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Nearshore Epibenthos of the Campbell River Estuary and Discovery Passage, 1984, in Relation to Juvenile Chinook Diets

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NEARSHORE EPIBENTHOS OF THE CAMPBELL RIVER ESTUARY AND DISCOVERY PASSAGE, 1984, IN RELATION TO JUVENILE CHINOOK DIETS

by

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As part of a continuing study, two hundred and eighty four epibenthic sled samples were collected from ten sites in the Campbell River estuary and surrounding area. These sites included established areas and newly created islands in the estuary as well as sites in the transition area immediately off the river mouth and in the marine zone. The epifauna was counted and compared to the food organisms present in juvenile chinook collected in the same areas. Comparisons were also made of the epibenthos and the diets of the juvenile chinook in all three zones from 1982-1984.

RÉSUMÉ

Kask, B. A., T. J. Brown, and C. D. McAllister. 1988. Nearshore epibenthos of the Campbell River estuary and Discovery Passage, 1984, in relation to juvenile chinook diets. Can. Tech. Rep. Fish. Aquat. Sci. 1637: 73 p.

Dans le cadre d'une étude permanente, deux cent quatre-vingt-quatre échantillons d'épibenthos ont été prélevés au moyen d'un traîneau à dix endroits dans l'estuaire de la rivière Campbell et la région avoisinante. Ces endroits comprenaient des zones établies et des îles nouvellement formées dans l'estuaire ainsi que des endroits dans la zone de transition immédiatement au large de l'embouchure et dans la zone marine. On a dénombré les organismes composant l'épifaune et on a établi des comparaisons avec les organismes qui ont servi d'aliment aux saumons quinnats juvéniles prélevés dans les mêmes zones. On a également comparé l'épibenthos et les régimes alimentaires des juvéniles de quinnat dans les trois zones pendant la période de 1982 à 1984.

INTRODUCTION

The Campbell River estuary, on the east coast of Vancouver Island, was the site of extensive rehabilitation in 1981-1982. This relatively small estuary has been subjected to extensive alteration by man, where marina construction, pile bulkheads and industrial facilities have altered the natural shoreline extensively.

In 1981 a new dryland log sort and booming pocket were built on the east side of the estuary. To replace the lost marshes, British Columbia Forest Products built four new intertidal islands and planted them with marsh grasses. Since 1982, there has been a continuing study of this estuary and the surrounding area carried out by a number of groups. The survival and growth of the marshes, use by birds and fish, and availability of food have been assessed. Agencies involved included the Dept. of Fisheries and Oceans, British Columbia Forest Products, the Canadian Wildlife Service and the Ministry of the Environment as well as others (Brownlee et al. 1984).

A hatchery on the Quinsam River, tributary to the Campbell River, augments the natural populations of juvenile salmon migrating out to sea each spring. Preliminary investigations have shown the new islands to be providing shelter habitat and a source of food largely for wild chinook fry (Brown et al. 1984).

Surveys of the estuary were initiated in 1982 and concluded in 1986. As part of the study, epibenthic organisms were sampled from 1982 to 1984 using a small sled-mounted net. Of interest were colonization, changes in density and the presence of prey suitable for juvenile salmonids. The data are reported in Kask et al. (1984, 1985, 1986a, 1986b, 1988).

Here the results of the 1984 survey are discussed, including seasonal and zonal differences in density and taxa composition. Differences between established and new island sites are also considered and comparisons are made between juvenile chinook diets and available epibenthos.

MATERIALS AND METHODS

Seventeen trips were made to the Campbell River area either once or twice monthly in 1984 and epibenthic zooplankton sampling was conducted at ten sites in the study area. Three zones were defined. The estuarine zone consisted of the intertidal area at the mouth of the Campbell River and had five sampling sites. The transition zone had three sites immediately off the mouth of the river. There were two sites within the marine zone which was considered to be the remainder of Discovery Passage and Seymour Narrows (Figs. 1 and 2). These were, for the most part, sites which had been sampled in previous years, representing common nearshore habitats available for the young salmon. A description may be found in Kask et al. 1986b.

The epibenthic sled used for sampling was described by Sibert et al. 1977. It had a mouth opening 10 cm x 10 cm and was fitted with a 100 µ mesh net. After a 5 m tow was taken along the shoreline, the samples were preserved in 4% formalin and rose bengal. A Beckman RS-5 salinometer was used to record surface water temperature and salinity. Other physical factors recorded included tide height and stage (ebbing or flooding) at the time of sampling.

The epibenthos samples were decanted through a 68 µ sieve and counted on a dissecting microscope. If required they were split with a Folsom splitter and 100 of the dominant organisms were counted. The sample total was then calculated and recorded. Organisms were identified as far as possible in the time available.

The data was analyzed using a VAX computer and SAS system software. T-tests were carried out on the thirteen most common epibenthic categories over the three years analyzed (1982-1984). The data was $\log_{10}$ transformed for these tests. The analysis of variance was carried out on the untransformed counts.

RESULTS

A. ESTUARINE ZONE 1984

A-1 Sampling regime

Sampling was carried out in the estuary between 9 January and 26 September and altogether 148 samples were collected from five sites (Kask et al. 1986b). Twelve of these samples were collected at high tide at stations 1, 7 and 17. These high tide samples have not been included in the analysis (Table 1). Stations 1, 7, 11 and 17 were sampled approximately every two weeks, usually on a flooding tide. A comparison of these four stations may be found in Kask et al. 1986b. Station 10, located on the south shore of the south arm of Baikie's slough at the confluence with the Campbell River, has been dredged, and the shoreline is a mixture of mud and sand with a moderate drop-off. Since this site was sampled only once, it has not been included in the analysis (Fig. 1).

A-2 Physical characteristics

The temperature profiles at the four sites which were sampled consistently were similar, reaching a maximum in July and ranging from 3.5-20.7°C. The highest values were recorded at station 11. The salinity profiles varied between sites, seeming to reflect the differing influence by the river flow and salt wedge over the estuary. The highest values were recorded at station 1 and the lowest at stations 11 and 17. Tide heights appeared to have little effect on surface salinities. They varied the most at stations 1 and 7 and were the most constant at stations 11 and 17 (Table 1).

Studies on the salt wedge in the Campbell River estuary have shown it to extend mainly up the river and into the seaplane channel on the east side of the estuary. Remnants of salt water remain even at low tide in this channel as well as the log sort pond and in the sloughs off the river (unpublished data).

A-3 Epibenthos in the estuarine zone

The total mean density of epibenthos m^{-2} (± 1SE) was 668 ± 107 in 1984 (Table 2). For all samples combined, nematodes (33.8%), ostracods (20.3%), copepod nauplii (16.3%) and harpacticoids (11.5%) were dominant. The populations of epibenthic animals fluctuated substantially throughout the sampling period, reaching the greatest densities in April (1887 ± 1101 m^{-2}) and July (2427 ± 89 m^{-2}) (Fig. 3).

The total mean densities at the four sites ranged from 314 ± 54 m^{-2} at station 1 to 1291 ± 333 m^{-2} at station 17. An analysis of variance of the total counts between all four sites showed only two significant differences. The total densities were significantly greater at station 17 compared to stations 1 (ANOVA, $p = 0.01$) and 7 (ANOVA, $p = 0.05$). All the sites showed fluctuations in population numbers throughout the sampling period, especially the two island locations (Fig. 4a, 4b; 5a, 5b).

A-4 Comparison of epibenthos and chinook diets

The wild chinook were captured between 21 March and 31 July. During this period they fed primarily on freshwater cladocera, insects, marine calanoids and cyclopoids and benthic amphipods (Table 3). The marked hatchery chinook were caught between 25 April and 28 August. These same groups were also important to their diet (Table 4). Both groups used food from the river, salt wedge and estuarine benthos (Cross 1985).

B COMPARISON OF ESTUARINE ZONE 1982-1984

B-1 Comparison of epibenthos in the estuarine zone 1982-1984

For between year comparisons of the zone, only data from similar time periods have been included (23 March - 29 September 1982, 14 March to 5 October 1983 and 20 March - 25 September 1984). Similar time spans were also considered for the comparison of the four stations from year to year: station 1 (14 March - 5 October 1983 and 20 March - 25 September 1984), station 7 (23 March - 29 September 1982, 14 March - 5 October 1983 and 20 March - 25 September 1984), station 11 (15 March - 6 September 1983 and 20 March - 25

September 1984) and station 17 (15 March - 6 September 1983 and 20 March - 25 September 1984) (Tables 5-7).

There were three different patterns evident in the density of total epibenthos in the estuarine zone between 1982 and 1984. The overall yearly mean for 1984 (759 ± 126 m^{-2}) was similar to 1982 (604 ± 103 m^{-2}) but lower than 1983 (1360 ± 129 m^{-2}) (Table 5). While 1982 and 1983 exhibited three peaks in abundance, 1984 only showed two (Fig. 6).

Copepod nauplii and nematodes were dominant in 1982, eggs and copepod nauplii in 1983 and nematodes and ostracods in 1984 (Table 5). A comparison of this zone between years, using t-tests of the thirteen dominant epibenthic categories and the total counts, showed the greatest change to be between 1982 and 1983. Cladocerans ($p=0.05$), eggs ($p=0.01$), mysids ($p=0.05$), ostracods ($p=0.05$) and the total counts ($p=0.05$) were all significantly greater in 1983. The 1982-84 comparison showed there to be a significant increase in 1984 for cladocerans ($p=0.01$), mysids ($p=0.01$), and ostracods ($p=0.01$). From 1983 to 1984, there were significant decreases in two categories (copepod nauplii ($p=0.05$) and eggs ($p=0.01$)).

For station 7, the ANOVA's showed a significant increase in total number m^{-2} between 1982 and 1983 ($P = 0.01$) and a significant decrease between 1983 and 1984 ($P = 0.05$). There was no difference between 1982 and 1984. T-tests between years of the thirteen most common epibenthic categories showed significant differences to be present for only five categories. There was a significant increase from 1982 to 1983 for eggs ($P = 0.01$) and mysids ($P = 0.01$). From 1983 to 1984 copepod nauplii ($P = 0.01$), cladocerans ($P = 0.05$) and eggs ($P = 0.01$) showed a downward shift. Between 1982 and 1984, cladocerans ($P = 0.01$), mysids ($P = 0.05$) and ostracods ($P = 0.01$) all increased significantly while copepod nauplii decreased ($P = 0.05$) (Table 7). The ANOVA for station 1 between 1983 and 1984 showed the total number m^{-2} to be significantly higher in 1983 ($P = 0.05$). The t-tests showed there were four significantly different categories at this station between these two years: amphipods ($P = 0.01$), copepod nauplii ($P = 0.01$), eggs ($P = 0.01$) and harpacticoids ($P = 0.05$) were all significantly lower in 1984 (Table 7). Station 11 was also sampled only in 1983 and 1984. Although the ANOVA showed there to be no significant difference in total number m^{-2} between years, t-tests indicated there were also four significantly different categories at this site: copepod nauplii ($P = 0.05$) and eggs ($P = 0.01$) decreased in 1984 while mysids ($P = 0.01$) and ostracods ($P = 0.01$) increased in 1984 (Table 6). The results were similar at station 17 for the 1983 to 1984 comparison, the ANOVA showing no difference in the total number m^{-2}. The t-tests indicated significant decreases in copepod nauplii ($P = 0.01$), eggs ($P = 0.01$) and harpacticoids ($P = 0.01$) while ostracods ($P = 0.01$) increased significantly in 1984 (Table 6).

Using t-tests, between site comparisons by year of the densities of the same thirteen epibenthic categories and the total number m^{-2} showed the greatest difference to be between stations 1 and 17. In 1983, there were four categories which were significantly higher at station 17: cladocerans ($P = 0.01$), harpacticoids ($P = 0.05$), nematodes ($P = 0.01$) and ostracods ($P = 0.05$). In 1984, there were six categories: amphipods ($P = 0.01$), cladocerans

(P = 0.05), eggs (P = 0.05), nematodes (P = 0.01) and ostracods (P = 0.01) were all significantly higher at station 17 while mysids (P = 0.05) were lower. For both years, the total number m^{-2} was also significantly higher at station 17 (P = 0.01). The next greatest difference was in 1983 between the two islands sites, stations 11 and 17. In this year, there were five categories and the total which were significantly higher at station 17: amphipods (P = 0.05), copepod nauplii (P = 0.05), harpacticoids (P = 0.05), nematodes (P = 0.01), ostracods (P = 0.05) and the total (P = 0.01). In 1984 two categories (amphipods (P = 0.05) and nematodes (P = 0.05)) were significantly higher at station 17. There was no difference in the totals in this year. Tests between station 7 and station 17 showed three significant categories in 1983: cladocerans (P = 0.01) and nematodes (P = 0.01) were all higher at station 17 while mysids (P = 0.05) were higher at station 7. In 1984 it was nematodes (P = 0.01) and the total number m^{-2} (P = 0.05) that were significantly higher at station 17 while isopods were lower (P = 0.05). The two established sites, stations 1 and 7, seemed to be the least different, with no significant differences in 1983. In 1984, two categories (amphipods (P = 0.01) and ostracods (P = 0.05)) were both significantly higher at station 7. Both these sites were also fairly similar to station 11. In 1983, only mysids (P = 0.01) were significantly higher at station 7 compared to station 11. In 1984, amphipods (P = 0.01) and isopods (P = 0.05) were significantly higher at station 7. Compared to station 1 in 1983, station 11 had only one significantly lower category (mysids (P = 0.01)). In 1984 ostracods (P = 0.01) and eggs (P = 0.05) were significantly higher at station 11.

At each site, patterns of abundance for the dominant categories, such as copepod nauplii and nematodes, and for the total mean densities of epifauna were different between years. For example, the densities at station 1 showed a large peak in April in 1983 while in 1984 the numbers m^{-2} were much lower in April and the first increase didn't occur until early June. Stations 11 and 17 appear to have begun to be colonized by epibenthic organisms within the first year. Rapid colonization of new or disturbed sediments in estuarine areas has also been reported by other researchers (Chandler et al. 1983, Sherman et al. 1980).

B-2 Comparison of epibenthos and chinook diets 1982-1984

At station 7, analysis of stomach contents was carried out for 39 wild and 43 marked hatchery chinook in 1982 (Anderson et al. 1984), 40 wild and 67 marked hatchery chinook in 1983 (M. Kotyk unpublished data) and 48 wild and 35 marked hatchery chinook in 1984 (Cross 1985) (Table 8). Although they relied on them in different proportions, especially between years, both the wild and hatchery fish consumed mainly pelagic calanoids, insects and freshwater cladocera. These food organisms were most likely produced outside the estuarine system and transported into the estuary, either by the river or the tidal wedge. The estuarine epibenthos were present in the diet fairly consistently, but in lower numbers. In the wild fish the epibenthos made up from 8.5% to 15% of the diet consisting of mainly amphipods, harpacticoids and isopods. The marked hatchery fish also consumed the same three epibenthic groups, constituting between 5.2% and 19.1% of the total diet (Table 8). Some of the differences in diet may be due to the fish being captured at different times of the year.

C TRANSITION ZONE 1984

C-1 Sampling regime

This zone was sampled from 9 January to 26 September for a total of 92 samples from three sites (Table 1) (described in Kask et al. 1986b). Three sites (20, 21 and 34) were sampled regularly, usually on a flooding tide. Station 21 is located on a moderately sloping gravel and cobble beach adjacent to a rip rap wall (Fig. 2).

C-2 Physical characteristics

Although the range of temperatures in this zone was less than that recorded in the estuary, the three sites all exhibited different patterns. Station 34 showed the greatest variation, peaking at 19.1°C. The other two sites also showed some variation, but less than that at station 34. Salinity values in this zone were usually much higher than those recorded in the estuary, and again the greatest variation was at station 34. The river flow appears to have the most influence at this site, as stations 20 and 21 were both much more saline and stable. Tide heights at the time of sampling were similar at all three sites and ranged from 1.2-3.2 m (Table 1).

C-3 Epibenthos in the transition zone

For all three sites in this zone the total mean density of epibenthos m^{-2} (± 1SE) was 1407 ± 147 (Table 9). The populations were dominated by copepod nauplii (28.3%) and harpacticoids (22.0%). The mean numbers of animals m^{-2} were fairly constant throughout late spring and summer, rising from <100 m^{-2} in January to 2200 m^{-2} in late September (Fig. 7).

Stations 20 and 21 were dominated by copepod nauplii, and station 34 by harpacticoids. Amphipods were second in importance at station 20, harpacticoids at site 21 and copepod nauplii at station 34 (Table 9). The total mean densities were similar at stations 20 (1282 ± 259 m^{-2}) and 34 (1211 ± 224 m^{-2}) and the highest at station 21 (1731 ± 267 m^{-2}). The greatest seasonal change in densities occurred at station 20, while stations 21 and 34 were more stable (Fig. 8a, 8b, 8c). A between stations analysis of variance at these three sites showed no significant difference between the total counts.

C-4 Comparison of epibenthos and chinook diets

In the transition zone, the wild fish were caught between 16 April and 1 August. They relied mainly on epibenthic harpacticoids and cumaceans and freshwater cladocera (Table 10). The marked hatchery fish, caught between 27 April and 5 July, relied more on marine calanoids, freshwater cladocera and some insects, epibenthic harpacticoids and cumaceans (Cross 1985). Both groups showed some differences in diet between sites (Table 11). Some of this difference may have been due to the fish being caught at different times during the season.

