 20 and 21, with r=0.67 ($P<0.01$).

The freshwater cladocera correlate at $r \geq 0.76$ in both the macro and micro zooplankton at stations 20 and 34 ($P<0.01$). The cladocera from station 21 do not correlate with other transition stations. This is expected considering the distance station 21 is from the cladocera source, the Campbell River.

Calanoids at station 20 and 34 correlate at $r \geq 0.51$ ($P<0.01$) for both the macro and micro zooplankton samples. Station 21 correlates with stations 20 and 34 for the calanoid abundance ($r=0.57$ and $r=0.82$) for macro net zooplankton only ($P<0.05$ and $P<0.01$, respectively).

The transition stations 20 and 34 were influenced by the Campbell River as indicated by the presence of cladocera. Station 21 is similar to stations 20 and 34 in concentrations of calanoids and is considered to have the least estuarine influence.

Juvenile Chinook Diets in the Transition Zone

Fifty-one hatchery and 10 wild juvenile chinook salmon were examined for stomach contents from March to August, 1983 (M. Kotyk, unpublished data) (Table 9). The hatchery fish ate harpacticoids, amphipods, cumaceans, and calanoids which made up 96.7% of their stomach contents. The wild chinook consumed primarily amphipods, harpacticoids, calanoids, and decapod zoea.

In 1984, 37 hatchery and 68 wild juvenile chinook were examined for stomach contents (Cross 1985). The hatchery fish ate cumaceans, calanoids, harpacticoids, and cladocera, which represented 91.6% of all food items consumed (Table 7). The wild chinook consumed harpacticoids, cladocera, cumaceans, and calanoids which represented 88.3% of the total food consumed.

The categories common to both hatchery and wild chinook in 1983 were harpacticoids, amphipods (mainly *Corophium* sp. and unidentified Gammarids), and calanoids while harpacticoids, cladocera, and cumaceans were common in 1984. Harpacticoids were consumed by both hatchery and wild chinook in 1983 and 1984. These data indicate that a limited number of food categories were exploited by the juvenile hatchery and wild chinook, but utilized in different proportions.

Of the four most abundant taxa in the transition zone zooplankton, only the calanoids and amphipods were consumed in any number by the juvenile chinook. The 1984 chinook consumed cladocera which were about 25% as abundant as in 1983. Cladocerans and harpacticoids were present in 1984, but were not in the top 4 categories in catches by either the macro or micro nets. The cumaceans being primarily benthic organisms were not sampled efficiently using Miller nets and should be estimated by other techniques.

MARINE ZONE

Sampling Regime

Station 27 has swift tidal currents with an exposed gravel beach and a moderate incline leading to a subtidal (Nereocystis) kelp bed. The currents are almost uniform in speed from top to bottom in Discovery Passage with an ebb maximum of 250 cm/sec and a flood maximum of 300 cm/sec diminishing toward the shores (Bell and Thompson 1977). Station 31 is more sheltered, has slower currents, and a beach consisting of gravel, sand, and mud with an intertidal eel grass bed.

Fifty samples were taken from station 27 and 31 (Fig. 3) in 1983, and 54 in 1984, producing 104 zooplankton samples from March 15, 1983 to September 26, 1984. Station 27 was sampled on all trips while station 31 was not sampled during the winter months (November 7, 1983 to March 21, 1984).

The samples were collected at a mean tide height of 2.5 ± 0.2 and 2.3 ± 0.1 m for stations 27 and 31 respectively (Table 2). The minimum and maximum temperatures for this zone were both recorded from station 27 (7.7, 13.5°C). The minimum surface salinity of 25.6°/₀₀ was recorded from station 31 while the maximum surface salinity of 32.3°/₀₀ was recorded at station 27.

Zooplankton Concentrations in the Marine Zone

The macro zooplankton had a spring peak in May and a gradual decrease until the following March when the spring bloom began again (Fig. 5). The micro zooplankton showed a similar trend but the peak was one month later in June in both years (Fig. 5).

The mean total abundance for the 1983 and 1984 macro zooplankton were 339.0 ± 91.7 and 173.1 ± 33.3 m^{-3} respectively (Table 3). Calanoids, unidentified eggs and ectoprocts were the main components of the macro samples (Table 8). The micro zooplankton total counts for the two years were 3750.0 ± 401.5 and 6425.4 ± 1184.8 m^{-3} respectively (Table 4). The main components of the micro samples were calanoids, copepod nauplii, and unidentified eggs (Table 8).

Marine Zone Station Comparisons

An examination of the between year variation (t-test) showed no significant difference ($P>0.05$) in the macro zooplankton counts for both stations 27 and 31 and the micro zooplankton for station 31. The micro zooplankton concentrations at station 27 in 1984 was significantly higher ($t=2.12$, $P<0.05$) than in 1983. This increase was due mainly to an increase in the copepod nauplii and calanoid categories.

Data from stations 27 and 31 showed few differences for the macro net zooplankton total catches and calanoids in both 1983 and 1984. The micro zooplankton data showed a higher total abundance at station 27 than station 31 in 1984. This is also reflected in an increase in the micro net calanoids at station 27 in 1984 (Table 4). An examination of 12 categories including total counts, unidentified eggs, barnacle nauplii, and copepod nauplii using a one way analysis of variance showed no significant differences between station 27 and 31 for the macro samples. Calanoid copepod abundance was the only category that was significantly higher at station 27.

The correlation coefficient for total abundance was $r=0.55$ and $r=0.47$ for the macro and micro zooplankton between stations 27 and 31 ($P<0.05$ and 0.01, respectively). The cladocerans from the micro net correlate with $r=0.46$ ($P<0.05$). The cladocera had very low counts in the marine zone, and were comprised of the marine species *Evadne* and *Podon*, not the freshwater forms found in the estuarine and transition zones. The calanoids correlated well only for the macro net catches, with $r=0.96$ ($P<0.01$), as did the copepod nauplii ($P<0.01$) in micro zooplankton samples. These two stations had similar copepod concentrations and were dominated by calanoids and copepod nauplii.

Juvenile Chinook Diets in the Marine Zone

Twenty-one wild and 18 hatchery chinook were examined for gut contents in 1984 (Cross 1985), and 14 wild chinook in 1983 (M. Kotyk, unpublished data) (Table 9). The main food item consumed by the chinook examined from the marine zone was harpacticoid copepods. Barnacle cyprids and epibenthic amphipods were in the top 4 dietary items for both the hatchery and wild chinook in 1984 (Table 7). However, the barnacle cyprids from wild chinook in 1984 were consumed by one fish from station 27.

BETWEEN ZONE COMPARISONS OF ZOOPLANKTON AND CHINOOK DIETS

Macro Zooplankton Samples

The estuarine zone had the lowest total abundance (mean 52.5 $m^{-3} \pm 9.8$) followed by the transition and marine zones (247.4 $m^{-3} \pm 65.6$ and 254.5 $m^{-3} \pm 49.0$ respectively, Table 3). The estuarine samples were dominated by cladocera (mean 26.3 $m^{-3} \pm 6.9$). The transition and marine zones showed a decrease in cladocerans compared to the estuarine zone (13.8 $m^{-3} \pm 7.8$ and 0.8 $m^{-3} \pm 0.2$ respectively, Table 3). This seaward decrease is expected because the most likely source of the cladocera is in the headwater lakes of the Campbell River.