D COMPARISON OF TRANSITION ZONE 1982-1984

D-1 Comparison of epibenthos in the transition zone 1982-1984

Only twelve samples were collected in this zone in 1982 and so these have not been included in the comparison between years.

Similar time spans were chosen for comparison of 1983 and 1984 data for the zone (14 March - 7 September 1983 and 7 March - 11 September 1984) and at stations 20 (14 March - 7 September 1983 and 7 March - 11 September 1984) and 34 (14 April - 17 August 1983 and 16 April - 15 August 1984) (Tables 12-13). In 1983-84 the highest densities were recorded in July 1983. Densities were at their lowest in 1984 and the overall mean value for this year was only half that for 1983. There were three peaks in density in 1983 while in 1984 the numbers were less variable in the late spring and summer (Fig. 9).

The populations were dominated by copepod nauplii and harpacticoids in both 1983 and 1984 (Table 12).

A comparison of this zone across the years, using t-tests of the thirteen dominant epibenthic categories and the total number m^{-2}, showed there to be a significant increase in barnacle nauplii ($P = 0.05$), mysids ($P = 0.05$) and the total ($P = 0.05$) from 1983 to 1984 while eggs ($P = 0.01$) decreased.

Comparisons between 1983 and 1984 can be made for stations 20 and 34 (Table 13).

At station 20 there was a significant difference between the total number m^{-2} for these two years (ANOVA, $P = 0.01$), the total dropping from 1983 to 1984. At this site there were also four categories which were significantly lower in 1984: calanoids ($P = 0.01$), copepod nauplii ($P = 0.01$), eggs ($P = 0.05$) and nematodes ($P = 0.05$). At station 34, an analysis of variance showed there was no significant difference in the total number m^{-2} between years but t-tests indicated there were six categories which were significantly different. Barnacle nauplii ($P = 0.05$), mysids ($P = 0.01$), ostracods ($P = 0.05$) and tunicates ($P = 0.01$) all increased from 1983 to 1984 while copepod nauplii ($P = 0.05$) and eggs ($P = 0.05$) both decreased.

Comparisons of the three sites sampled using t-tests showed the greatest difference to be between stations 21 and 34 in 1984. At these two sites, ten of the thirteen categories were significantly different: amphipods ($P = 0.01$), calanoids ($P = 0.05$), copepod nauplii ($P = 0.05$), eggs ($P = 0.05$), harpacticoids (P = 0.05) and nematodes (P = 0.01) were all lower at station 34. Cladocerans (P = 0.01), isopods (P = 0.05), mysids (P = 0.01) and ostracods (P = 0.01) were all higher at this station. There were also eight categories which were significantly different in 1984 between stations 20 and 34. Amphipods (P = 0.05), calanoids (P = 0.05), eggs (P = 0.05) and tunicates (P = 0.05) were all lower while isopods (P = 0.05), mysids (P = 0.01), nematodes (P = 0.05) and ostracods (P = 0.01) were all higher at station 34. The least difference was between stations 20 and 34 in 1983 when calanoids (P = 0.01) and tunicates (P = 0.01) were both lower at station 34. At stations 20 and 21 in 1984 cladocerans (P = 0.05) were significantly higher at station 20 while harpacticoids (P = 0.01) were significantly higher at station 21.

Annual patterns of abundance differed at both stations 20 and 34. Station 21 was only sampled in 1984 and so could not be compared. Four peaks in numbers m^{-2} occurred at station 20 in 1983 and only three in 1984. Both 1983 and 1984 showed large fluctuations in densities, both between samplings and over the season. At station 34, the two years exhibited two different patterns in seasonal abundance. In 1983, the numbers m^{-2} dropped substantially in June after peaking in May. The year 1984 showed three peaks in abundance at somewhat different times.

D-2 Comparison of epibenthos and chinook diets 1982-1984

In this zone, stomach analysis was carried out for 129 marked hatchery chinook: 41 fish in 1982 (Anderson et al. 1984), 51 fish in 1983 (M. Kotyk unpublished data) and 37 fish in 1984 (Cross 1985).

This analysis shows an opportunistic feeding pattern, with calanoids, insects, amphipods, harpacticoids and cumaceans being important in the diet at different sites and years (Table 14). These fish were caught between 23 April and 21 July. There did not appear to be any preferred prey from year to year, although the epibenthos were prominent. Comparisons of the diet of the wild chinook are not possible due to insufficient data.

E MARINE ZONE 1984

E-1 Sampling regime

Fifty-six samples were collected from this zone between 10 January and 26 September from two sites (Table 1). Station 27 was sampled most frequently because of the difficulty of reaching station 31 during the winter season. Most of the samples were collected on an ebbing tide. These two sites differed in physical characteristics quite substantially and detailed descriptions may be found in Kask et al. 1986b.

E-2 Physical characteristics

The temperatures recorded in this zone ranged from 7.9-14.0°C. Station 27 showed the most variation and was almost 2°C warmer than station 31 in late July. The salinity profiles were very similar at the two sites and ranged from 27.4-32.3 ‰. Tide heights at the time of sampling were more consistent at station 31 and ranged from 0.5-3.9 m at station 27 (Table 1).

E-3 Epibenthos in the marine zone

The total mean density of epibenthos m^{-2} (± 1SE) in this zone reached 3265 ± 599 m^{-2} in 1984 (Table 15). This zone was dominated by harpacticoids (47.8%), barnacle nauplii (13.1%) and copepod nauplii (11.1%). There were two main peaks in density in the season, one in April (9082 ± 5323 m^{-2}) and one in late August (7244 ± 3524 m^{-2}) (Fig. 10).

Copepod nauplii, harpacticoids and calanoids dominated station 27 and harpacticoids and barnacle nauplii station 31. Mean densities at the two stations were 5703 ± 1329 m^{-2} at station 31 and 1687 ± 254 m^{-2} at station 27 (Table 15). The two sites seemed to show reverse trends in densities throughout the season (Fig. 11a, 11b), and an analysis of variance between the two sites showed a significant difference (p=0.05).

E-4 Comparison of epibenthos and chinook diets

In the marine zone the wild fish were captured from 5 June to 2 August while the marked hatchery juveniles were caught between 25 April and 4 July. In this zone, both the wild and marked chinook juveniles consumed barnacle cypris (stations 27 and 24). The wild chinook also ate insects (station 28). The marked hatchery chinook relied more on harpacticoids (stations 32, 212 and 292) and some marine calanoids (station 32) (Tables 16 and 17) (Cross 1985). Compared to the sled tows, harpacticoids and calanoids were the only food organisms caught in reasonably large numbers (Table 15).

F COMPARISON OF MARINE ZONE 1982-1984

F-1 Comparison of epibenthos in the marine zone 1982-1984

Similar time spans were chosen for the zonal comparison between the three years (23 March - 29 September 1982, 29 March - 4 October 1983 and 21 March - 26 September 1984). Data from similar time periods was also chosen from station 27 (23 March - 29 September 1982, 29 March - 4 October 1983 and 21 March - 26 September 1984) and station 31 (6 April - 9 September 1982, 13 April - 7 September 1983 and 4 April - 29 August 1984) (Tables 18-19).

In the zone overall, the patterns of abundance in the epibenthos were similar in 1982 and 1983, but overall densities were lower in 1984 and the population showed smaller peaks (Fig. 12). Harpacticoids and copepod nauplii were dominant in 1982 and 1983 and harpacticoids and barnacle nauplii in 1984 (Table 18). In this zone the greatest change was between 1983 and 1984 when t-tests showed five categories to be significantly different between years. Cladocerans ($P = 0.05$), copepod nauplii ($P = 0.01$), eggs ($P = 0.01$) and isopods ($P = 0.05$) decreased from 1983 to 1984 while barnacle nauplii ($P = 0.01$) increased. There were only four categories showing a significant change from 1982 to 1984. Copepod nauplii ($P = 0.01$), isopods ($P = 0.05$) and worms ($P = 0.01$) were all lower in 1984 while barnacle nauplii ($P = 0.01$) were higher. Comparisons of the number m^{-2} in 1982 and 1983 showed only two significant differences: eggs ($P = 0.01$) were higher in 1983 while worms ($P = 0.01$) were lower.

Using analysis of variance, comparisons of each site over the period from 1982 to 1984 showed that at station 27 there was no significant difference in the total number m^{-2} between 1982 and 1983 or 1983 and 1984. However, there was a significant difference between 1982 and 1984 (ANOVA, $P = 0.05$), the total number m^{-2} dropping between these two years. Between year t-test comparisons of the thirteen dominant categories showed five significant categories between 1982 and 1983. Amphipods ($P = 0.05$), copepod nauplii ($P = 0.01$), harpacticoids ($P = 0.01$) and worms ($P = 0.01$) were all lower in 1983 while eggs ($P = 0.05$) were higher. There were also five categories which increased significantly from 1983 to 1984: amphipods ($P = 0.01$), barnacle nauplii ($P = 0.01$), cladocerans ($P = 0.05$), harpacticoids ($P = 0.01$) and worms ($P = 0.05$). From 1982 to 1984, three categories decreased (cladocerans ($P = 0.05$), copepod nauplii ($P = 0.01$) and worms ($P = 0.01$)) and one increased significantly (barnacle nauplii ($P = 0.01$)). At station 31, analysis of variance showed there was no significant difference in the total number m^{-2} for any of the three years. Between 1982 and 1984, t-tests indicated that six categories decreased significantly (calanoids ($P = 0.01$), copepod nauplii ($P = 0.01$), isopods ($P = 0.01$), nematodes ($P = 0.05$), tunicates ($P = 0.01$) and worms ($P = 0.01$)) and one increased (barnacle nauplii ($P = 0.01$)). There were four significantly lower categories between 1983 and 1984 (calanoids ($P = 0.01$), copepod nauplii ($P = 0.01$), eggs ($P = 0.01$) and isopods ($P = 0.01$)) and one higher (barnacle nauplii ($P = 0.05$)). The years 1982 and 1983 were the most similar, with only two significantly different categories. Eggs ($P = 0.05$) increased from 1982 to 1983 while worms ($P = 0.01$) decreased. In 1982 at both sites, copepod nauplii were estimated for one sampling period due to densities. This appears as the calculated value in the table (Table 19).

Comparisons of stations 27 and 31 for each year showed the greatest difference to be in 1983. When compared to station 27, t-tests showed seven categories were significantly higher at station 31. This included amphipods ($P = 0.01$), calanoids ($P = 0.05$), copepod nauplii ($P = 0.01$), eggs ($P = 0.05$), harpacticoids ($P = 0.01$), isopods ($P = 0.05$) and worms ($P = 0.05$). The total number m^{-2} was also significantly higher at station 31 ($P = 0.01$). There was less difference between these sites in 1984. Calanoids ($P = 0.01$) and tunicates ($P = 0.05$) were lower at site 31 while harpacticoids ($P = 0.01$), ostracods ($P = 0.01$) and the total ($P = 0.05$, ANOVA) were higher.

Changes in the overall mean densities of epifauna showed a different type of pattern at station 27 compared to station 31 for all three years analyzed. The fluctuations at station 27 seemed to be less extreme than those at station 31. Station 31 also reached much higher densities in all three years compared to station 27. Between 1982 and 1984, the overall mean density at both stations dropped (Table 19).

F-2 Comparison of epibenthos and chinook diets 1982-1984

In this zone, stomach analysis was carried out for 24 chinook salmon, 5 wild and 9 marked hatchery fish in 1982 (Anderson et al. 1984) and 5 wild and 5 marked hatchery fish in 1984 (Cross 1985). Comparisons of the diets between these two years show a reliance on different food organisms in each year (Table 20). Both pelagic and epibenthic animals were important as a food source at both stations in both 1982 and 1984. The fish analyzed were caught at different times of the year, from June through August, so some of the variation in diet may be due to this difference.

G COMPARISON OF ESTUARINE, TRANSITION AND MARINE ZONES 1984

G-1 Comparison of sampling regimes

There were 136 samples collected in the estuarine zone, 92 in the transition and 56 in the marine zone. Most of the samples were collected on a flooding tide in the estuarine and transition zones and on an ebb tide in the marine zone (Table 1).

G-2 Comparison of physical characteristics

The range of tidal heights at the time of sampling was greatest in the marine zone (0.5-3.9 m) followed by the estuarine (0.6-3.8 m) and transition zones (1.2-3.2 m). Salinities varied the most in the transition zone (2.6-32.0 °/₀₀), followed by the estuarine (0-9.9 °/₀₀) and marine zones (27.4-32.3 °/₀₀). The greatest change in temperatures was measured in the estuarine area (3.5-20.7°C). Temperatures were more stable in the transition (6.3-19.1°C) and marine zones (7.9-14.0°C) (Table 1).

G-3 Comparison of epibenthos in the three zones

The total mean density of epibenthos m^{-2} was the lowest in the estuarine zone on 13 of the 17 sampling trips. However, all three zones tended to overlap on the remaining sampling dates, and in late July, the densities recorded in the estuary exceeded even the marine zone value (Fig. 13). The overall means were lowest in the estuarine zone (668 ± 107 m^{-2}) followed by the transition (1407 ± 147 m^{-2}) and marine zones (3265 ± 599 m^{-2}), and these between zone differences were all significant (ANOVA, p=0.01).

Nematodes and ostracods dominated the estuarine zone, copepod nauplii and harpacticoids the transition zone, and harpacticoids and barnacle nauplii the marine zone. Many categories reached their greatest densities at the marine sites (harpacticoids, calanoids, eggs and barnacle nauplii). The estuarine zone had the highest densities of nematodes and ostracods and there were slightly more copepod nauplii in the transition zone (Table 21).

G-4 Comparison of epibenthos and chinook diets in the three zones

In the estuary, the wild chinook consumed mainly freshwater cladocera transported down the river, juvenile and adult insects, some pelagic calanoids transported in with the salt wedge and epibenthic estuarine amphipods (Table 3). The marked hatchery chinook ate mainly marine calanoids and freshwater cladocera (Table 4). At some sites, the epibenthic estuarine amphipods were also important (sites 16, 18 and 151).

In the transition zone the wild chinook relied almost exclusively on the freshwater cladocera and epibenthic harpacticoids (Table 10). At station 4, the freshwater cladocera formed a large part of the diet, seeming to indicate transport of food organisms by the river currents past this site. Epibenthic harpacticoids were more important at station 34. The marked hatchery chinook were still relying on insects and calanoids (station 4), calanoids and cladocera (station 5) and epibenthic cumaceans and harpacticoids (station 34). Fish dominated the diet at station 21 (Table 11). Food organisms from all sources were thus important in this zone.

In the marine zone, epibenthic amphipods and insects were still important in the diet of the wild fish, but barnacle cypris were dominant at station 27 (Table 16). At three sites the marked hatchery chinook relied on epibenthic harpacticoids (32, 212 and 292), but at station 24 the barnacle cypris were again dominant (Table 17) (Cross 1985).

There appeared to be more of a change in the diet of the chinook from the transition to the marine zone than from the estuarine to the transition zone.

H COMPARISON OF ESTUARINE, TRANSITION AND MARINE ZONES 1982-1984

Throughout the three years that epibenthic data was collected in the Campbell River area, there appeared to be a consistent difference in the densities m^{-2} that were recorded in the estuarine, transition and marine zones. T-tests of the thirteen most common epibenthic categories and the total number m^{-2} were carried out between zones for each year. The results of these tests seemed to emphasize this zonal difference.

In 1982, there were enough samples collected from only two zones, the estuarine and marine, to make a comparison. Of the thirteen categories tested, t-tests showed eight categories and the total number m^{-2} were significantly higher in the marine zone: amphipods ($P = 0.05$), barnacle nauplii ($P = 0.01$), calanoids ($P = 0.01$), copepod nauplii ($P = 0.01$), eggs

(P = 0.01), harpacticoids (P = 0.01), tunicates (P = 0.01), worms (P = 0.01) and the total (P = 0.01). Only one category, mysids (P = 0.01), was slightly higher in the estuarine zone.

In 1983 comparisons of the densities of the thirteen epibenthic categories and the total number m^{-2} were carried out between all three zones. The estuarine zone and the transition zone had eight categories and the total number m^{-2} significantly different between them: amphipods (P = 0.05), barnacle nauplii (P = 0.01), calanoids (P = 0.01), copepod nauplii (P = 0.05), eggs (P = 0.05), tunicates (P = 0.01) and the total (P = 0.01) were all higher in the transition zone while isopods (P = 0.05) and mysids (P = 0.01) were slightly higher in the estuarine zone. The estuarine zone and the marine zone had seven categories and the total number m^{-2} significantly different: barnacle nauplii (P = 0.01), calanoids (P = 0.01), copepod nauplii (P = 0.01), eggs (P = 0.05), tunicates (P = 0.01) and the total (P = 0.01) were all higher in the marine zone while mysids (P = 0.01) and nematodes (P = 0.01) were lower. A comparison of the transition and marine zones showed only three categories significantly different: calanoids (P = 0.05) and tunicates (P = 0.05) were highest in the marine zone while nematodes (P = 0.05) were most numerous in the transition zone.

In 1984 the estuarine zone differed from the other zones even more than it had in the previous years. Tested against the transition zone, using t-tests, seven of the thirteen categories and the total number m^{-2} were all significantly higher in the marine zone: amphipods (P = 0.01), barnacle nauplii (P = 0.01), calanoids (P = 0.01), copepod nauplii (P = 0.01), eggs (P = 0.01), harpacticoids (P = 0.01), tunicates (P = 0.01) and the total (P = 0.05). Cladocerans (P = 0.05), mysids (P = 0.01), ostracods (P = 0.05) and worms (P = 0.05) were all more numerous in the estuarine zone. Comparing the estuarine zone against the marine zone showed that eight categories and the total number m^{-2} were significantly higher in the marine zone: amphipods (P = 0.01), barnacle nauplii (P = 0.01), calanoids (P = 0.01), copepod nauplii (P = 0.01), eggs (P = 0.01), harpacticoids (P = 0.01), isopods (P = 0.01), tunicates (P = 0.01) and the total (P = 0.01). Cladocerans (P = 0.01), mysids (P = 0.01), nematodes (P = 0.01) and ostracods (P = 0.05) were higher in the estuarine zone. There was only a slight difference between the transition and marine zones, with three categories being significantly higher in the transition zone: cladocerans (P = 0.05), isopods (P = 0.05) and mysids (P = 0.01).

I GENERAL DISCUSSION

Enhancement of the juvenile salmon rearing capacity, especially for chinook, through production of both new shelter and food, was one of the main goals of the Campbell River estuary restoration project.

By 1984, the islands appeared to have remained largely physically stable, with some transport of gravel to different locations. Input from the river and salt wedge intrusion had added silt and nutrients to the original gravel base. During the spring and summer, the growth of algae and marsh grasses had produced new habitat which closely resembled much of the original estuarine marshes (visual observation).

Sampling in 1984 indicated that, for the estuary overall, the density of epibenthos had dropped to approximately half of that recorded in 1983 (Fig. 6). This was due mainly to the drop in eggs and copepod nauplii (Table 5). The epibenthos which were important as fish prey had also dropped. Densities in the other two zones were down also.

From 1982-1984, the epibenthic sled samples seem to indicate that the islands began to colonize within the first year. Overall densities had equalled or exceeded those recorded at the established sites and from 1983 to 1984 there was no significant change in the total counts at the two island sites.

All the zones showed seasonal fluctuations in abundance, the overall means usually being the highest in the transition and marine zones. For all the years sampled, 1983 produced the highest densities. The counts were the lowest in 1984 in the transition and marine zones.

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Table 1. Summary of samples and physical data at each site in the three Campbell River zones 1984.

Dates	Zone	Stn. no.	No. samples	Tide: Type (ebb, flood)	Tide: Ht. (m)	Surface: Sal. (‰)	Surface: Temp. (°C)
9 Jan.-25 Sept.	Estuarine	1	34	4E, 13F	0.7-3.8	0.4-9.9	3.9-18.2
9 Jan.-25 Sept.	Estuarine	7	34	7E, 10F	0.6-3.0	0.3-3.6	3.7-17.8
3 Apr.	Estuarine	10	2	1F	2.0	0.2	6.5
9 Jan.-25 Sept.	Estuarine	11	32	1E, 15F	1.8-3.0	0.0-5.5	4.7-20.7
10 Jan.-25 Sept.	Estuarine	17	34	1E, 16F	1.5-2.7	0.0-0.9	3.5-18.5
9 Jan.-26 Sept.	Transition	20	34	3E, 14F	1.5-3.2	25.7-31.5	7.5-14.9
7 Mar.-26 Sept.	Transition	21	30	2E, 13F	1.2-3.2	23.4-32.0	8.4-16.4
8 Mar.-26 Sept.	Transition	34	28	14F	1.3-2.9	2.6-29.9	6.3-19.1
10 Jan.-26 Sept.	Marine	27	34	9E, 8F	0.5-3.9	28.0-32.3	7.9-14.0
4 Apr.-29 Aug.	Marine	31	22	11E	2.2-3.3	27.4-31.6	8.4-11.8

Table 2. Mean density $m^{-2} \pm 1SE$ and percent of total population of dominant epibenthos at four stations and all stations combined in the Campbell River estuarine zone 1984.

Station no.	1		7		11		17		All	
No. samples	34		34		32		34		134	
	$\bar{x}$ m^{-2} ± 1SE	%	$\bar{x}$ m^{-2} ± 1SE	%	$\bar{x}$ m^{-2} ± 1SE	%	$\bar{x}$ m^{-2} ± 1SE	%	$\bar{x}$ m^{-2} ± 1SE	%
Taxa										
Nematodes	78.2 ± 12.5	24.9	119.0 ± 40.8	24.1	128.1 ± 35.8	22.6	571.9 ± 170.0	44.3	225.7 ± 48.1	33.8
Ostracods	20.6 ± 7.9	6.6	85.8 ± 32.1	17.4	118.4 ± 65.0	20.9	315.6 ± 107.0	24.5	135.3 ± 33.4	20.3
Copepod nauplii	66.5 ± 11.7	21.2	112.7 ± 28.4	22.9	84.3 ± 19.7	14.9	171.6 ± 50.1	13.3	109.1 ± 15.8	16.3
Harpacticoids	50.2 ± 13.8	16.0	73.4 ± 21.1	14.9	92.3 ± 34.7	16.3	92.5 ± 25.4	7.2	76.9 ± 12.2	11.5
Worms	16.8 ± 5.0	5.4	17.5 ± 9.3	3.6	70.1 ± 51.0	12.4	28.5 ± 13.1	2.2	32.7 ± 12.9	4.9
Mysids	35.9 ± 16.4	11.4	6.9 ± 2.4	1.4	16.8 ± 8.6	3.0	6.6 ± 2.1	<1.0	16.6 ± 4.8	2.5
Cladocerans	6.4 ± 1.4	2.0	10.5 ± 2.3	2.1	8.8 ± 2.2	1.6	33.6 ± 15.5	2.6	14.9 ± 4.1	2.2
Calanoids	10.3 ± 2.2	3.3	10.4 ± 2.4	2.1	14.8 ± 6.1	2.6	23.2 ± 8.4	1.8	14.7 ± 2.7	2.2
Amphipods	2.9 ± 1.0	<1.0	31.5 ± 12.8	6.4	4.6 ± 2.2	<1.0	11.6 ± 5.2	<1.0	12.8 ± 3.7	1.9
Acarinans	8.9 ± 2.0	2.8	5.5 ± 1.7	1.1	14.9 ± 4.3	2.6	14.5 ± 2.8	1.1	10.9 ± 1.4	1.6
Eggs	4.1 ± 1.1	1.3	5.1 ± 1.0	1.0	7.3 ± 1.6	1.3	12.6 ± 3.5	<1.0	7.3 ± 1.1	1.1
Isopods	6.5 ± 2.1	2.1	9.9 ± 3.2	2.0	2.7 ± 1.0	<1.0	2.6 ± 0.9	<1.0	5.5 ± 1.1	<1.0
TOTAL	313.8 ± 53.7		493.1 ± 137.0		567.8 ± 196.2		1290.9 ± 332.6		667.9 ± 107.4	

Table 3. Dominant food items in juvenile wild chinook stomachs in the Campbell River estuarine zone 1984.

Station	7			14			15			16			17			141		
Dates	4 Apr-31 July			4 Apr-4 June			21 Mar-18 June			3 July			21 Mar-15 May			17 July		
No. Fish analyzed	48			8			13			5			18			4		
Range in length (mm)	38-164			39-54			37-51			62-70			38-47			63-73		
Range in weight (gm)	0.6-51.4			0.5-1.9			0.6-1.8			3.3-4.7			0.6-1.2			2.8-4.9		
Number stomachs empty	8			0			0			0			0			0		
Food group	Num. %	% freq. occur	x̄ # per fish	Num. %	% freq. occur	x̄ # per fish	Num. %	% freq. occur	x̄ # per fish	Num. %	% freq. occur	x̄ # per fish	Num. %	% freq. occur	x̄ # per fish	Num. %	% freq. occur	x̄ # per fish
Freshwater cladocera	31.9	16.7	7.2	80.6	62.5	239.5	45.2	38.5	10.2	83.2	80.0	189.2	12.2	27.8	3.0	4.1	50.0	1.8
Juvenile and adult insects	26.5	54.2	6.0	<1.0	75.0	2.1	7.9	76.9	1.8	<1.0	20.0	<1.0	13.8	83.3	3.4	46.0	100.0	19.8
Pelagic calanoids & cyclopoids	10.7	10.4	2.4	<1.0	25.0	<1.0	2.4	23.1	<1.0	<1.0	40.0	<1.0	35.5	50.0	8.7	-	-	-
Epibenthic amphipods	8.8	47.9	2.0	2.3	100.0	6.9	19.2	69.2	4.3	4.8	100.0	11.0	25.8	83.3	6.3	49.1	75.0	21.3
Freshwater calanoids & cyclopoids	8.5	6.3	1.9	-	-	-	4.8	15.4	1.1	-	-	-	1.4	27.8	<1.0	-	-	-
Cladocera	5.8	6.3	1.3	15.8	62.5	46.9	10.6	38.5	2.4	9.6	80.0	21.8	<1.0	11.1	<1.0	1.2	25.0	<1.0
Epibenthic harpacticoids	4.5	22.9	1.0	<1.0	37.5	<1.0	8.6	38.5	1.9	2.1	60.0	4.8	10.0	44.4	2.4	-	-	-
Epibenthic isopods	1.7	10.4	<1.0	<1.0	12.5	<1.0	<1.0	15.4	<1.0	-	-	-	<1.0	5.6	<1.0	-	-	-

Table 4. Dominant food items in juvenile marked hatchery chinook stomachs in the Campbell River estuarine zone 1984.

Station	6			7			16			18			37			151		
Dates	4 June-4 July			25 Apr-28 Aug			4 June-3 July			15 May-3 July			2 May-3 July			26 April		
No. Fish analyzed	14			35			2			2			10			3		
Range in length (mm)	69-112			57-137			89-92			74-101			70-110			63-68		
Range in weight (gm)	3.3-15.7			2.5-25.0			7.0-8.3			5.1-12.1			4.3-16.0			2.9-4.1		
Number stomachs empty	0			6			0			0			1			0		
Food group	Num. %	% freq. occur	$\bar{x}$ # per fish	Num. %	% freq. occur	$\bar{x}$ # per fish	Num. %	% freq. occur	$\bar{x}$ # per fish	Num. %	% freq. occur	$\bar{x}$ # per fish	Num. %	% freq. occur	$\bar{x}$ # per fish	Num. %	% freq. occur	$\bar{x}$ # per fish
Pelagic calanoids & cyclopoids	50.2	80.0	101.2	44.0	14.3	21.9	-	-	-	63.2	50.0	21.5	86.2	50.0	34.3	-	-	-
Freshwater cladocera	38.0	100.0	73.7	28.3	73.3	14.1	-	-	-	-	-	-	-	-	-	-	-	-
Epibenthic amphipods	3.0	100.0	5.8	9.6	48.6	4.8	95.1	100.0	19.5	26.5	100.0	9.0	1.3	20.0	<1.0	62.5	100.0	5.0
Cladocera	2.3	64.3	4.4	1.8	14.3	<1.0	-	-	-	-	-	-	-	-	-	-	-	-
Crustacea	2.1	46.7	4.3	6.6	14.3	3.3	-	-	-	-	-	-	<1.0	20.0	<1.0	-	-	-
Epibenthic harpacticoids	1.1	40.0	2.1	<1.0	11.4	<1.0	-	-	-	1.5	50.0	<1.0	-	-	-	-	-	-
Epibenthic isopods	<1.0	6.7	<1.0	1.7	17.1	<1.0	4.9	100.0	1.0	-	-	-	4.8	10.0	1.9	4.2	33.3	<1.0
Juvenile and adult insects	<1.0	42.9	1.5	6.8	51.4	3.4	-	-	-	1.5	50.0	<1.0	1.0	10.0	<1.0	29.2	33.3	2.3
Epibenthic mysids	-	-	-	-	-	-	-	-	-	4.4	50.0	1.5	3.3	30.0	1.3	-	-	-
Epibenthic cumaceans	-	-	-	-	-	-	-	-	-	2.9	50.0	1.0	-	-	-	-	-	-
Fish	-	-	-	-	-	-	-	-	-	-	-	-	1.0	20.0	<1.0	-	-	-
Araneida	-	-	-	-	-	-	-	-	-	-	-	-	<1.0	10.0	<1.0	4.2	33.3	<1.0

Table 5. Mean density $m^{-2} \pm$ 1SE and percent of total population of dominant epibenthos at all stations combined in the Campbell River estuarine zone 1982-1984.

Year	1982		1983		1984	
Dates	23 Mar-29 Sept		14 Mar-5 Oct		20 Mar-25 Sept	
No. samples	62		112		112	
Taxa	$\bar{x}m^{-2} \pm$ 1SE	%	$\bar{x}m^{-2} \pm$ 1SE	%	$\bar{x}m^{-2} \pm$ 1SE	%
Copepod nauplii	220.3 ± 49.2	36.5	404.0 ± 91.1	29.7	124.3 ± 18.6	16.4
Nematodes	184.6 ± 37.1	30.5	207.4 ± 24.1	15.3	252.9 ± 56.9	33.3
Harpacticoids	106.0 ± 25.0	17.5	137.9 ± 17.8	10.1	87.8 ± 14.4	11.6
Calanoids	15.6 ± 3.2	2.6	23.9 ± 3.3	1.8	16.7 ± 3.2	2.2
Eggs	15.3 ± 4.0	2.5	417.1 ± 112.1	30.7	7.7 ± 1.2	1.0
Worms	12.3 ± 1.9	2.0	31.1 ± 16.0	2.3	38.1 ± 15.4	5.0
Ostracods	12.0 ± 2.9	2.0	56.4 ± 18.2	4.2	161.4 ± 39.6	21.3
Amphipods	9.3 ± 2.0	1.5	20.8 ± 6.3	1.5	13.1 ± 4.3	1.7
Cladocerans	3.3 ± 0.9	<1.0	20.8 ± 4.4	1.5	17.0 ± 4.9	2.2
Mysids	1.0 ± 0.3	<1.0	9.0 ± 2.1	<1.0	18.7 ± 5.7	2.5
Acarinans	3.9 ± 0.7	<1.0	4.9 ± 0.7	<1.0	11.9 ± 1.7	1.6
Total	604.4 ± 102.9		1359.6 ± 128.5		758.6 ± 126.4	

Table 6. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at stations 11 and 17 in the Campbell River estuarine zone 1983-1984.

Station	11				17			
Year	1983		1984		1983		1984	
Dates	15 Mar-6 Sept		20 Mar-25 Sept		15 Mar-6 Sept		20 Mar-25 Sept	
No. samples	24		28		26		28	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Copepod nauplii	195.9 ± 50.2	31.8	91.6 ± 22.2	14.6	934.5 ± 363.4	37.2	199.5 ± 59.6	13.1
Nematodes	131.6 ± 27.9	21.3	140.7 ± 40.4	22.5	405.3 ± 77.1	16.1	678.4 ± 201.2	44.4
Eggs	98.3 ± 25.7	15.9	7.9 ± 1.8	1.3	636.8 ± 314.6	25.3	14.8 ± 4.1	1.0
Harpacticoids	73.0 ± 10.9	11.8	102.4 ± 39.3	16.4	230.4 ± 41.8	9.2	105.6 ± 30.2	6.9
Calanoids	27.9 ± 9.4	4.5	15.9 ± 6.9	2.5	29.0 ± 7.2	1.2	27.2 ± 10.0	1.8
Cladocerans	25.3 ± 10.0	4.1	9.2 ± 2.5	1.5	42.9 ± 14.2	1.7	39.8 ± 18.7	2.6
Ostracods	20.2 ± 8.9	3.3	134.6 ± 73.9	21.5	129.0 ± 71.0	5.1	383.0 ± 126.7	25.1
Worms	16.1 ± 7.2	2.6	79.9 ± 58.2	12.8	19.8 ± 7.9	<1.0	33.7 ± 15.8	2.2
Polychaetes	9.0 ± 3.9	1.5	1.7 ± 0.5	<1.0	2.8 ± 1.1	<1.0	0.3 ± 0.2	<1.0
Acarinans	3.8 ± 0.9	<1.0	15.8 ± 4.9	2.5	6.2 ± 2.5	<1.0	16.3 ± 3.2	1.1
Amphipods	3.7 ± 1.1	<1.0	2.4 ± 0.7	<1.0	39.1 ± 22.3	1.6	12.3 ± 6.2	<1.0
Mysids	1.3 ± 0.7	<1.0	18.6 ± 9.8	3.0	8.6 ± 5.3	<1.0	8.1 ± 2.5	<1.0
Total	617.0 ± 97.2		626.1 ± 222.5		2514.8 ± 707.2		1527.8 ± 390.3	

Table 7. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at stations 1 and 7 in the Campbell River estuarine zone 1982-1984.