The transition and marine zones were dominated by calanoids which were second in importance in the estuarine zone (Table 8). Calanoid concentrations were highest in the marine zone and decreased in the transition and estuarine zones (144.5 $m^{-3} \pm 38.7$, 65.4 $m^{-3} \pm 11.1$ and 10.4 $m^{-3} \pm 3.0$ respectively, Table 3). The low calanoid counts from surface samples in the estuarine zone confirm the poor exchange between the incoming saltwedge and the upper layer.

Micro Zooplankton Samples

Abundance of micro zooplankton from the estuarine zone were the lowest followed by those in the transition and marine zones ($635.0\ m^{-3} \pm 87.8$, $4429.3\ m^{-3} \pm 637.3$ and $5139.5\ m^{-3} \pm 665.6$ respectively, Table 4). The calanoids were also lowest in the estuarine zone increasing to the transition and marine zones ($150.0\ m^{-3} \pm 24.6$, $1234.5\ m^{-3} \pm 145.0$ and $2050.1\ m^{-3} \pm 234.9$ respectively, Table 4). The calanoid category was the first or second in importance for both the macro and micro samples for all three zones (Table 8). The micro samples from the estuarine and transition zones were dominated by copepod nauplii while the macro estuarine samples were dominated by cladocera.

Correlations Between Stations and Zones

The results of station and zone comparisons of total zooplankton, calanoids, cladocera, harpacticoids, and copepod nauplii were complex but some trends were evident. Station 31 is an area having little similarity to other stations. If a correlation occurred, it was usually with station 27. Station 27 correlated with the transition zone (stations 20, 21, and 34) but not with stations from within the estuary.

The transition zone stations 20 and 34 correlate to all the estuarine stations for the cladocera only. The calanoids, which originate in the marine zone, correlate between estuarine stations and station 20 in the transition zone. Station 34 is most similar to station 20 and correlates poorly with estuarine stations.

The estuarine stations (1, 7, 15, and 371) fluctuated in unison for cladocera only. The other consistent correlations within the estuary are between stations 7 and 15 for the micro net samples. The latter correlations were consistent for the 5 categories examined.

Three "accidental" correlations occurred between station 31 and estuarine stations. The total catches at station 31 correlated with station 15 ($r=0.55$ and $P<0.01$) and the harpacticoid counts from station 31 correlated with stations 1 and 371 for the macro samples ($r=0.94$ and 0.86 respectively, $P<0.01$). The number of harpacticoids in the macro samples was small and direct influence between stations within the estuary and station 31 (Fig. 3) is doubtful.

Zonal Comparison of Chinook Diets

The chinook examined in 1982 (Anderson and Galbraith 1984), 1983 (M. Kotyk, unpublished data), and 1984 (Cross 1985) yielded stomach analysis for 447 hatchery and 432 wild chinook. These fish were collected from stations within the specified zones but not necessarily at the same stations where plankton was collected (Brown et al. 1983, 1984a,b).

The low consumption of calanoids in the marine zone, despite their prominence in the zooplankton, in 1983 and 1984 (7.2 and 1.7/fish respectively, Table 7) is notable. The juvenile chinook consumed relatively more calanoids in the estuarine and transition zones though less abundant. Studies from the Fraser River plume (LeBrasseur et al. 1969) showed that juvenile salmon required prey densities of 3000-4000 m^{-3} for Calanus plumchrus while Microcalanus sp. was required in concentrations of 9300-23,000 m^{-3} for maximum ration. The concentrations of total calanoids from the marine zone, when the fish were examined, ranged from 1700-4000 m^{-3}. These low concentrations of calanoids, compared to the optimal prey densities (LeBrasseur et al. 1969), would preclude them as a major food source in all three zones. The juvenile chinook examined in this study consumed calanoids in the estuarine and transition zones at mean concentrations far below the optimal prey densities identified by LeBrasseur et al. However, the sampling method may have obscured patches and aggregation with higher concentration.

The Miller nets accurately estimated the calanoid densities in the marine zone but these crustacea were not extensively utilized by the juvenile chinook examined. The harpacticoids, amphipods, barnacle cyprids and insects could all be classed as epibenthos and surface drift and were present in low numbers in the zooplankton samples (Table 5, 6).

The four most important food items by zone for these 3 years are shown in Table 9. Calanoid copepods and amphipods were important to both the hatchery and wild chinook from all 3 zones. The cladocera and insects were a main food item from the estuarine zone while harpacticoids and cumacea were utilized in the transition zone. The chinook examined from the marine zone consumed a variety of prey species including harpacticoids, cumaceans, insects, decapod zoea and barnacle cyprids. Cumaceans and isopods were utilized mainly by the hatchery chinook, while cladocera, insects, barnacle cyprids, and decapod zoea were used by wild chinooks (Table 9).

Comparison with Other Investigations

Sibert et al. (1976) found zooplankton concentrations in Cowichan Bay on July 15, 1975, similar to the July counts from this investigation (113.1 $m^{-3} \pm 20.6$ and 137.9 $m^{-3} \pm 40.1$* respectively 350 μ mesh).

Mackas et al. (1980), using a continuous sampling device (counting particles between 0.3 and 3.0 mm diameter) in July, 1978 noted that the most striking feature of the Georgia Strait zooplankton was a series of intense patches (5-20 x 10^4 zooplankton m^{-3}) along Vancouver Island. The individual peaks were associated with shoals and banks. The marine zone micro counts in July from this investigation were 4-10 x 10^4 zooplankton m^{-3}. Mackas et al. looked only at the large zooplankton (300-3000 μ diameter). If the sensitivity of his sampling device included plankton in the range of 100 μ then his counts would have been significantly higher. The lower counts found from our investigation is indicative of the intense mixing in Discovery Passage and Seymore Narrows.

*mean of all July 19-20 samples from the estuarine, transition, and marine zone.

Mundie and Mounce (1976) studied the lower Campbell River drift in September 1973. The zooplankton from the John Hart head pond composed 63-78% of the river drift. The main components were cladocera (Bosmina sp.) and copepods (Cyclops sp. and Diaptomus sp.), similar to the main items from micro net catches in the estuary during the present study. The micro net mesh was finer than the 200 μ net used by Mundie and Mounce (1976) and its catches were dominated by copepod nauplii. If the copepod nauplii are removed from consideration then cladocera and calanoids dominate the micro samples.

The major food items of juvenile chinook in the Campbell River estuary identified by Goodman and Vroom (1974) were Anisogammarus sp. (now called Eogammarus) and harpacticoid copepods. Corophium sp., mysids, ostracods and cumaceans also represented a significant portion (76.3%) of the biomass used by these wild chinook. These items can all be classed as estuarine benthic organisms associated with the intertidal and subtidal portions of the estuary. The second most important food groups were the fresh water and terrestrial invertebrates consisting of cladocera and insects (16.5% of the chinook stomach biomass).