Station	1				7					
Year	1983		1984		1982		1983		1984	
Dates	14 Mar-5 Oct		20 Mar-25 Sept		23 Mar-29 Sept		14 Mar-5 Oct		20 Mar-25 Sept	
No. samples	28		28		26		26		28	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Eggs	364.6 ± 235.8	38.1	3.4 ± 0.8	1.0	7.8 ± 1.7	1.7	524.6 ± 254.2	41.3	4.6 ± 1.0	<1.0
Copepod nauplii	167.3 ± 25.5	17.5	76.4 ± 13.5	22.3	192.0 ± 48.4	40.6	305.5 ± 72.8	24.0	129.6 ± 33.6	24.1
Nematodes	149.6 ± 26.0	15.6	78.7 ± 12.4	22.9	95.8 ± 19.1	20.2	136.9 ± 38.9	10.8	113.6 ± 43.7	21.1
Worms	81.5 ± 63.2	8.5	18.9 ± 6.0	5.5	11.9 ± 2.5	2.5	9.2 ± 1.9	<1.0	19.7 ± 11.2	3.7
Harpacticoids	79.8 ± 18.4	8.3	59.9 ± 16.2	17.5	96.4 ± 24.9	20.4	169.0 ± 51.8	13.3	83.2 ± 24.9	15.5
Calanoids	27.6 ± 7.4	2.9	11.7 ± 2.5	3.4	9.4 ± 1.6	2.0	15.2 ± 3.6	1.2	11.9 ± 2.9	2.2
Ostracods	20.1 ± 7.3	2.1	24.8 ± 9.4	7.2	16.9 ± 5.1	3.6	34.8 ± 12.4	2.7	103.2 ± 38.3	19.2
Amphipods	15.7 ± 5.0	1.6	2.7 ± 1.2	<1.0	13.0 ± 4.1	2.8	29.3 ± 14.4	2.3	34.9 ± 15.5	6.5
Cladocerans	12.7 ± 5.4	1.3	6.5 ± 1.7	1.9	4.0 ± 1.8	<1.0	8.6 ± 4.8	<1.0	12.6 ± 2.6	2.4
Mysids	11.7 ± 3.1	1.2	39.9 ± 19.8	11.6	1.8 ± 0.7	<1.0	16.4 ± 6.4	1.3	8.2 ± 2.8	1.5
Acarinans	3.2 ± 0.6	<1.0	9.7 ± 2.3	2.8	3.8 ± 1.0	<1.0	4.0 ± 1.3	<1.0	5.8 ± 2.0	1.1
Isopods	3.4 ± 1.1	<1.0	4.0 ± 1.5	1.2	3.0 ± 2.3	<1.0	4.8 ± 1.9	<1.0	5.0 + 1.8	<1.0
Total	958.1 ± 265.1		343.1 ± 63.3		473.4 ± 76.8		1271.1 ± 275.4		537.3 ± 161.1	

Table 8. Dominant food items as a percent of total diet in juvenile wild and marked hatchery chinook stomachs at station 7 in the Campbell River estuarine zone 1982-1984.

Wild or marked	Wild	Wild	Wild	Marked	Marked	Marked
Dates	24 Mar-8 Sept	26 Jan-9 Nov	4 Apr-31 July	10 May-27 Sept	23 Feb- 2 Aug	25 April-28 Aug
Year	1982	1983	1984	1982	1983	1984
No. analyzed	39	40	48	43	67	35
Range in length (mm)	37-97	33-178	38-164	61-125	58-152	57-137
Range in weight(gm)	0.45-11.80	0.30-74.20	0.60-51.40	2.95-24.40	2.30-43.30	2.50-25.00
Number stomachs empty	1	7	8	13	7	6
Food group						
Pelagic calanoids & cyclopoids	19.7	40.5	10.7	63.9	31.2	44.0
Juvenile and adult insects	47.8	14.2	26.5	6.0	4.9	6.8
Epibenthic amphipods	7.0	5.2	8.8	11.5	2.8	9.6
Epibenthic harpacticoids	5.5	<1.0	4.5	1.1	1.4	<1.0
Freshwater cladocera	18.1	18.0	31.9	4.0	50.6	28.3
Pelagic amphipods	<1.0	<1.0	-	2.4	<1.0	<1.0
Epibenthic isopods	<1.0	3.3	1.7	6.5	1.0	1.7
Decapod larvae	<1.0	<1.0	<1.0	1.8	1.8	6.6
Pelagic cirripede larvae	-	8.0	<1.0	-	3.8	<1.0
Herring eggs	-	6.5	-	-	-	-
Gastropods	-	1.0	-	<1.0	<1.0	-
Freshwater calanoids	<1.0	-	8.5	<1.0	-	<1.0
Cladocera	-	-	5.8	-	-	1.8

Table 9. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at three stations and all stations combined in the Campbell River transition zone 1984.

Station no.	20		21		34		All	
No. samples	34		30		28		92	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Copepod nauplii	343.6 ± 65.0	26.8	564.7 ± 113.5	32.6	285.9 ± 58.1	23.6	398.1 ± 48.6	28.3
Harpacticoids	195.8 ± 56.5	15.3	440.6 ± 65.5	25.5	309.0 ± 92.7	25.5	310.1 ± 42.0	22.0
Nematodes	178.8 ± 93.1	14.0	69.1 ± 9.6	4.0	194.9 ± 42.9	16.1	147.9 ± 37.0	10.5
Calanoids	98.3 ± 18.9	7.7	201.9 ± 89.0	11.7	78.8 ± 17.5	6.5	126.1 ± 30.5	9.0
Amphipods	228.3 ± 114.0	17.8	100.6 ± 29.5	5.8	10.3 ± 2.3	<1.0	120.3 ± 43.8	8.6
Barnacle nauplii	55.2 ± 11.5	4.3	59.2 ± 10.7	3.4	130.0 ± 47.4	10.7	79.3 ± 15.6	5.6
Eggs	58.4 ± 23.7	4.6	60.5 ± 11.7	3.5	37.9 ± 12.8	3.1	52.9 ± 10.3	3.8
Gastropod eggs	29.6 ± 9.5	2.3	47.5 ± 11.2	2.7	36.1 ± 8.0	3.0	37.4 ± 5.6	2.7
Polychaetes	17.1 ± 3.4	1.3	59.9 ± 22.2	3.5	9.4 ± 1.8	<1.0	28.7 ± 7.7	2.0
Tunicates	22.1 ± 6.4	1.7	14.4 ± 3.5	<1.0	9.4 ± 3.4	<1.0	15.7 ± 2.8	1.1
Ostracods	4.4 ± 0.8	<1.0	5.8 ± 1.5	<1.0	38.4 ± 7.6	3.2	15.2 ± 2.9	1.1
Barnacle cypris	4.5 ± 1.3	<1.0	24.9 ± 10.8	1.4	9.5 ± 5.6	<1.0	12.7 ± 4.0	<1.0
Echinoderm larvae	6.4 ± 2.3	<1.0	18.4 ± 10.6	1.1	4.4 ± 2.5	<1.0	9.7 ± 3.7	<1.0
Gastropods	4.1 ± 0.7	<1.0	18.1 ± 5.5	1.1	1.7 ± 0.5	<1.0	8.0 ± 1.9	<1.0
Total	1281.9 ± 258.7		1731.0 ± 266.7		1211.1 ± 224.1		1406.8 ± 146.5	

Table 10. Dominant food items in juvenile wild chinook stomachs in the Campbell River transition zone 1984.

Station	4	34
Dates	16 Apr-1 Aug	1 May-3 July
No. fish analyzed	45	19
Range in length (mm)	38-134	40-95
Range in weight(gm)	0.5-28.8	0.6-10.0
Number stomachs empty	1	0

Food group	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish
Freshwater cladocera	46.0	51.1	38.4	1.1	21.1	1.3
Epibenthic harpacticoids	30.7	53.3	25.6	66.8	94.7	77.8
Pelagic calanoids & cyclopoids	6.2	37.8	5.1	2.9	42.1	3.3
Freshwater calanoids	4.7	26.7	3.9	<1.0	26.3	<1.0
Juvenile & adult insects	3.5	48.9	3.0	2.2	68.4	2.6
Epibenthic amphipods	3.0	53.3	2.5	3.0	68.4	3.5
Pelagic amphipods	1.5	6.7	1.2	-	-	-
Epibenthic cumaceans	1.3	31.1	1.0	23.1	63.2	26.8
Cladocera	1.2	17.8	1.0	<1.0	5.3	<1.0

Table 11. Dominant food items in juvenile marked hatchery chinook stomachs in the Campbell River transition zone 1984.

Station	4	5	21	34
Dates	27 Apr-3 July	4 June	5 July	2 May-19 June
No. fish analyzed	15	5	4	13
Range in length (mm)	65-111	77-92	108-135	56-138
Range in weight(gm)	3.5-16.4	5.1-8.6	12.3-27.5	2.1-22.3
Number stomachs empty	1	0	0	0

Food group	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish
Juvenile & adult insects	29.8	33.3	9.4	<1.0	80.0	3.2	-	-	-	<1.0	38.5	<1.0
Pelagic calanoids & cyclopods	15.2	6.7	4.8	61.9	40.0	202.2	-	-	-	1.9	23.1	4.2
Freshwater cladocera	12.9	26.7	4.1	25.5	100.0	83.2	-	-	-	<1.0	23.1	<1.0
Parasitic copepods	12.5	6.7	3.9	-	-	-	-	-	-	<1.0	7.7	<1.0
Epibenthic harpacticoids	11.2	33.3	3.5	1.7	80.0	5.4	-	-	-	24.7	76.9	56.1
Epibenthic amphipods	7.0	33.3	2.2	2.9	100.0	9.6	-	-	-	<1.0	61.5	1.3
Epibenthic cumaceans	6.6	20.0	2.1	1.7	80.0	5.6	-	-	-	72.0	76.9	163.6
Epibenthic isopods	2.3	20.0	<1.0	<1.0	40.0	1.2	-	-	-	<1.0	7.7	<1.0
Crustacea	<1.0	6.7	<1.0	1.8	40.0	6.0	-	-	-	<1.0	7.7	<1.0
Cladocera	<1.0	13.3	<1.0	2.3	80.0	7.6	-	-	-	-	-	-
Pelagic amphipods	-	-	-	-	-	-	14.3	25.0	<1.0	-	-	-
Fish	<1.0	6.7	<1.0	-	-	-	85.7	100.0	1.5	-	-	-

Table 12. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at all stations combined in the Campbell River transition zone 1983-1984.

Year	1983		1984	
Dates	14 Mar-7 Sept		7 Mar-11 Sept	
No. samples	40		82	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Copepod nauplii	761.0 ± 99.3	26.4	434.7 ± 53.0	31.0
Harpacticoids	598.0 ± 114.4	20.7	319.9 ± 45.5	22.8
Eggs	502.5 ± 134.8	17.4	58.0 ± 11.4	4.1
Amphipods	328.0 ± 122.8	11.4	69.7 ± 21.3	5.0
Nematodes	270.8 ± 102.2	9.4	117.5 ± 20.3	8.4
Calanoids	178.1 ± 30.3	6.2	134.8 ± 34.1	9.6
Barnacle nauplii	48.5 ± 12.6	1.7	88.0 ± 17.3	6.3
Gastropod eggs	40.8 ± 8.2	1.4	39.4 ± 6.2	2.8
Polychaetes	19.6 ± 3.2	<1.0	30.3 ± 8.5	2.2
Tunicates	21.6 ± 10.6	<1.0	17.3 ± 3.1	1.2
Ostracods	15.2 ± 3.7	<1.0	16.6 ± 3.2	1.2
Barnacle cypris	0.9 ± 0.6	<1.0	14.2 ± 4.5	1.0
Total	2885.6 ± 318.3		1403.3 ± 136.8	

Table 13. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at stations 20 and 34 in the Campbell River transition zone 1983-1984.

Station	20				34			
Year	1983		1984		1983		1984	
Dates	14 Mar-7 Sept		7 Mar-11 Sept		14 Apr-17 Aug		16 Apr-15 Aug	
No. samples	26		28		14		18	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Copepod nauplii	734.2 ± 125.8	22.4	386.9 ± 76.0	33.8	810.7 ± 166.4	37.8	382.6 ± 80.1	24.8
Harpacticoids	679.7 ± 168.5	20.7	178.9 ± 59.7	15.6	446.3 ± 89.3	20.8	370.7 ± 131.5	24.1
Eggs	575.2 ± 192.6	17.5	68.4 ± 28.5	6.0	367.4 ± 145.3	17.1	51.6 ± 19.2	3.4
Amphipods	486.4 ± 182.3	14.8	112.1 ± 56.8	9.8	33.9 ± 14.7	1.6	12.4 ± 3.5	<1.0
Nematodes	306.9 ± 156.3	9.4	104.9 ± 37.6	9.2	203.7 ± 40.7	9.5	247.1 ± 62.2	16.0
Calanoids	232.2 ± 41.5	7.1	103.9 ± 22.5	9.1	77.6 ± 22.7	3.6	85.2 ± 22.6	5.5
Barnacle nauplii	49.7 ± 14.6	1.5	65.9 ± 13.1	5.8	46.1 ± 24.7	2.2	190.4 ± 70.1	12.4
Gastropod eggs	43.8 ± 9.8	1.3	33.5 ± 11.3	2.9	35.3 ± 15.1	1.6	37.2 ± 9.5	2.4
Tunicates	32.7 ± 16.0	1.0	26.0 ± 7.5	2.3	1.1 ± 0.6	<1.0	10.1 ± 3.7	<1.0
Polychaetes	24.0 ± 4.4	<1.0	16.6 ± 3.1	1.5	11.4 ± 3.0	<1.0	9.0 ± 1.9	<1.0
Cladocerans	9.6 ± 3.6	<1.0	4.4 ± 2.2	<1.0	24.1 ± 13.5	1.1	12.0 ± 3.5	<1.0
Ostracods	10.6 ± 2.9	<1.0	4.5 ± 1.0	<1.0	23.7 ± 8.7	1.1	50.1 ± 10.1	3.3
Total	3283.5 ± 433.5		1143.9 ± 166.7		2146.6 ± 364.4		1541.0 ± 305.0	

Table 14. Dominant food items as a percent of total diet in juvenile marked hatchery chinook stomachs at stations 4, 5, 21 and 34 in the Campbell River transition zone 1982-1984.

Station	4	4	5	5	21	21	34	34
Dates	29 May-17 July	27 Apr-3 July	29 May-9 July	4 June	23 Apr- 8 July	5 July	28 May-21 July	2 May-19 June
Year	1982	1984	1982	1984	1983	1984	1982	1984
No. analyzed	19	15	10	5	51	4	12	13
Range in length(mm)	76-110	65-111	85-109	77-92	65-125	108-135	76-111	56-138
Range in weight(gm)	5.30-14.90	3.5-16.4	8.20-15.10	5.1-8.6	2.60-18.50	12.3-27.5	5.20-16.60	2.1-22.3
Number stomachs empty	3	1	5	0	3	0	0	0
Food group								
Pelagic calanoids & cyclopoids	78.3	15.2	33.0	61.9	2.4	-	25.1	1.9
Juvenile and adult insects	<1.0	29.8	-	<1.0	<1.0	-	<1.0	<1.0
Epibenthic amphipods	7.2	7.0	58.9	2.9	9.6	-	4.6	<1.0
Epibenthic harpacticoids	3.5	11.2	-	1.7	81.4	-	54.0	24.7
Epibenthic cumaceans	3.4	6.6	2.5	1.7	4.0	-	15.8	72.0
Epibenthic ostracods	2.1	-	-	<1.0	-	-	-	<1.0
Decapod larvae	3.9	-	<1.0	-	1.5	-	<1.0	-
Freshwater cladocera	-	12.9	-	25.5	-	-	-	<1.0
Parasitic copepods	<1.0	12.5	-	-	-	-	<1.0	<1.0
Epibenthic isopods	-	2.3	5.1	<1.0	<1.0	-	<1.0	<1.0
Crustacea	-	<1.0	-	1.8	-	-	-	<1.0
Cladocera	-	<1.0	-	2.3	-	-	-	-
Pelagic amphipods	<1.0	-	-	-	<1.0	14.3	<1.0	-
Fish	-	<1.0	-	-	<1.0	85.7	<1.0	-

Table 15. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at two stations and all stations combined in the Campbell River marine zone 1984.

Station no.	27		31		All	
No. samples	34		22		56	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Harpacticoids	385.0 ± 88.0	22.8	3378.1 ± 965.1	59.2	1560.9 ± 425.9	47.8
Barnacle nauplii	185.3 ± 72.1	11.0	803.7 ± 312.9	14.1	428.3 ± 135.0	13.1
Copepod nauplii	417.1 ± 88.6	24.7	274.7 ± 62.8	4.8	361.2 ± 59.5	11.1
Gastropod eggs	53.0 ± 21.9	3.1	464.5 ± 120.2	8.1	214.6 ± 55.5	6.6
Calanoids	236.6 ± 42.9	14.0	106.5 ± 19.5	1.9	185.5 ± 28.3	5.7
Eggs	160.7 ± 84.4	9.5	149.2 ± 59.6	2.6	156.2 ± 55.9	4.8
Amphipods	48.1 ± 11.8	2.9	244.3 ± 98.5	4.3	125.2 ± 40.9	3.8
Nematodes	57.3 ± 9.5	3.4	75.6 ± 15.4	1.3	64.5 ± 8.4	2.0
Ectoprocts	22.7 ± 3.8	1.4	34.9 ± 8.7	<1.0	27.5 ± 4.2	<1.0
Ostracods	4.4 ± 1.8	<1.0	63.1 ± 20.9	1.1	27.4 ± 9.1	<1.0
Tunicates	33.8 ± 9.8	2.0	9.1 ± 2.2	<1.0	24.1 ± 6.2	<1.0
Worms	26.4 ± 9.9	1.6	13.9 ± 3.6	<1.0	21.5 ± 6.2	<1.0
Total	1686.5 ± 254.2		5703.3 ± 1328.7		3264.5 ± 598.6	

Table 16. Dominant food items in juvenile wild chinook stomachs in the Campbell River marine zone 1984.

Station	27			28		
Dates	20 June			5 June-2 Aug		
No. fish analyzed	5			16		
Range in length (mm)	57-71			50-120		
Range in weight(gm)	2.4-4.1			1.5-15.6		
Number stomachs empty	0			0		
Food group	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish
Pelagic cirripede larvae	71.9	20.0	91.2	-	-	-
Epibenthic amphipods	14.0	100.0	17.8	8.4	68.8	2.4
Juvenile & adult insects	9.3	100.0	11.8	70.0	100.0	19.8
Epibenthic harpacticoids	2.8	80.0	3.6	3.5	37.5	1.0
Crustacea	-	-	-	7.1	43.8	2.0
Pelagic amphipods	-	-	-	3.8	12.5	1.1
Araneida	-	-	-	2.7	50.0	<1.0
Pelagic decapods	-	-	-	1.3	18.8	<1.0

Table 17. Dominant food items in juvenile marked hatchery chinook stomachs in the Campbell River marine zone 1984.

Station	24			32			212			292		
Dates	4 July			25 April			26 April			2 May		
No. fish analyzed	5			5			3			5		
Range in length (mm)	102-116			49-67			64-73			64-70		
Range in weight(gm)	10.7-19.1			1.0-3.1			2.2-3.8			2.5-3.6		
Number stomachs empty	1			4			1			0		
Food group	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish	Num. %	% Freq. occur	$\bar{x}$ # per fish
Pelagic cirripede larvae	83.7	20.0	21.6	-	-	-	-	-	-	-	-	-
Epibenthic harpacticoids	12.4	40.0	3.2	65.8	20.0	5.0	93.6	66.7	19.3	87.9	100.0	110.2
Fish	1.6	40.0	<1.0	-	-	-	-	-	-	-	-	-
Epibenthic amphipods	<1.0	20.0	<1.0	7.9	20.0	<1.0	1.6	33.3	<1.0	4.9	100.0	6.2
Pelagic calanoids & cyclopoids	<1.0	20.0	<1.0	26.3	20.0	2.0	1.6	33.3	<1.0	3.0	80.0	3.8
Juvenile & adult insects	<1.0	20.0	<1.0	-	-	-	1.6	33.3	<1.0	-	-	-
Crustacea	-	-	-	-	-	-	1.6	33.3	<1.0	<1.0	20.0	<1.0
Epibenthic ostracods	-	-	-	-	-	-	-	-	-	3.5	100.0	4.4

Table 18. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at all stations combined in the Campbell River marine zone 1982-1984.

Year	1982		1983		1984	
Dates	23 Mar-29 Sept		29 Mar-4 Oct		21 Mar-26 Sept	
No. samples	64		50		50	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Harpacticoids	3836.6 ± 1258.0	38.9	5908.9 ± 2971.1	51.1	1746.0 ± 470.6	48.1
Copepod nauplii	3792.2 ± 1206.1	38.4	2812.1 ± 815.5	24.3	394.2 ± 65.1	10.9
Amphipods	886.1 ± 311.7	9.0	785.0 ± 327.0	6.8	140.0 ± 45.4	3.9
Calanoids	351.0 ± 41.8	3.6	356.2 ± 56.0	3.1	201.0 ± 31.0	5.5
Eggs	175.3 ± 39.7	1.8	1200.5 ± 319.5	10.4	173.2 ± 62.3	4.8
Tunicates	167.5 ± 71.6	1.7	47.2 ± 12.4	<1.0	26.4 ± 6.9	<1.0
Nematodes	165.0 ± 37.0	1.7	156.6 ± 79.6	1.4	71.3 ± 8.9	2.0
Barnacle nauplii	136.3 ± 73.6	1.4	40.2 ± 9.2	<1.0	479.4 ± 149.8	13.2
Gastropod eggs	130.0 ± 30.9	1.3	111.8 ± 31.3	<1.0	240.4 ± 61.2	6.6
Total	9876.2 ± 2691.0		11567.8 ± 3582.6		3631.1 ± 651.8	

Table 19. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at stations 27 and 31 in the Campbell River marine zone 1982-1984.

Station	27						31					
Year	1982		1983		1984		1982		1983		1984	
Dates	23 Mar-29 Sept		29 Mar-4 Oct		21 Mar-26 Sept		6 Apr-9 Sept		13 Apr-7 Sept		4 Apr-29 Aug	
No. samples	28		26		28		24		22		22	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	xm^{-2} ± 1SE	%	xm^{-2} ± 1SE	%
Eggs	100.9 ± 28.9	3.2	988.3 ± 332.3	45.1	192.1 ± 101.9	9.6	280.8 ± 93.8	2.3	1525.5 ± 612.7	7.2	149.2 ± 59.6	2.6
Copepod nauplii	*1098.0 ± 146.5*	35.2	603.0 ± 127.0	27.5	488.1 ± 102.8	24.4	*4920.8 ± 2348.2	*39.7	4810.1 ± 1683.5	22.7	274.7 ± 62.8	4.8
Calanoids	394.7 ± 69.2	12.6	227.7 ± 29.2	10.4	275.2 ± 49.1	13.7	378.5 ± 70.0	3.1	520.0 ± 114.4	2.5	106.5 ± 19.5	1.9
Harpacticoids	735.2 ± 224.5	23.6	136.5 ± 31.8	6.2	463.6 ± 101.0	23.2	5114.2 ± 2438.9	41.2	12066.6 ± 6548.2	56.9	3378.1 ± 965.1	59.2
Tunicates	334.1 ± 158.7	10.7	59.2 ± 21.0	2.7	40.1 ± 11.6	2.0	51.1 ± 19.6	<1.0	37.3 ± 13.3	<1.0	9.1 ± 2.2	<1.0
Nematodes	74.1 ± 16.9	2.4	31.2 ± 6.0	1.4	67.9 ± 10.5	3.4	177.3 ± 50.6	1.4	313.1 ± 177.4	1.5	75.6 ± 15.4	1.3
Barnacle nauplii	38.1 ± 10.2	1.2	25.7 ± 4.1	1.2	224.5 ± 86.0	11.2	35.0 ± 17.1	<1.0	60.9 ± 19.6	<1.0	803.7 ± 312.9	14.1
Amphipods	133.4 ± 76.8	4.3	14.8 ± 5.5	<1.0	58.0 ± 13.6	2.9	885.3 ± 322.6	7.1	1421.8 ± 688.2	6.7	244.3 ± 98.5	4.3
Worms	74.9 ± 25.6	2.4	4.2 ± 1.2	<1.0	32.0 ± 11.8	1.6	75.1 ± 14.0	<1.0	14.7 ± 6.0	<1.0	13.9 ± 3.6	<1.0
Barnacle cypris	31.4 ± 9.8	1.0	0.3 ± 0.3	<1.0	11.7 ± 4.0	<1.0	7.8 ± 2.1	<1.0	1.9 ± 1.5	<1.0	2.9 ± 1.9	<1.0
Polychaetes	31.6 ± 18.0	1.0	14.7 ± 3.5	<1.0	16.9 ± 3.3	<1.0	3.3 ± 1.8	<1.0	40.9 ± 9.7	<1.0	15.5 ± 4.3	<1.0
Gastropod eggs	20.0 ± 2.4	<1.0	19.4 ± 2.7	<1.0	64.4 ± 26.2	3.2	298.2 ± 70.4	2.4	231.1 ± 63.1	1.1	464.5 ± 120.2	8.1
Ectoprocts	5.9 ± 1.2	<1.0	13.5 ± 3.5	<1.0	26.1 ± 4.3	1.3	12.8 ± 4.4	<1.0	21.5 ± 14.7	<1.0	34.9 ± 8.7	<1.0
Ostracods	4.7 ± 1.8	<1.0	14.3 ± 6.9	<1.0	5.1 ± 2.2	<1.0	113.3 ± 66.5	<1.0	28.6 ± 9.4	<1.0	63.1 ± 20.9	1.1
Total	3122.1 ± 416.2		2189.9 ± 353.8		2002.9 ± 273.4		12400.2 ± 4881.4		21212.2 ± 7577.5		5703.3 ± 1328.7	

*Calculated value

Table 20. Dominant food items as a percent of total diet in juvenile wild and marked hatchery chinook stomachs at stations 24 and 27 in the Campbell River marine zone 1982-1984.

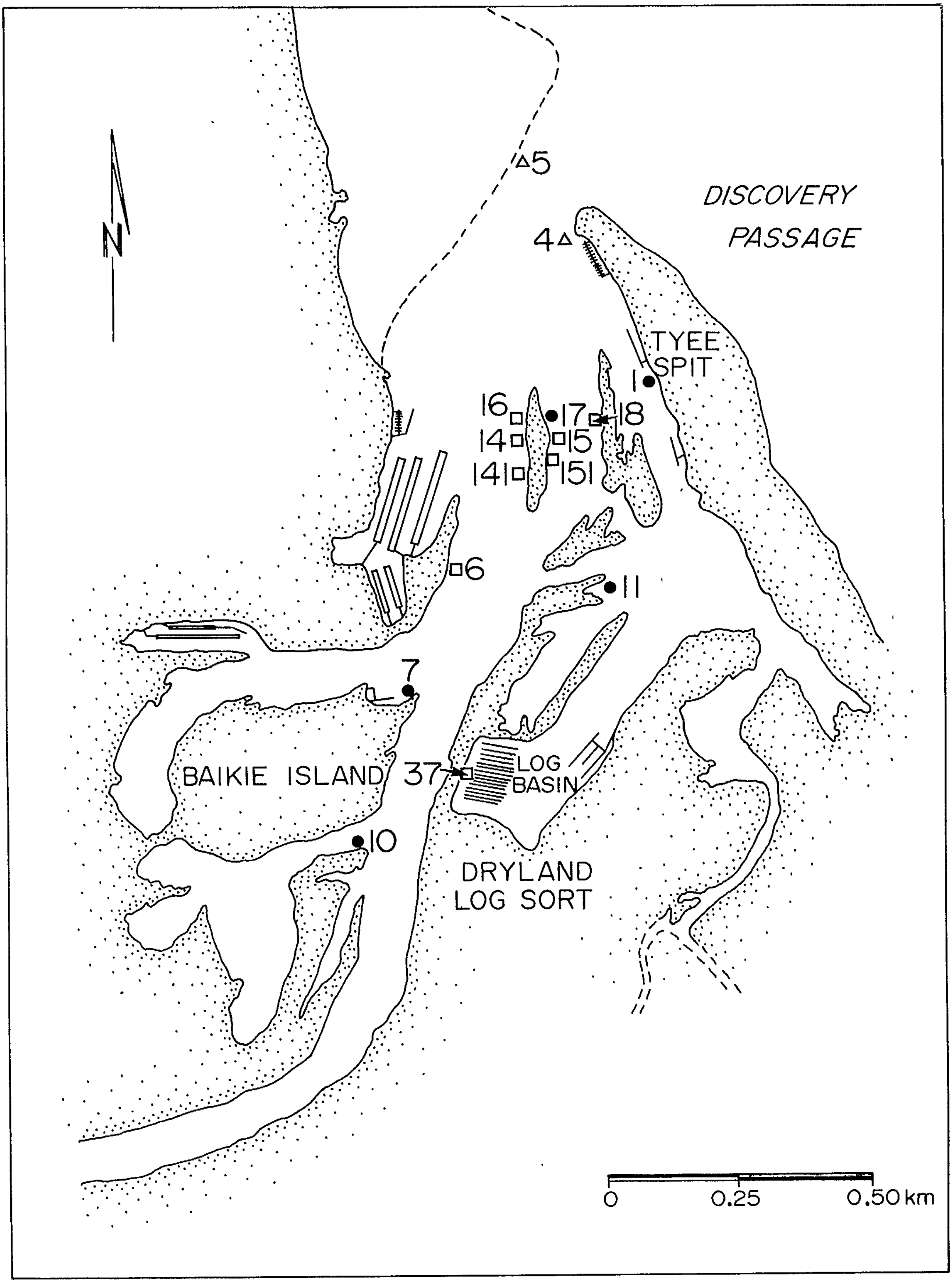
Wild or Marked	wild	wild	marked	marked
Station	27	27	24	24
Dates	4 Aug	20 June	20 July-4 Aug	4 July
Year	1982	1984	1982	1984
No. analyzed	5	5	9	5
Range in length(mm)	69-80	57-71	100-121	102-116
Range in weight(gm)	3.80-6.00	2.4-4.1	10.80-19.50	10.7-19.1
Number stomachs empty	0	0	0	1
Food group				
Pelagic calanoids & cyclopoids	11.4	<1.0	3.2	<1.0
Juvenile and adult insects	7.4	9.3	<1.0	<1.0
Epibenthic amphipods	15.9	14.0	2.2	<1.0
Epibenthic harpacticoids	1.7	2.3	-	12.4
Pelagic amphipods	4.6	-	16.7	-
Decapod larvae	56.8	-	68.5	-
Fish	1.1	-	<1.0	1.6
Pelagic euphausiids	-	-	1.5	<1.0
Epibenthic ostracods	-	-	6.0	-
Pelagic cirripede larvae	-	71.9	-	83.7

Table 21. Mean density m^{-2} ± 1SE and percent of total population of dominant epibenthos at all stations combined Campbell River zonal comparison 1984.

Zone	Estuarine		Transition		Marine	
Dates	9 Jan-25 Sept		9 Jan-26 Sept		10 Jan-26 Sept	
No. samples	134		92		56	
Taxa	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%	$\bar{x}m^{-2}$ ± 1SE	%
Nematodes	225.7 ± 48.1	33.8	147.9 ± 37.0	10.5	64.5 ± 8.4	2.0
Ostracods	135.3 ± 33.4	20.3	15.2 ± 2.9	1.1	27.4 ± 9.1	<1.0
Copepod nauplii	109.1 ± 15.8	16.3	398.1 ± 48.6	28.3	361.2 ± 59.5	11.1
Harpacticoids	76.9 ± 12.2	11.5	310.1 ± 42.0	22.0	1560.9 ± 425.9	47.8
Worms	32.7 ± 12.9	4.9	7.6 ± 1.3	<1.0	21.5 ± 6.2	<1.0
Mysids	16.6 ± 4.8	2.5	1.4 ± 0.5	<1.0	-	-
Cladocerans	14.9 ± 4.1	2.2	4.1 ± 1.0	<1.0	<1.0	<1.0
Calanoids	14.7 ± 2.7	2.2	126.1 ± 30.5	9.0	185.5 ± 28.3	5.7
Amphipods	12.8 ± 3.7	1.9	120.3 ± 43.8	8.6	125.2 ± 40.9	3.8
Acarinans	10.9 ± 1.4	1.6	5.1 ± 1.1	<1.0	3.3 ± 1.0	<1.0
Eggs	7.3 ± 1.1	1.1	52.9 ± 10.3	3.8	156.2 ± 55.9	4.8
Gastropod eggs	1.3 ± 0.2	<1.0	37.4 ± 5.6	2.7	214.6 ± 55.5	6.6
Barnacle nauplii	<1.0	<1.0	79.3 ± 15.6	5.6	428.3 ± 135.0	13.1
Tunicates	<1.0	<1.0	15.7 ± 2.8	1.1	24.1 ± 6.2	<1.0
Polychaetes	<1.0	<1.0	28.7 ± 7.7	2.0	14.6 ± 2.4	<1.0
Total	667.9 ± 107.4		1406.8 ± 146.5		3264.5 ± 598.6	

FIGURES

Fig. 1. Map of the Campbell River estuary and surrounding area showing the location of the five estuarine zone stations (solid circles) sampled with the epibenthic sled in 1984. Open squares (estuarine zone) and open triangles (transition zone) show additional locations where juvenile chinook salmon were collected for stomach analysis.



DISCOVERY
PASSAGE
TYEE
SPIT
BAIKIE ISLAND
LOG
BASIN
DRYLAND
LOG SORT
N
1
4
5
6
7
10
11
14
141
15
151
16
17
18
37
0
0.25
0.50 km

Fig. 2. Map of Discovery Passage showing the location of the three transition zone stations (open circles) and two marine zone stations (solid triangles) sampled with the epibenthic sled in 1984. Solid squares show additional locations in the marine zone where juvenile chinook salmon were collected for stomach analysis.