Raymond et al. (1985) examined the surface zooplankton at 7 sites in the Campbell River estuary on August 1, 1980 using a 351 μ net. The fresh water cladoceran (Bosmina sp.) and copepods (Diaptomus sp. and Cyclops sp.) were the dominant taxa. These species probably originated in the lakes upstream of the estuary (Raymond et al. 1985). The most common prey items in juvenile chinook stomachs in Raymond et al.'s study were immature and adult insects (aquatic and terrestrial origin), benthic invertebrates (amphipods, isopods, and mysids) and planktonic crustaceans (marine and freshwater calanoids and cladocera). These gut content data are similar to those presented by Goodman and Vroom (1974), Anderson and Galbraith (1984) and Cross (1985).

Macdonald et al. (1985) examined the plankton, river drift and juvenile chinook stomach contents from May to July 1984 at stations 7 and 34. They found the drift samples from station 34 and the subsurface salt wedge had large numbers of estuarine and marine zooplankton. Station 7 samples, at both low and high tide, were dominated by zooplankton of freshwater origin (Bosmina sp.).

The wild chinook diets from station 7 were more similar to the plankton composition of the surface water than the salt wedge (Macdonald et al. in press). The larger hatchery chinook from station 7 consumed fewer cladocera than the wild fish in favour of a more diverse diet that included benthic organisms and marine zooplankton. This is consistent with the observation that the larger fish are observed further offshore and in deeper water than the smaller wild fish (Macdonald et al. in press).

Kask et al (in prep.) report yearly mean concentrations in 1983 of epibenthos at Campbell River of 11,476 m^{-3} ± 1,635, 29,710 m^{-3} ± 3272 and 104,151 m^{-3} ± 32,267 SE for the estuarine, transition, and marine zones, respectively. These concentrations were obtained using an epibenthic sled sampling 10 centimeters of water above the bottom. Sibert (1981) indicated a 2 to 20 fold increase in zooplankton 5 centimeters above the bottom compared to 30 centimeters. The epibenthos was composed mainly of eggs, copepod nauplii, nematodes and harpacticoids. A comparison of calanoid concentrations for 1983 and 1984 between the sled (100 µ mesh) and the micro Miller net (100 µ mesh) in the estuarine, transition and marine zones showed no significant differences (t-test, dF=30).

The data presented in this report and previous work on the Campbell River estuary indicate that juvenile chinook consume a variety of prey species. These include freshwater drift, pelagic zooplankton and the epibenthos. From the data it is obvious that juvenile chinook feed opportunistically within the habitats occupied and any one sampling technique is inefficient at estimating fish food availability.

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Table 1. Dates for 1983 and 1984 sampling trips.

1983 Trip No.	1983 Date	1984 Trip No.	1984 Date
2	Feb 22-23	1	Jan 9-11
3	Mar 14-16	2	Feb 6-8
4	Mar 28-30	3	Mar 7-9
5	Apr 12-14	4	Mar 20-21
7	May 5-8	5	Apr 3-5
9	May 26-29	6	Apr 16-18
10	Jun 6-9	7	Apr 24-28
11	Jun 16-19	8	May 1-4
12	Jul 7-10	9	May 14-17
13	Jul 18-21	10	Jun 4-6
14	Aug 2-5	11	Jun 18-21
15	Aug 16-18	12	Jul 3-6
16	Sep 6-8	13	Jul 17-19
17	Oct 3-6	14	Jul 31-Aug 2
18	Nov 7-8	15	Aug 14-16
19	Dec 6-7	16	Aug 28-30
		17	Sep 25-27

Table 2. Environmental conditions at the sampling stations: Total number of samples per station, mean tide height in meters ± SE, minimum and maximum temperatures in °C, minimum, maximum, and mean ± SE surface salinities in °/₀₀.

Stn.	Number of observations	Mean tide height ± SE	Minimum temp °C	Maximum temp °C	Minimum salinity °/₀₀	Maximum salinity °/₀₀	Mean Sal. ± SE
1	32	3.3 ± 0.1	4.3	16.5	0.1	6.4	2.7 ± 0.4
7	32	3.2 ± 0.1	3.7	17.1	0.2	8.7	1.9 ± 0.6
15	32	3.3 ± 0.1	4.2	15.8	0.4	5.6	2.6 ± 0.3
371	31	3.1 ± 0.1	4.3	17.2	0.0	26.9	5.1 ± 1.4
372	30	3.2 ± 0.1	7.4	11.5	22.6	30.5	28.5 ± 0.4
20	29	3.0 ± 0.2	7.7	12.9	25.4	32.1	29.3 ± 0.4
21	14	2.5 ± 0.2	8.5	14.6	27.8	31.5	29.2 ± 0.4
34	30	3.4 ± 0.1	4.4	15.9	1.4	19.9	5.4 ± 0.9
27	30	2.5 ± 0.2	7.7	13.5	27.7	32.3	30.2 ± 0.3
31	22	2.3 ± 0.1	8.4	13.0	25.6	31.7	29.9 ± 0.4

Table 3. Data on total counts, cladocera, calanoids, and harpacticoids (mean number m^{-3} ± SE) for all stations by year and zone for the macro (350 μ mesh) zooplankton samples.

	Numbers/m³±SE												
Macro net Station No.	1	7	15	371	Estuarine mean	20	34	21	Transition mean	27	31	Marine mean	372
Total													
1983	101.4±44.3	63.6±22.7	135.7±45.1	38.3±10.7	85.4±17.5	187.1±46.3	206.0±53.1	–	197.1±35.1	311.8±126.8	381.1±150.9	339.0±91.7	149.4±48.8
1984	8.5±2.4	12.0±3.7	47.4±20.4	4.4±1.7	18.0±5.5	169.6±44.3	447.8±343.7	223.0±58.2	280.2±105.9	196.4±49.7	139.4±38.5	173.1±33.3	57.1±18.4
1983/84	56.4±24.0	39.6±12.5	92.9±26.1	20.2±6.3	52.5±9.8	177.3±31.5	332.2±160.7	223.0±58.2	247.4±65.5	250.2±64.5	260.1±76.9	254.5±49.0	106.2±29.3
Cladocera													
1983	42.4±31.9	38.0±18.8	72.5±33.7	14.4±7.9	42.5±12.8	9.7±6.2	42.7±29.7	–	27.4±16.2	0.8±0.3	1.2±0.8	1.0±0.4	6.1±3.3
1984	5.1±2.1	5.9±2.4	24.9±12.6	1.4±1.0	9.3±3.4	3.4±1.4	2.6±0.7	0.6±0.2	1.5±0.6	1.8±1.0	0.2±0.2	0.6±0.2	0.4±0.2
1983/84	24.3±16.6	22.4±10.0	49.5±18.6	8.4±4.4	26.3±6.9	5.7±2.9	23.9±16.1	0.6±0.2	13.8±7.8	0.8±0.2	0.7±0.4	0.8±0.2	3.6±1.8
Calanoid													
1983	33.3±19.2	7.3±4.6	29.1±10.8	6.8±2.5	18.9±5.8	60.7±13.2	55.4±20.2	–	57.8±12.2	193.0±119.0	152.8±87.4	195.1±77.2	59.1±17.5
1984	0.7±0.2	0.5±0.2	4.3±1.9	0.6±0.4	1.5±0.5	60.6±18.6	81.5±32.7	70.9±36.6	70.3±16.6	98.6±29.1	96.2±25.5	97.6±19.8	40.2±17.1
1983/84	17.5±10.2	4.0±2.5	17.0±6.0	2.8±1.1	10.4±3.0	60.6±11.6	67.5±18.4	70.9±36.6	65.4±11.1	159.2±59.0	124.4±44.9	144.5±38.7	49.9±12.8
Harpacticoid													
1983	2.4±1.4	2.4±1.9	2.3±1.1	1.0±0.6	2.1±0.7	5.3±2.6	18.4±14.8	–	12.3±8.0	1.4±0.7	4.5±2.2	2.7±1.1	1.8±1.2
1984	0.3±0.1	0.7±0.4	1.3±1.1	0.3±0.2	0.7±0.3	24.0±19.4	72.8±68.4	5.3±1.8	32.6±21.7	0.6±0.3	0.3±0.1	0.4±0.2	0.2±0.1
1983/84	1.3±0.7	1.6±1.0	1.9±0.8	0.7±0.3	1.4±0.4	15.6±10.7	43.6±32.5	5.3±1.8	24.6±13.5	0.9±0.4	2.4±1.2	1.5±0.1	1.1±0.7