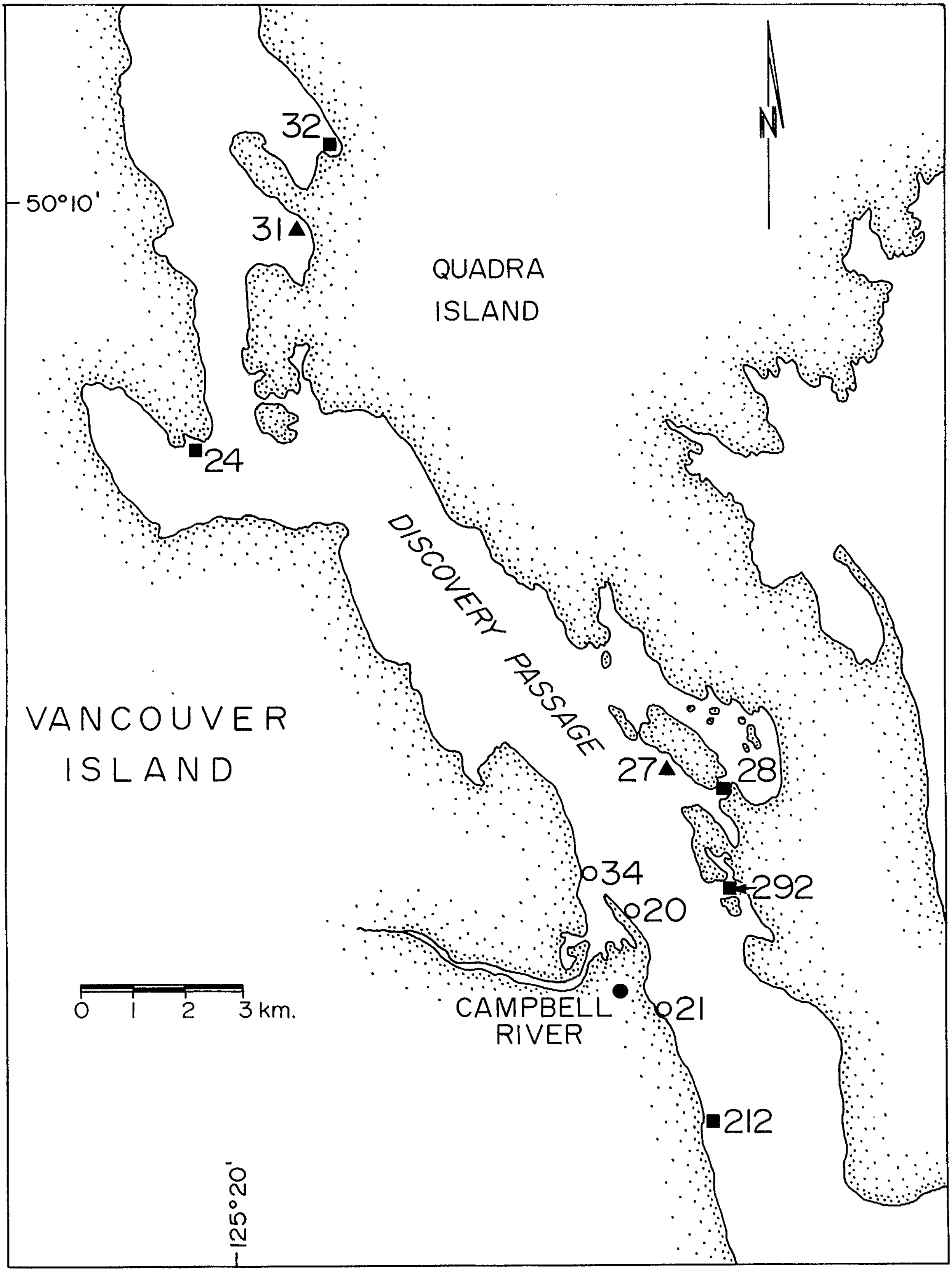

QUADRA
ISLAND
VANCOUVER
ISLAND
DISCOVERY PASSAGE
CAMPBELL
RIVER
N
50°10'
125°20'
0 1 2 3 km.
32
31
24
27
28
292
34
20
21
212

Fig. 3. Campbell River estuarine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

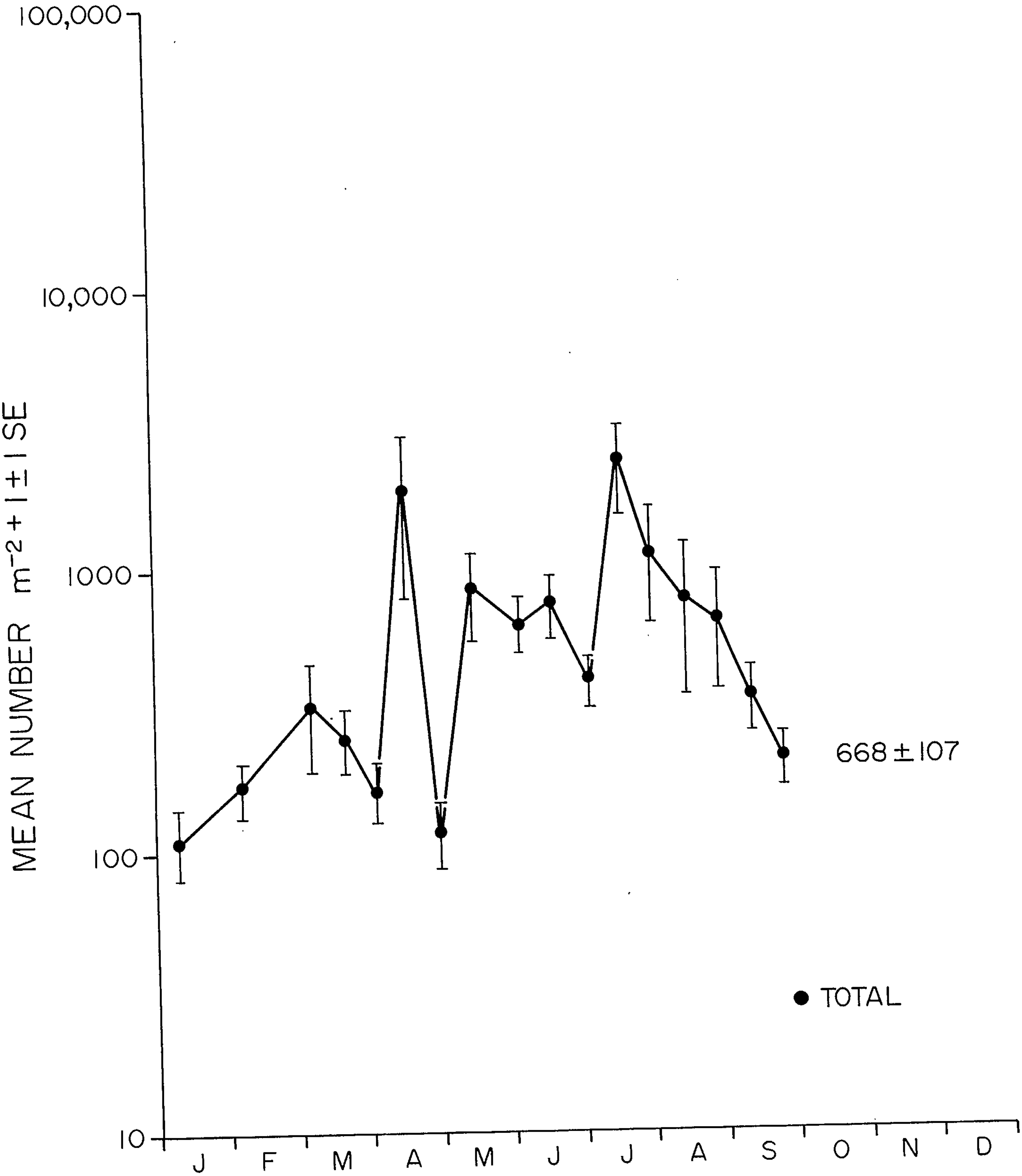

100,000
10,000
1000
100
10
MEAN NUMBER m-2 + 1 ± 1 SE
J
F
M
A
M
J
J
A
S
O
N
D
668 ± 107
● TOTAL

Fig. 4a. Campbell River estuarine zone 1984. Total mean epifauna m^{-2}+1 ± 1SE by date for station 1.

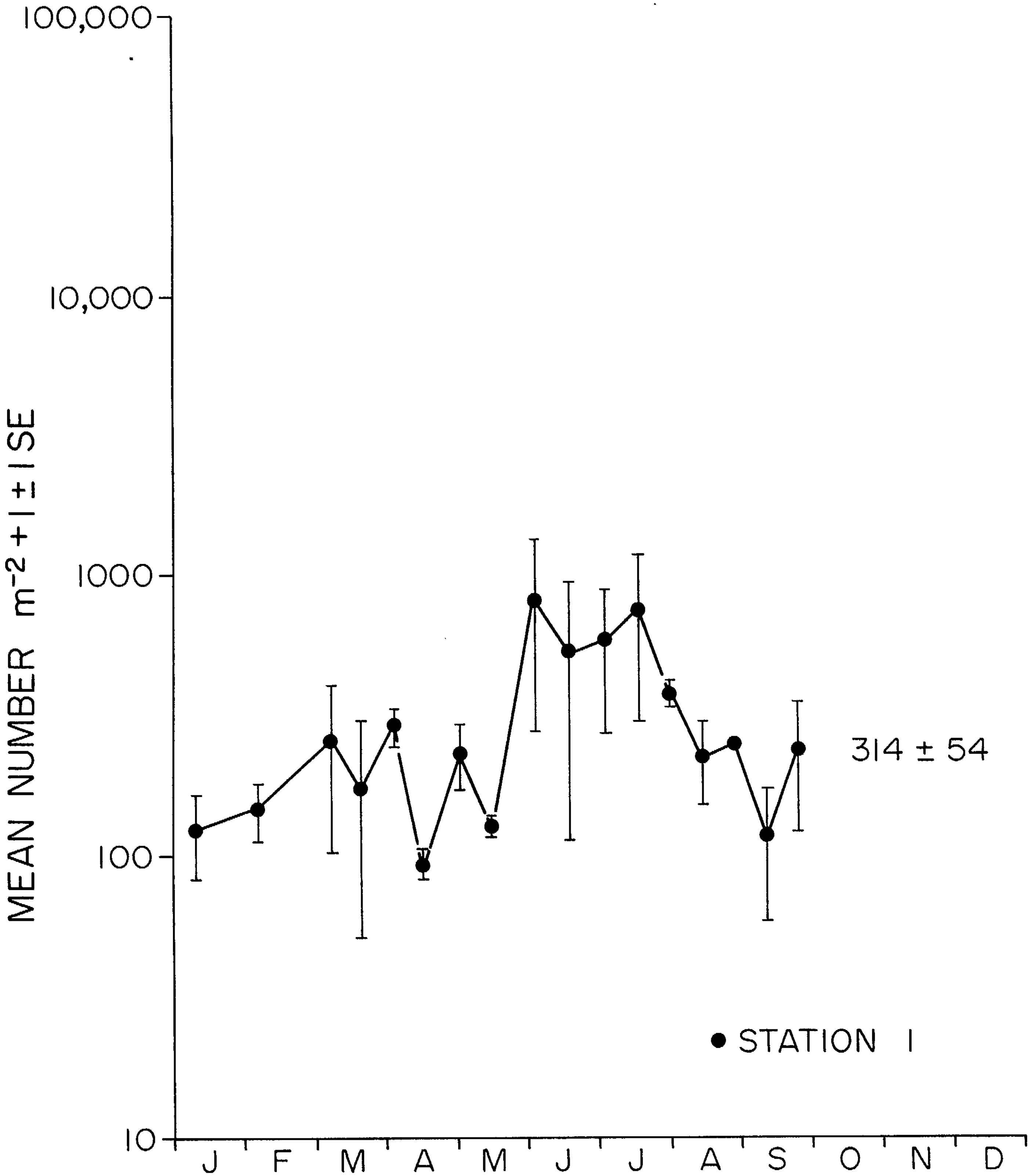

100,000
10,000
1000
100
10
MEAN NUMBER m-2 + 1 ± 1 SE
314 ± 54
STATION 1
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 4b. Campbell River estuarine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 7.

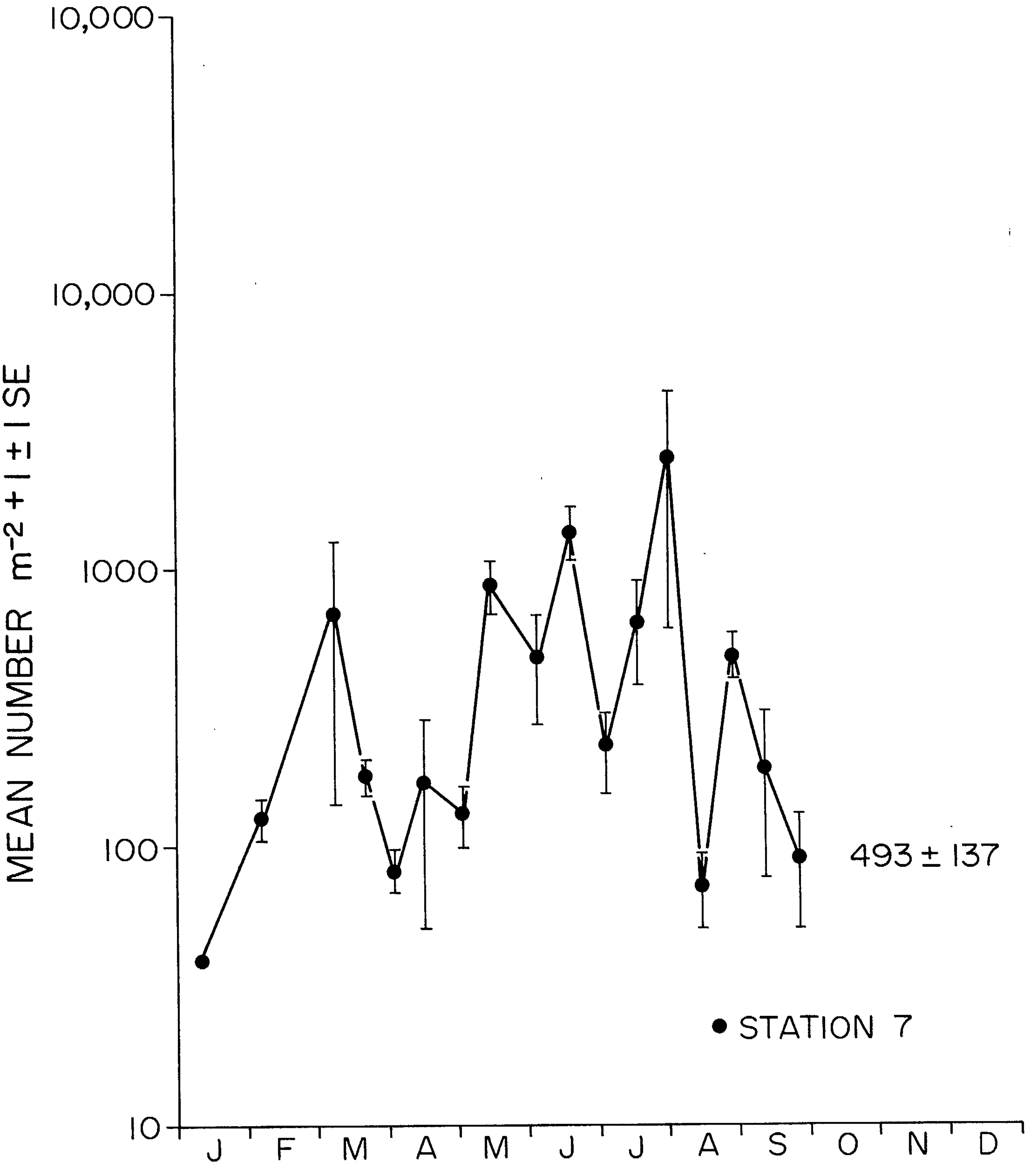

10,000
10,000
1000
100
10
MEAN NUMBER m-2 + 1 ± 1 SE
J
F
M
A
M
J
J
A
S
O
N
D
493 ± 137
STATION 7

Fig. 5a. Campbell River estuarine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 11.