Table 4. Data on total counts, cladocera, calanoids, and harpacticoids (mean number m^{-3} ± SE) for all stations by year and zone for the micro (100 μ mesh) zooplankton samples.

	Numbers/m³±SE												
Micro net Station No.	1	7	15	371	Estuarine mean	20	34	21	Transition mean	27	31	Marine mean	372
Total													
1983	1000.1±347.6	454.7±128.7	948.8±257.5	706.6±426.7	835.6±156.4	4678.2±1082.0	1955.7±482.4	-	3457.5±622.7	3655.5±560.3	3872.0±597.4	3750.7±401.5	3987.8±1000.4
1984	289.8±53.4	533.6±154.3	732.5±220.3	183.0±74.8	437.6±75.0	6319.9±1961.7	3676.9±1589.0	5018.4±1246.5	5034.0±953.2	7963.2±1836.1	4188.6±871.6	6425.4±1184.8	2069.6±395.8
1983/84	633.5±180.5	494.2±99.1	840.6±167.8	567.4±238.0	635.0±87.8	5583.9+1177.6	3038.3±841.8	5018.1±1264.5	4429.3±637.3	5952.9±1074.6	4030.3±516.9	5139.5±665.6	3238.2±594.4
Cladocera													
1983	123.4±74.1	142.1±72.5	229.1±128.2	48.2±23.0	136.5±42.3	91.1±43.1	214.6±124.1	-	163.0±71.6	11.7±5.8	15.1±4.4	13.8±3.8	34.2±18.4
1984	43.8±15.4	108.4±48.9	206.6±88.1	12.5±4.4	94.0±27.0	16.4±10.3	88.7±27.2	7.5±3.0	37.7±11.0	4.7±1.4	7.6±4.9	5.0±2.1	10.3±2.9
1983/84	82.3±37.0	125.2±43.1	217.8±76.5	31.8±12.6	115.9±25.0	49.8±20.9	151.6±63.4	7.5±3.0	83.6±28.0	7.2±2.8	11.4±3.3	9.1±2.2	23.9±10.3
Calanoid													
1983	320.0±181.8	67.1±17.0	183.7±39.2	112.3±35.0	170.4±37.9	1844.7±477.6	769.6±262.3	-	1202.3±278.1	1857.8±322.8	1533.5±334.1	1723.9±230.4	1379.8±444.9
1984	109.2±34.5	155.9±78.5	203.7±88.5	46.8±15.7	130.0±31.6	1661.6±321.5	740.8±273.0	1206.7±170.4	1213.1±162.5	3040.6±606.7	1387.1±257.2	2352.1±394.7	668.4±135.0
1983/84	211.2±71.8	111.5±40.3	193.7±47.6	81.4±20.7	150.0±24.6	1743.7±273.3	755.2±186.0	1206.7±170.4	1234.5±145.0	2475.3±361.6	1470.7±206.8	2050.1±234.9	1007.5±250.4
Harpacticoid													
1983	17.1±6.0	33.6±22.5	74.8±59.8	11.2±2.9	35.0±16.6	87.3±27.4	92.4±46.1	-	90.0±27.3	52.1±18.7	92.2±37.9	69.8±19.7	60.8±12.2
1984	9.1±1.8	54.5±35.8	41.5±30.2	4.2±1.1	27.7±11.9	142.5±93.0	40.0±17.1	103.7±24.4	96.2±34.3	21.3±7.5	16.3±4.9	18.5±4.9	38.4±9.3
1983/84	13.0±3.1	44.9±21.3	58.2±33.1	7.1±1.6	31.3±10.2	117.7±52.2	66.2±24.6	103.7±24.4	93.8±23.4	35.0±9.9	54.2±20.4	43.2±10.3	50.6±8.2

Table 5. Estuarine, transition, and marine zone macro and micro zooplankton abundance (mean number m^{-3}), weighted by station for 1983.

	Macro net			Micro net		
	Estuarine	Transition	Marine	Estuarine	Transition	Marine
Stations	1,7,15,371	20,34	27,31	1,7,15,371	20,34	27,31
Total samples	64	28	25	63	28	25
Cladocera	37.8	26.2	1.0	135.7	152.8	13.4
Calanoid copepods	17.8	57.7	190.6	170.8	1307.2	1677.5
Unidentified eggs	6.1	14.6	12.5	211.6	231.3	283.5
Amphipods	4.2	13.9	10.3	1.9	6.5	11.7
Ectoprocts	3.6	9.8	14.6	10.4	113.9	112.5
Copepod nauplii	2.9	5.0	1.0	213.8	1078.3	1088.7
Harpacticoid copepods	2.0	11.8	2.9	34.6	89.8	72.2
Gastropod nauplii	1.4	12.7	4.1	<1.0	25.4	6.4
Barnacle nauplii	<1.0	6.4	3.8	25.0	214.6	161.7
Nematodes	<1.0	1.7	<1.0	1.9	2.1	11.3
Worms	<1.0	<1.0	<1.0	1.5	3.6	2.2
Isopods	<1.0	4.0	<1.0	<1.0	2.5	5.6
Tunicates	<1.0	2.6	1.8	3.7	65.0	76.2
Euphausids	<1.0	4.2	14.8	2.4	15.5	30.3
Gastropods	<1.0	1.8	1.6	2.7	39.0	46.6
Mysids	<1.0	<1.0	-	<1.0	<1.0	-
Acarinans	<1.0	<1.0	<1.0	<1.0	1.5	2.6
Ostracods	<1.0	6.8	2.0	<1.0	6.7	11.6
Decapod Zoea	<1.0	1.1	1.0	<1.0	1.2	<1.0
Medusae	<1.0	4.1	1.5	<1.0	25.5	5.1
Insect larvae	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Barnacle cypris	<1.0	<1.0	<1.0	<1.0	3.0	<1.0
Ctenophores	<1.0	<1.0	1.7	<1.0	<1.0	1.3
Bivalves	<1.0	<1.0	<1.0	4.4	95.0	82.7
Cumaceans	<1.0	4.3	<1.0	<1.0	1.6	<1.0
Polychaete worms	<1.0	<1.0	<1.0	2.9	39.5	38.3
Echinoderm larvae	<1.0	<1.0	3.0	<1.0	11.1	47.4

Table 6. Estuarine, transition, and marine zone macro and micro zooplankton abundance (mean number m^{-3}), weighted by station for 1984.