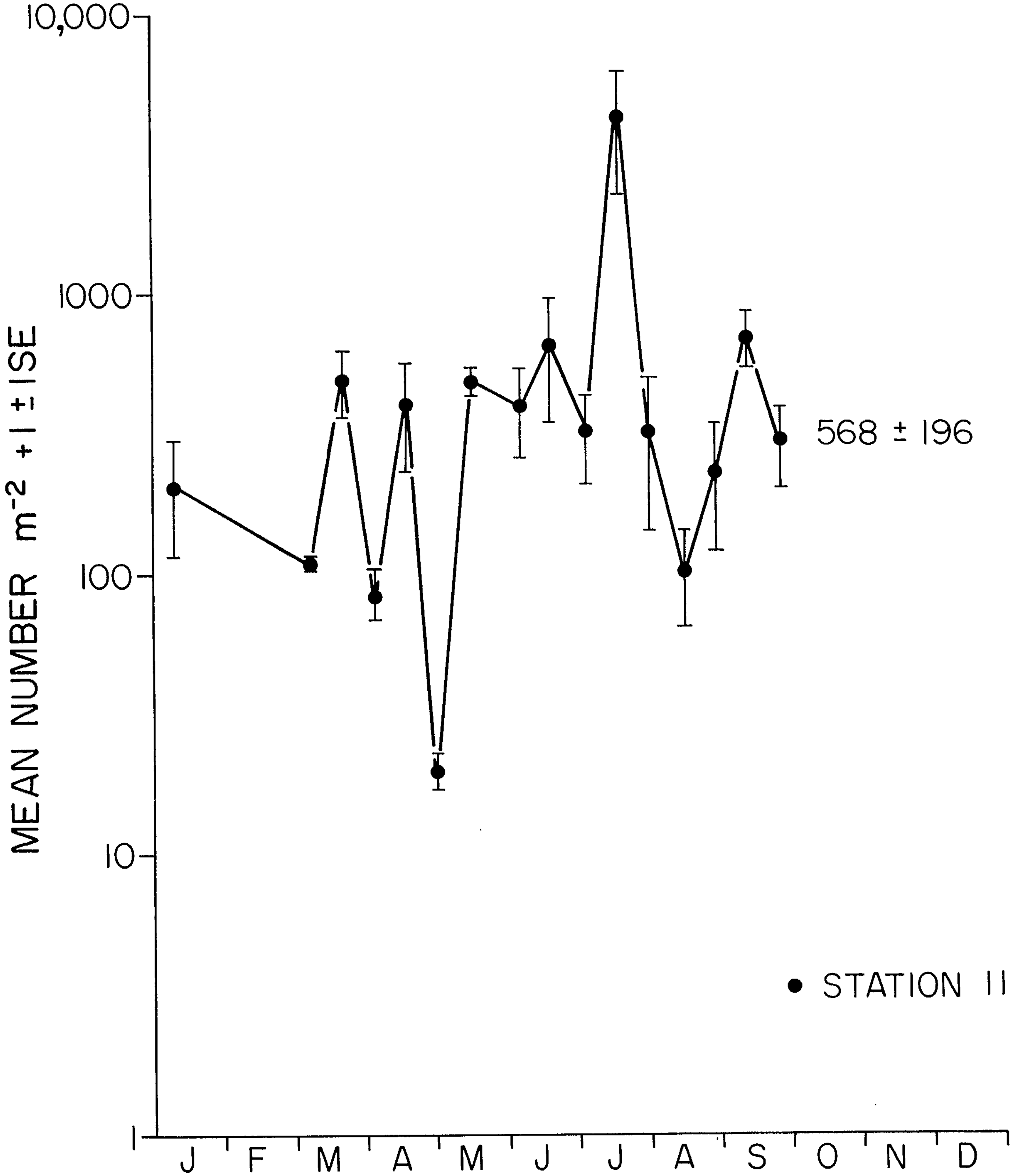

10,000
1000
100
10
1
MEAN NUMBER m-2 +1 ± 1SE
568 ± 196
● STATION 11
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 5b. Campbell River estuarine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 17.

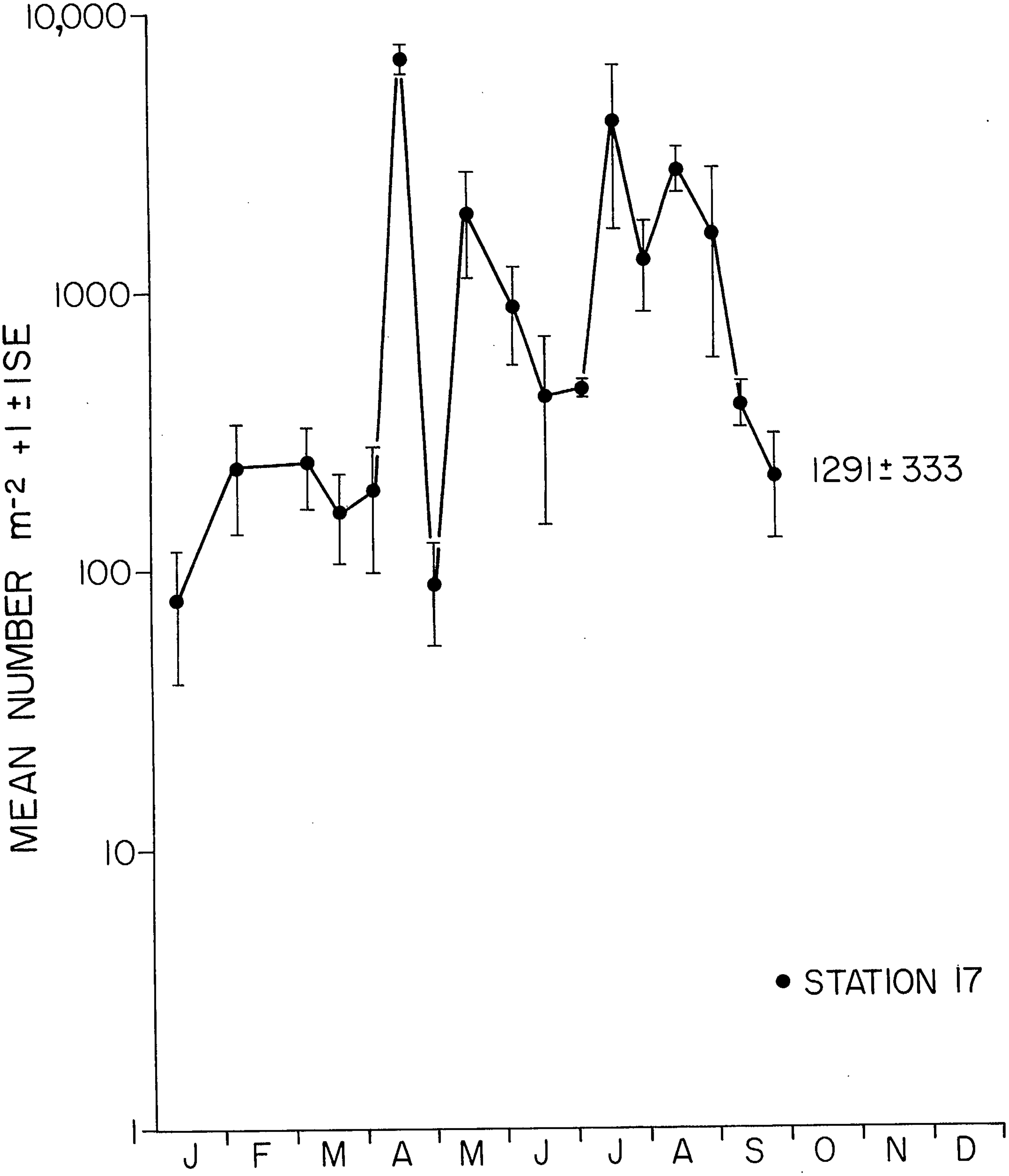

10,000
1000
100
10
1
MEAN NUMBER m-2 +1 ± ISE
1291 ± 333
• STATION 17
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 6. Campbell River estuarine zone 1982-1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

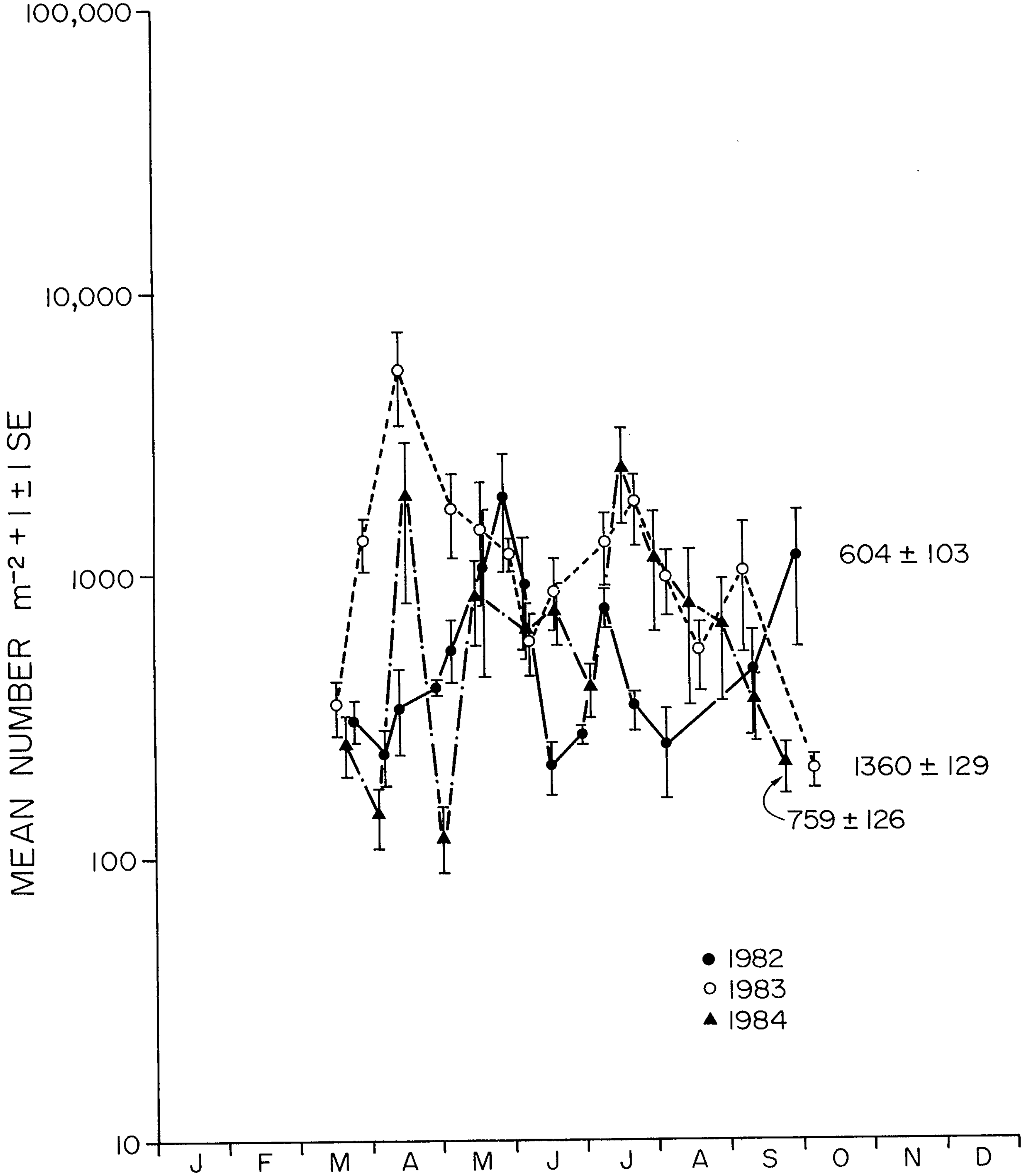

100,000
10,000
1000
100
10
MEAN NUMBER m^{-2} + I ± I SE
J
F
M
A
M
J
J
A
S
O
N
D
604 ± 103
1360 ± 129
759 ± 126
● 1982
○ 1983
▲ 1984

Fig. 7. Campbell River transition zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

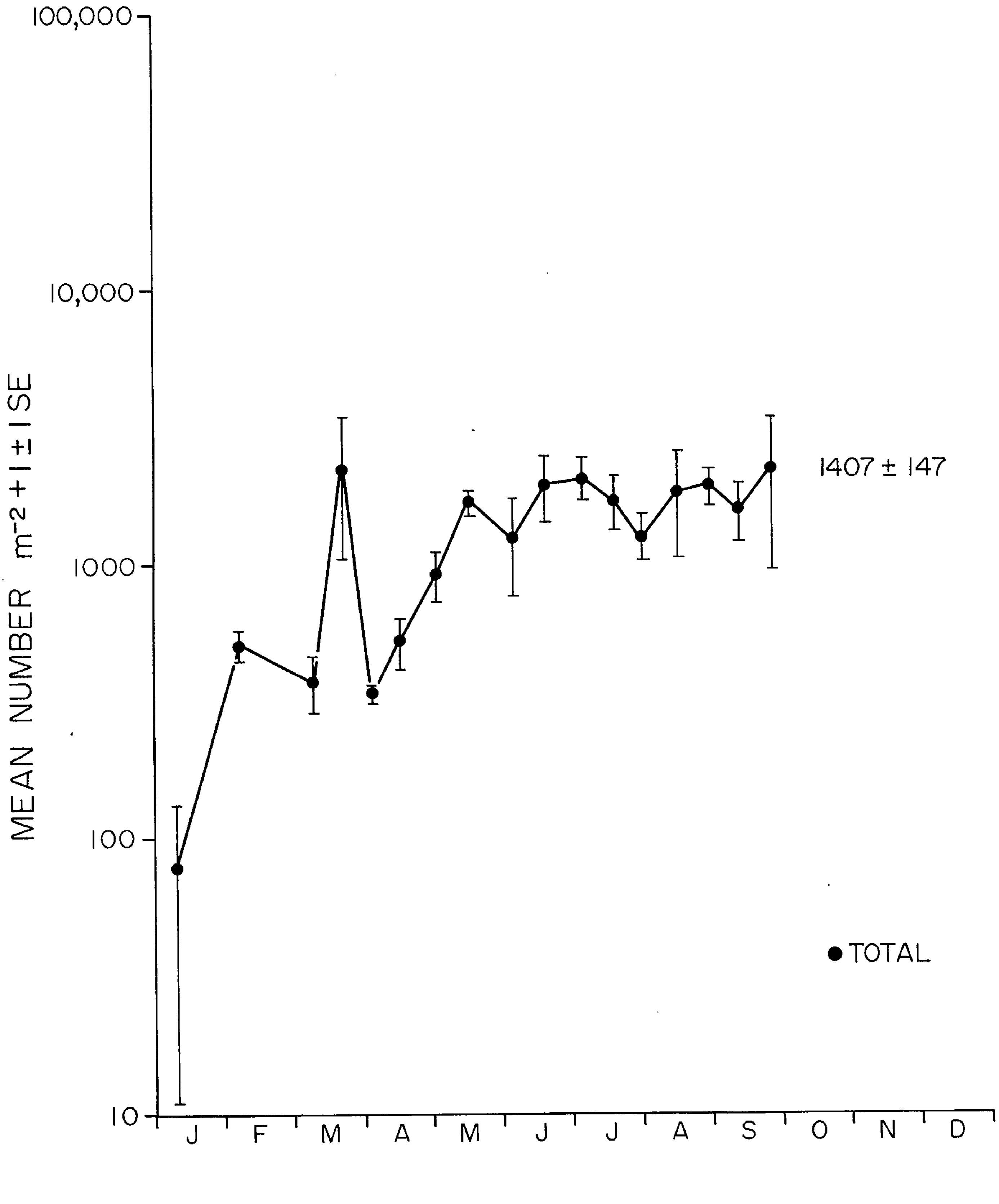

100,000
10,000
1000
100
10
MEAN NUMBER m-2 + 1 ± 1 SE
1407 ± 147
TOTAL
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 8a. Campbell River transition zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 20.

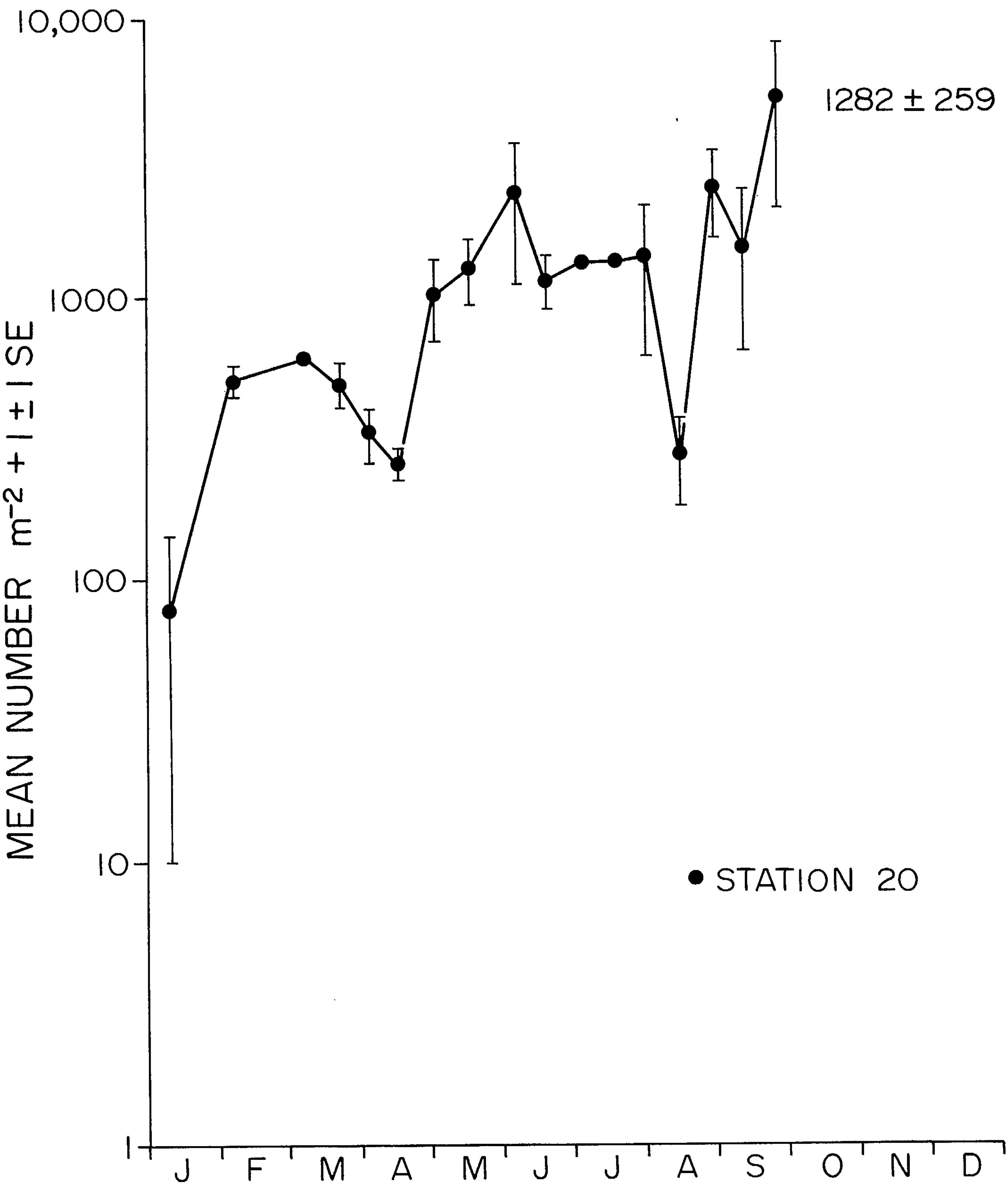

10,000
1000
100
10
1
MEAN NUMBER m-2 + I ± I SE
1282 ± 259
● STATION 20
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 8b. Campbell River transition zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 21.