	Macro net			Micro net		
	Estuarine	Transition	Marine	Estuarine	Transition	Marine
Stations	1,7,15,371	20,21,34	27,31	1,7,15,371	20,21,34	27,31
Total samples	60	43	27	63	45	27
Cladocera	9.3	1.9	<1.0	92.7	37.5	5.4
Calanoid copepods	1.5	71.0	97.4	128.7	1203.0	2201.3
Unidentified eggs	3.5	9.7	30.7	16.7	473.6	459.3
Amphipods	<1.0	2.5	1.4	1.1	7.2	1.8
Ectoprocts	<1.0	6.4	5.8	9.5	84.3	82.9
Copepod nauplii	<1.0	62.6	1.3	127.0	2224.5	2641.2
Harpacticoid copepods	<1.0	34.0	<1.0	27.3	95.4	18.2
Gastropod eggs	<1.0	44.5	3.4	1.0	77.4	11.8
Barnacle nauplii	<1.0	4.9	5.1	18.9	481.9	275.6
Nematodes	<1.0	33.5	<1.0	1.5	2.7	<1.0
Worms	<1.0	<1.0	1.6	<1.0	2.7	2.5
Isopods	<1.0	<1.0	<1.0	<1.0	1.4	<1.0
Tunicates	<1.0	3.0	1.9	1.7	148.7	189.3
Euphausids	<1.0	2.0	2.9	-	1.4	3.9
Gastropods	<1.0	<1.0	<1.0	1.2	44.2	35.2
Mysids	<1.0	<1.0	<1.0	-	<1.0	-
Acarinans	<1.0	<1.0	-	1.4	<1.0	1.4
Ostracods	<1.0	1.2	<1.0	<1.0	4.1	2.2
Decapod zoea	<1.0	4.2	5.2	<1.0	3.8	5.5
Medusae	<1.0	2.8	3.0	-	6.2	12.2
Insect larvae	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Barnacle cypris	<1.0	<1.0	<1.0	<1.0	1.6	-
Ctenophores	<1.0	1.2	3.4	-	2.9	13.0
Bivalves	<1.0	<1.0	<1.0	<1.0	30.7	72.1
Cumaceans	<1.0	<1.0	<1.0	-	<1.0	<1.0
Polychaete worms	<1.0	<1.0	<1.0	1.0	35.7	36.6
Echinoderm larvae	<1.0	1.2	<1.0	<1.0	28.6	75.1

Table 7. Main categories for 1983 and 1984 zooplankton samples (mean number per m^{-3}, weighted by station) compared with the main food items for juvenile hatchery and wild chinook (mean number/fish) for 1983 and 1984.

	Macro						Micro					
	Estuarine		Transition		Marine		Estuarine		Transition		Marine	
1983	Cladocera	37.8	Calanoids	57.7	Calanoids	190.6	Copepod nauplii	213.8	Calanoids	1307.2	Calanoids	1677.5
Zooplankton	Calanoids	17.8	Cladocera	26.2	Euphausids	14.8	Eggs	211.6	Copepod nauplii	1078.3	Copepod nauplii	1088.7
	Eggs	6.1	Eggs	14.6	Ectoprocts	14.6	Calanoids	170.8	Eggs	231.3	Eggs	283.5
	Amphipods	4.2	Amphipods	13.9	Eggs	12.5	Cladocera	135.7	Cladocera	152.8	Barnacle nauplii	161.7
% of total sample	81.1		57.2		82.2		88.6		80.1		84.6	
1984	Cladocera	9.3	Calanoids	71.0	Calanoids	97.4	Calanoids	128.7	Copepod nauplii	2224.5	Copepod nauplii	2641.2
Zooplankton	Eggs	3.5	Copepod nauplii	62.6	Eggs	30.7	Copepod nauplii	127.0	Calanoids	1203.0	Calanoids	2201.3
	Calanoids	1.5	Gastropod eggs	44.5	Ectoprocts	5.8	Cladocera	92.7	Barnacle nauplii	481.9	Eggs	459.2
	Gastropod eggs	0.9	Nematodes	33.5	Decapod zoea	5.2	Harpacticoids	27.3	Eggs	473.6	Barnacle nauplii	275.6
% of total sample	84.4		75.5		80.4		85.9		87.1		86.8	
	Estuarine				Transition				Marine			
1983	Hatchery		Wild		Hatchery		Wild		Hatchery		Wild	
Fish gut data	Cladocera	75.9	Cladocera	57.4	Harpacticoids	118.4	Amphipods	7.4			Harpacticoids	147.6
	Calanoids	23.9	Calanoids	33.5	Amphipods	13.9	Harpacticoids	3.0			Barnacle cypris	56.1
	Harpacticoids	4.3	Insects	6.8	Cumaceans	5.8	Calanoids	2.1			Decapod zoea	18.5
	Cumaceans	5.3	Amphipods	6.6	Calanoids	3.5	Decapod zoea	1.6			Calanoids	7.2
% of diet	88.4		83.6		96.7		87.6				96.3	

Table 7 (cont'd)

	Estuarine				Transition				Marine			
1984	Hatchery		Wild		Hatchery		Wild		Hatchery		Wild	
Fish gut data	Calanoids	38.3	Cladocera	40.7	Cumaceans	59.2	Harpacticoids	37.3	Harpacticoids	36.6	Barnacle cypris	23.3
	Cladocera	25.5	Insects	4.7	Calanoids	30.7	Cladocera	28.1	Barnacle cypris	6.0	Insects	17.3
	Amphipods	4.1	Amphipods	4.7	Harpacticoids	21.9	Cumaceans	8.7	Amphipods	2.0	Amphipods	6.8
	Insects	2.3	Calanoids	2.9	Cladocera	14.3	Calanoids	4.5	Calanoids	1.7	Decapod zoea	1.6
% of diet	95.1		93.6		91.6		88.3		93.0		93.2	

Table 8. Summary table of the main categories in estuarine, transition, and marine zones for macro and micro zooplankton samples in 1983 and 1984. (Mean number m^{-3}, weighted by station.)

	Macro						Micro					
	Estuary		Transition		Marine		Estuary		Transition		Marine	
	Clad	23.6	Cal	65.7	Cal	144.0	C. naup	170.4	C. naup	1766.0	Cal	1939.4
	Cal	9.7	C. naup	39.6	Egg	21.6	Cal	149.7	Cal	1244.7	C. naup	1864.9
	Egg	4.8	G. egg	31.8	Ecto	10.2	Clad	114.2	Egg	376.7	Egg	371.4
	Amp	2.3	Harp	25.1	Eup	8.8	Egg	114.2	B. naup	375.0	B. naup	218.7
	Ecto	2.0	Nema	20.8	Amp	5.8						
			Egg	11.7								
			Clad	11.6								
% Total counts	83.3		83.5		84.3		86.9		84.9		85.2	

Table 9. Summary table of juvenile chinook stomachs analyzed from the Campbell River estuary and Discovery Passage from 1982, 1983, and 1984.

A) Number of stomachs examined.

	Estuarine		Transition		Marine		Total	
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
1982	43	64	56	26	29	14	128	104
1983	146	123	51	10	-	14	197	147
1984	67	98	37	64	18	21	122	183
Total	256	285	144	100	47	49	447	434

B) The number of times a prey taxa was present in the first 4 categories consumed by juvenile chinook for the years 1982-1984.

	Estuarine		Transition		Marine		Total	
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
Calanoids	3	3	3	3	2	2	8	8
Amphipods	2	2	2	2	2	2	6	6
Harpacticoids	1	1	3	3	1	1	5	5
Cumaceans	1	-	3	2	1	1	5	3
Cladocera	2	3	1	1	-	-	3	4
Insects	2	3	-	-	-	1	2	4
Decapod zoea	-	-	-	1	1	3	1	4
Barnacle cypris	-	-	-	-	1	2	1	2
Isopods	1	-	-	-	-	-	1	-

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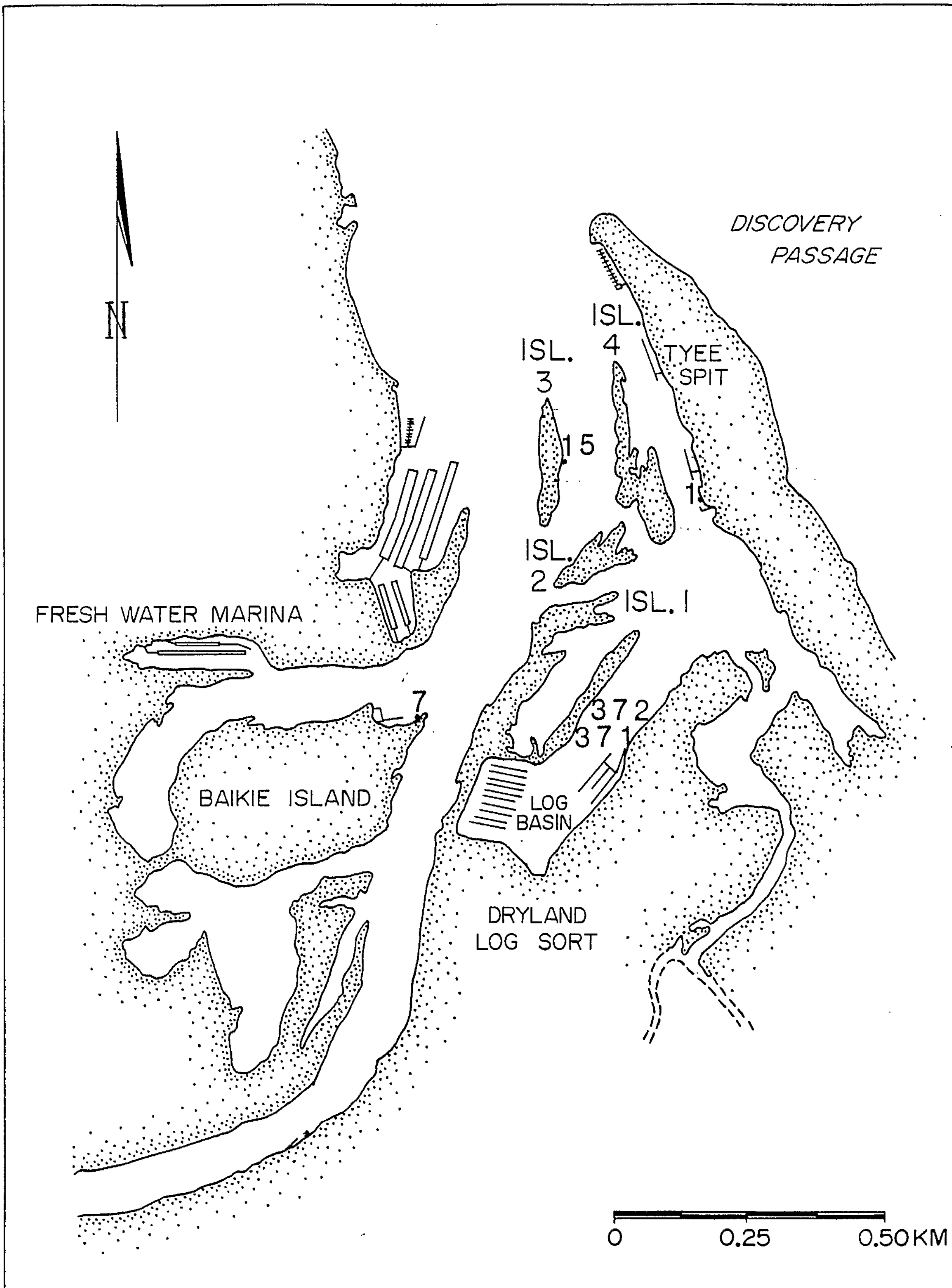

Fig. 1. Estuarine zone locations for zooplankton sampling.

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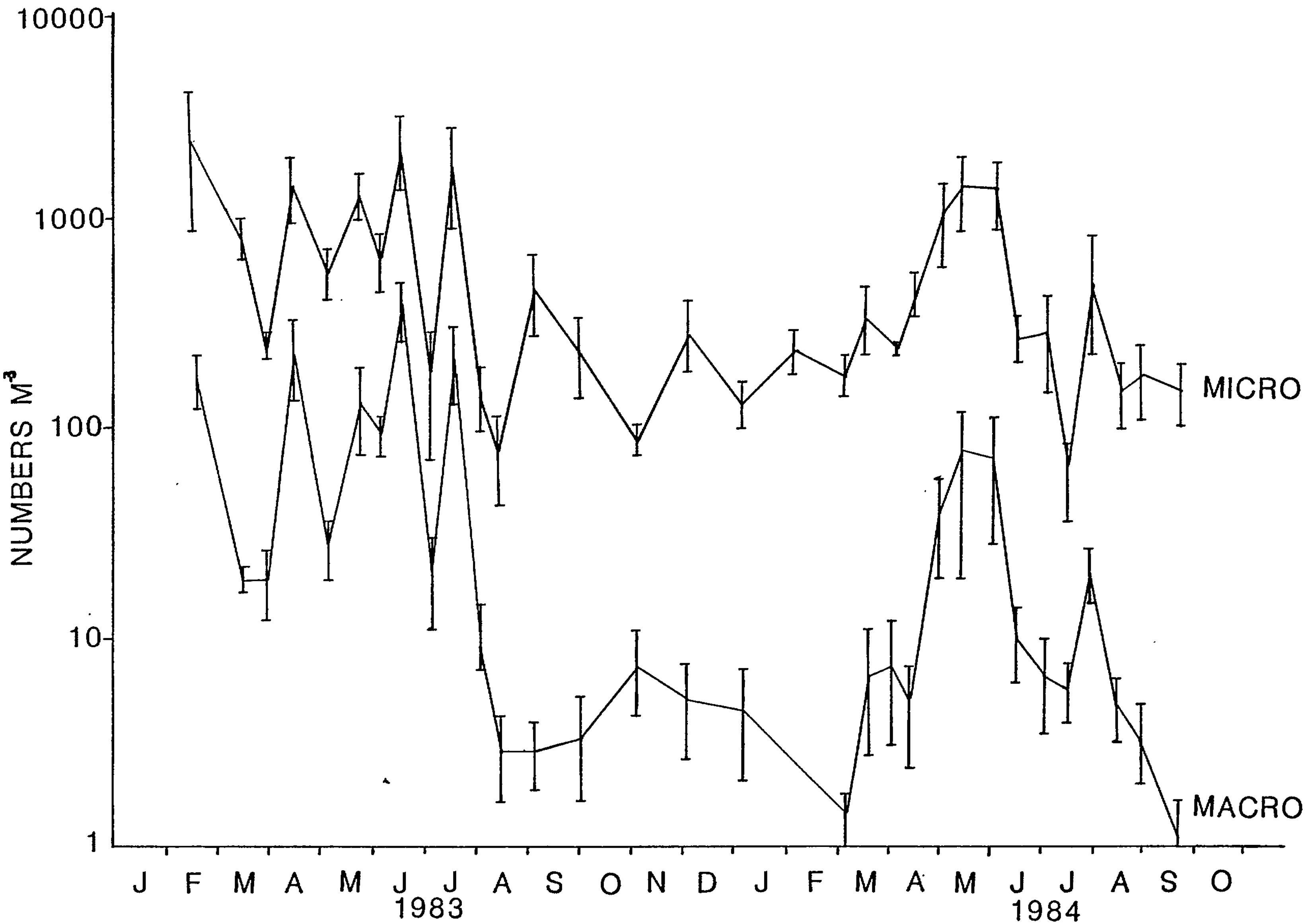

Fig. 2. Abundance of macro and micro zooplankton in samples from the estuarine zone. (Total counts $m^{-3} \pm SE$.)

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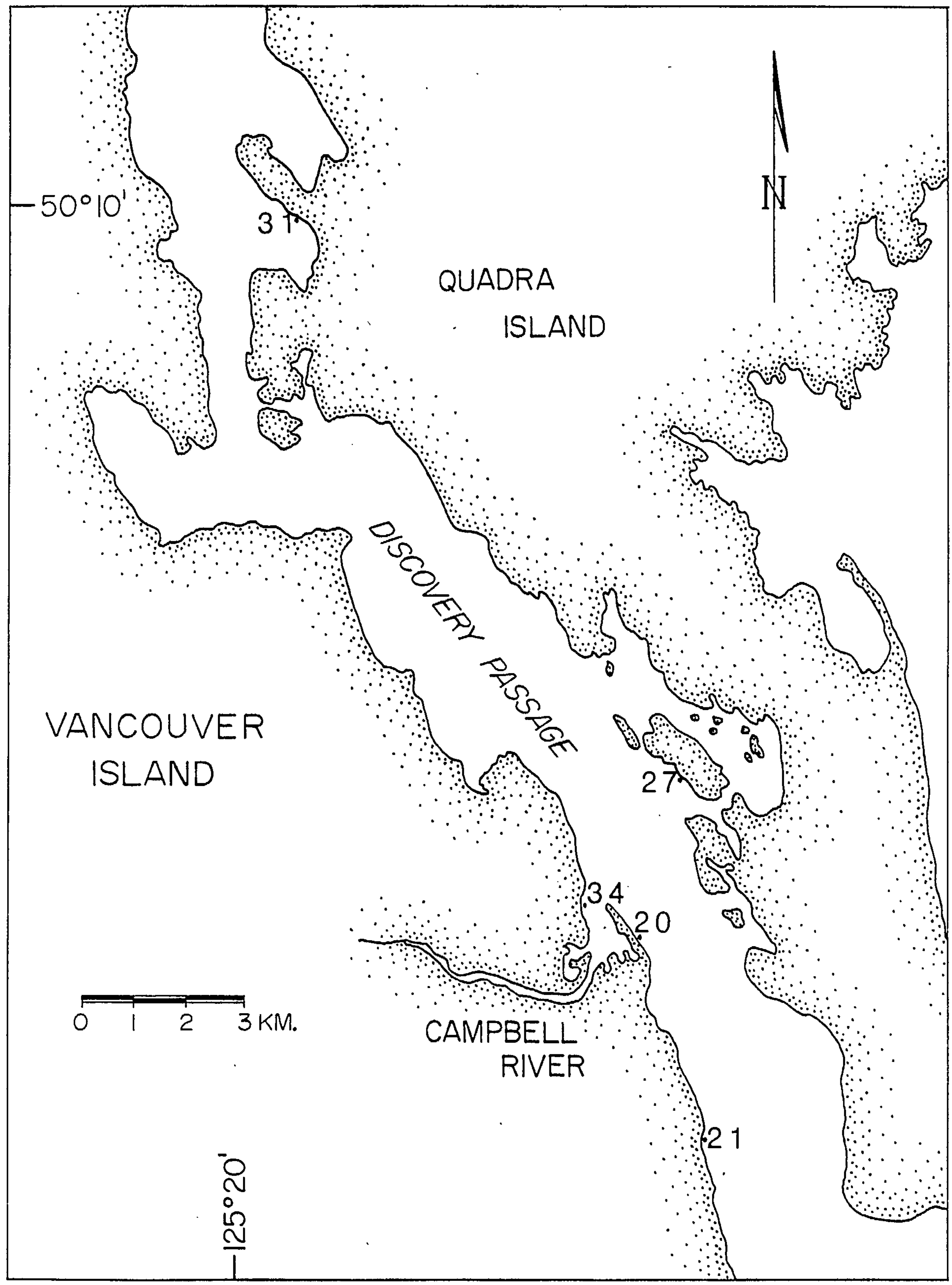

Fig. 3. Transition and marine zone locations for zooplankton sampling.

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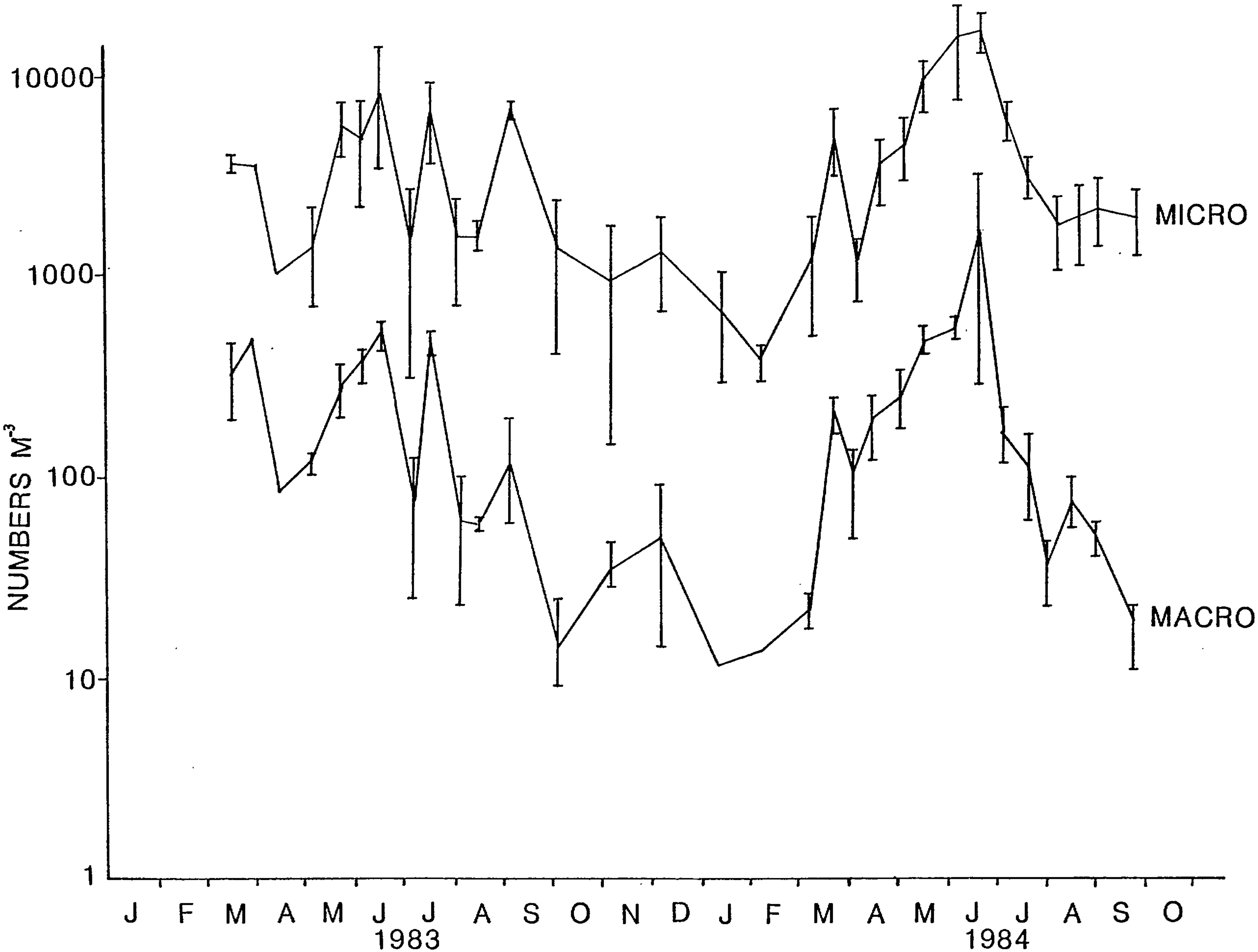

Fig. 4. Abundance of macro and micro zooplankton in samples from the transition zone. (Total counts $m^{-3} \pm SE$.)

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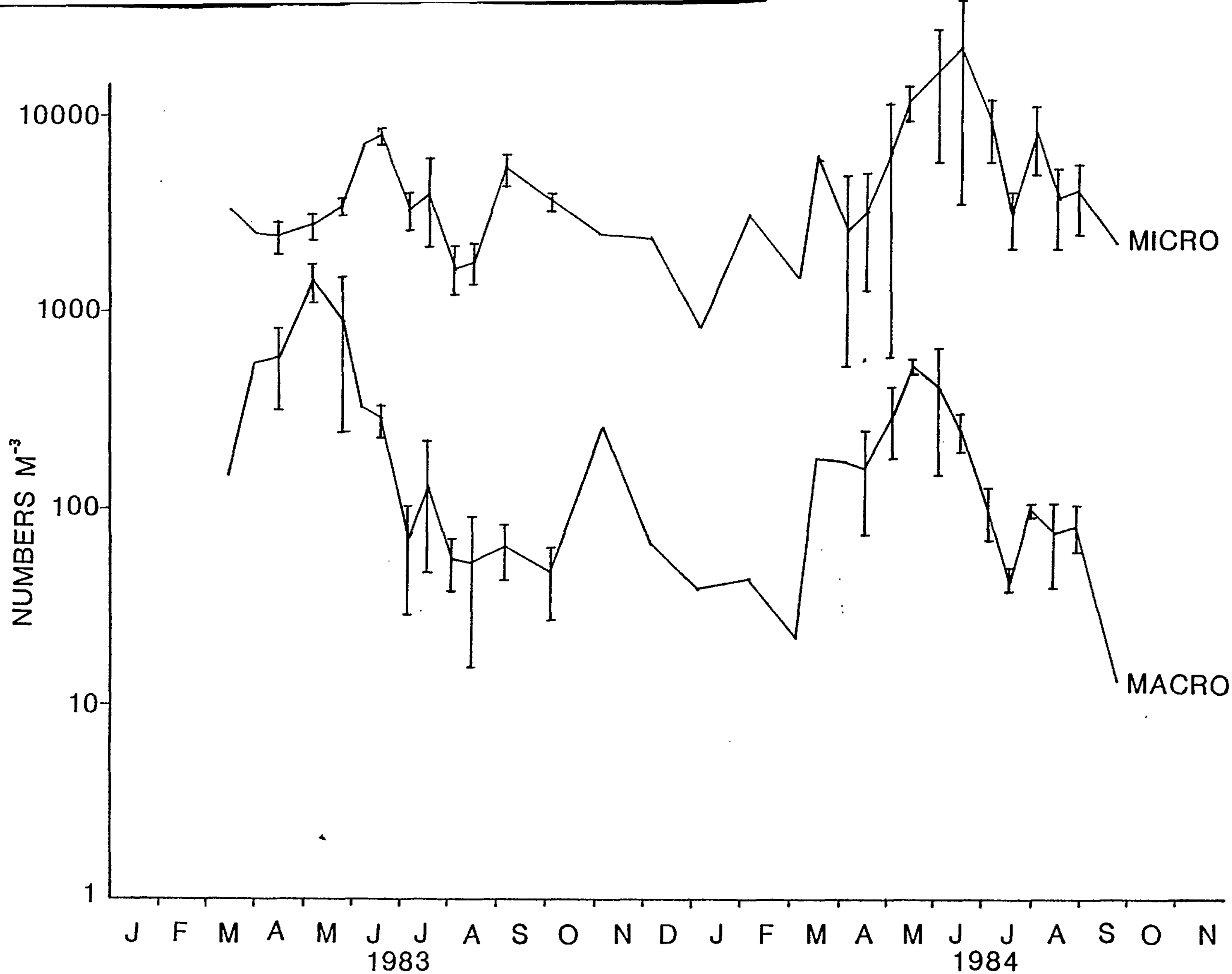

Fig. 5. Abundance of macro and micro zooplankton in samples from the marine zone. (Total counts $m^{-3} \pm SE$.)