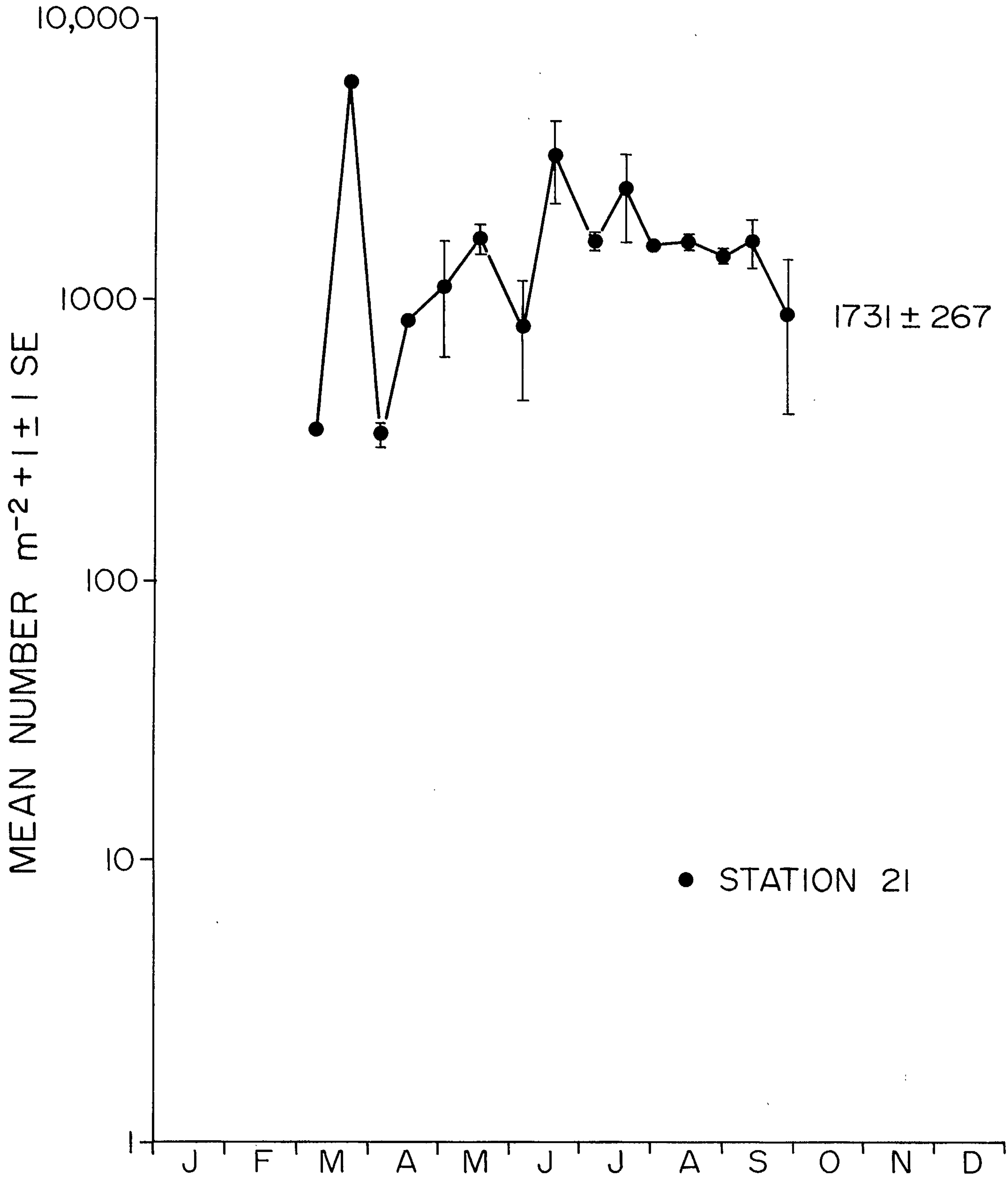

10,000
1000
100
10
1
MEAN NUMBER m⁻² + 1 ± 1 SE
1731 ± 267
STATION 21
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 8c. Campbell River transition zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 34.

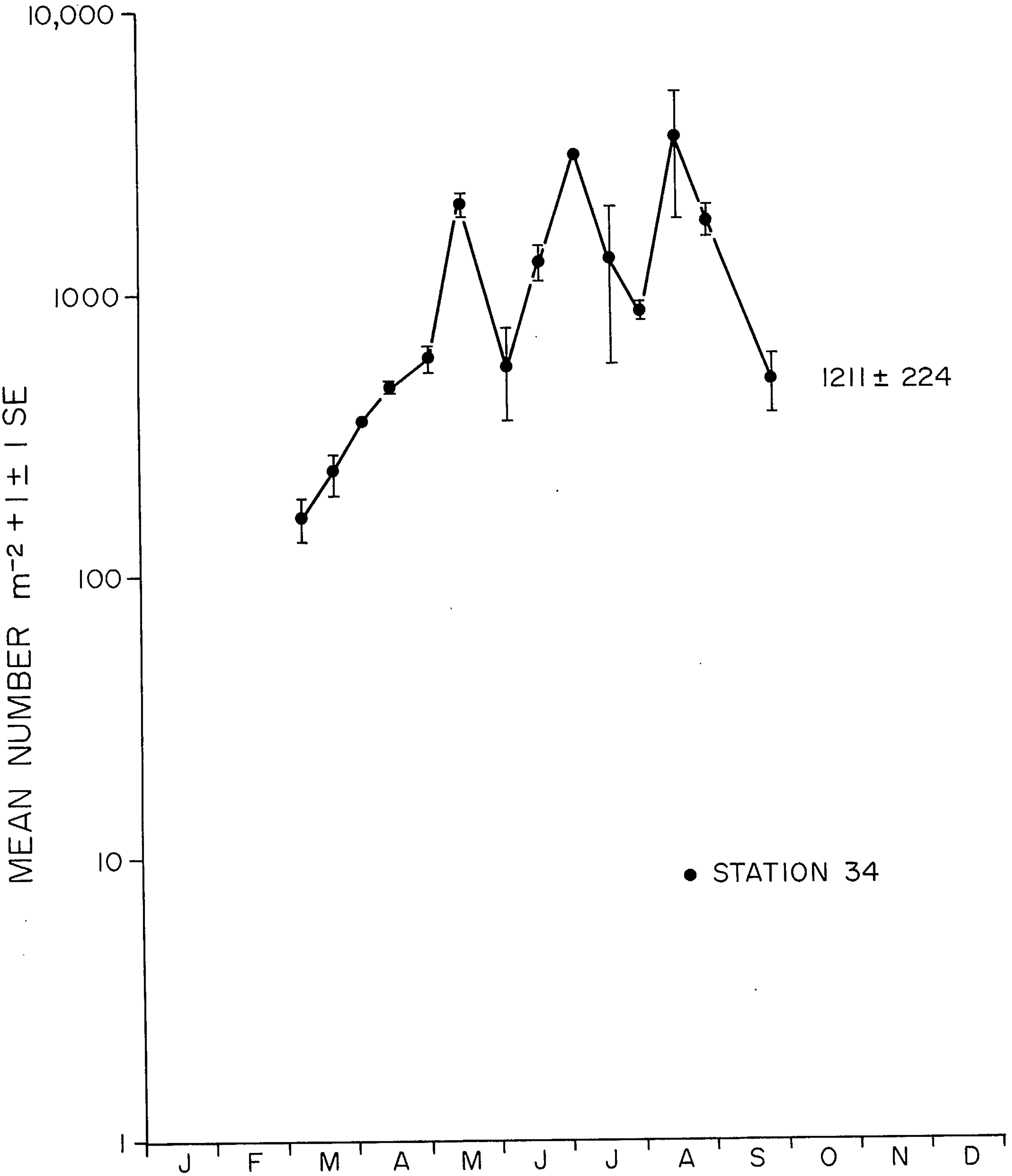

10,000
1000
100
10
1
MEAN NUMBER m⁻² + 1 ± 1 SE
1211 ± 224
● STATION 34
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 9. Campbell River transition zone 1983-1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

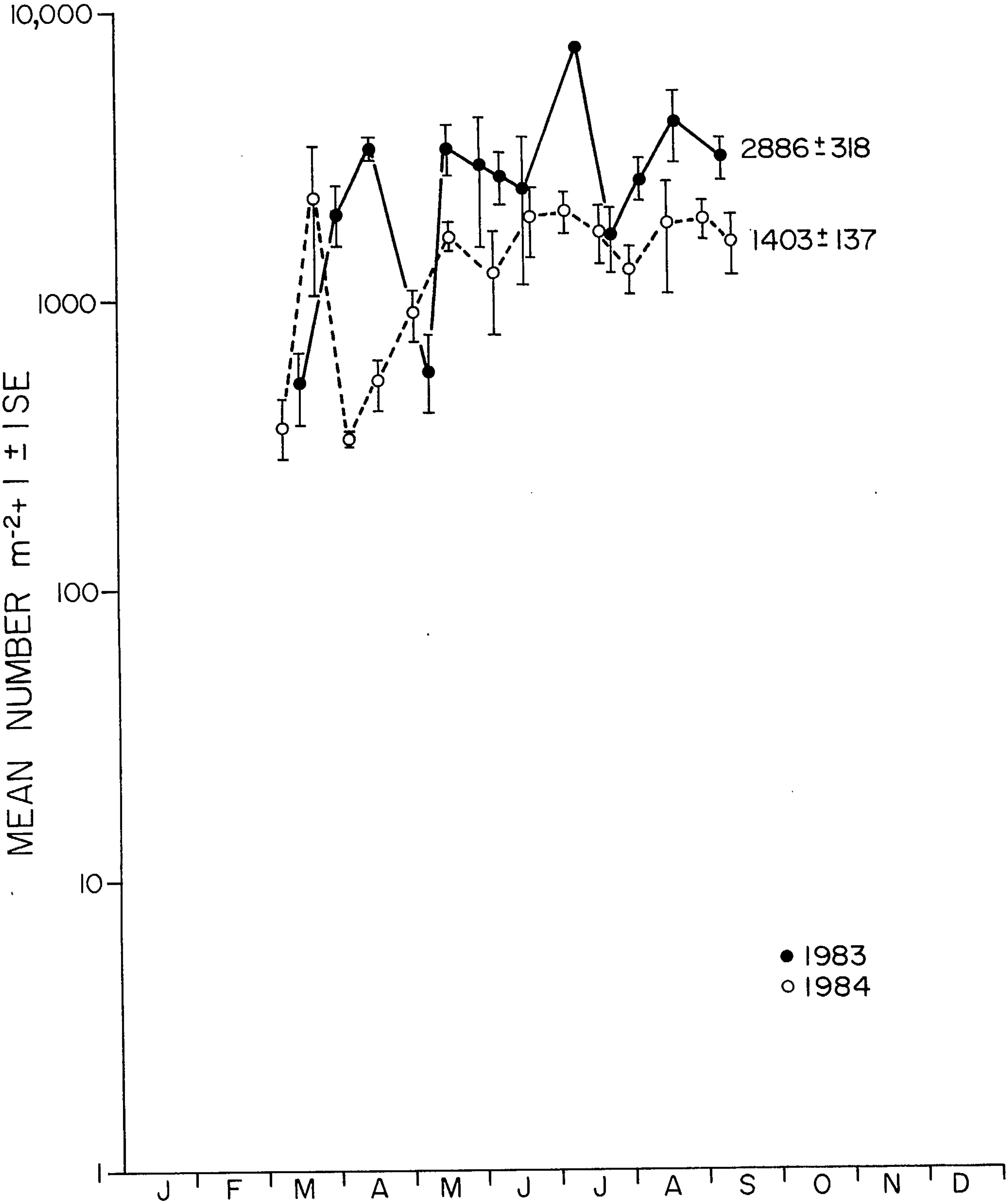

10,000
1000
100
10
1
MEAN NUMBER m-2 + 1 ± 1 SE
2886 ± 318
1403 ± 137
● 1983
○ 1984
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 10. Campbell River marine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

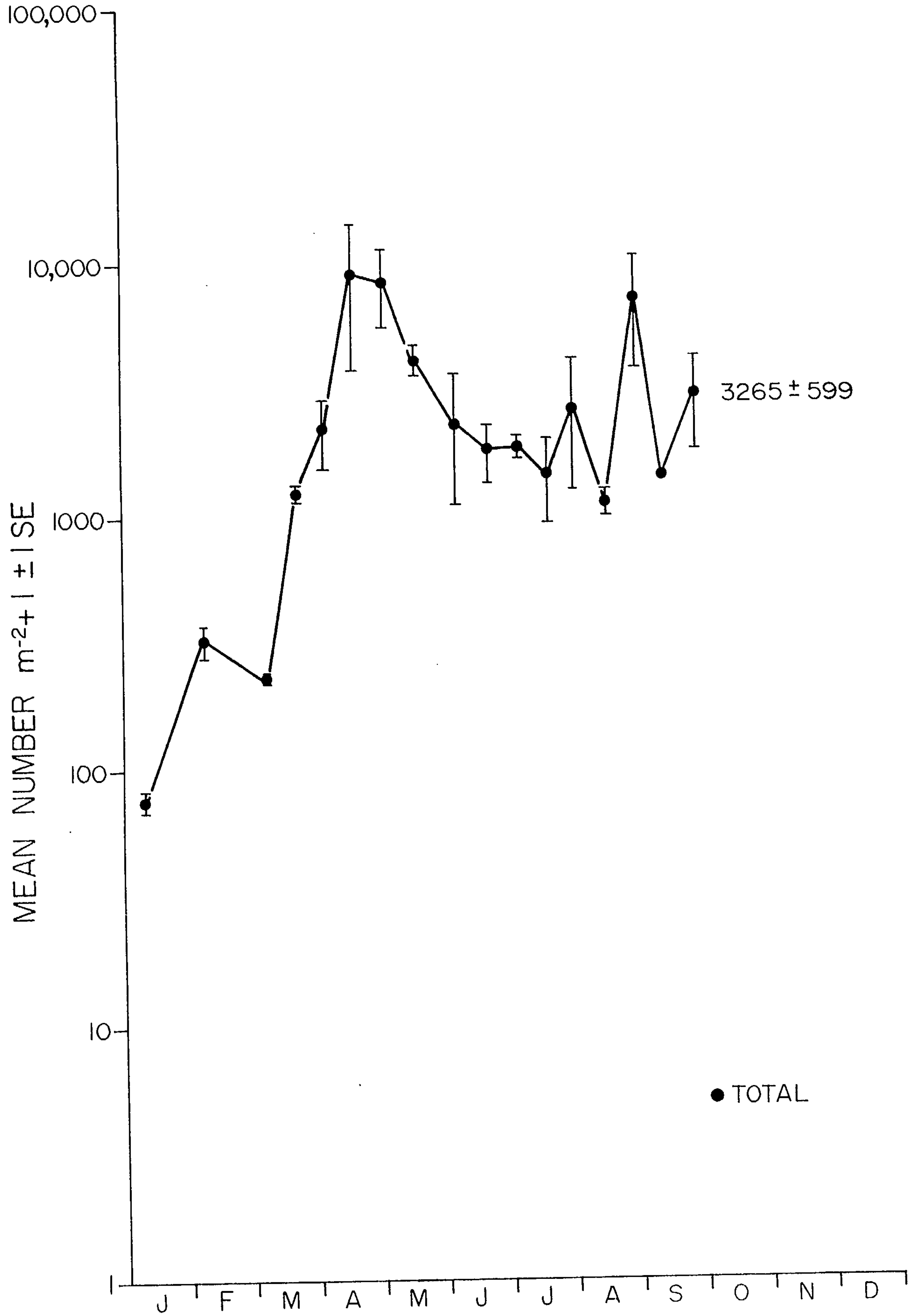

100,000
10,000
1000
100
10
1
MEAN NUMBER m-2 + 1 ± 1 SE
3265 ± 599
TOTAL
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 11a. Campbell River marine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 27.

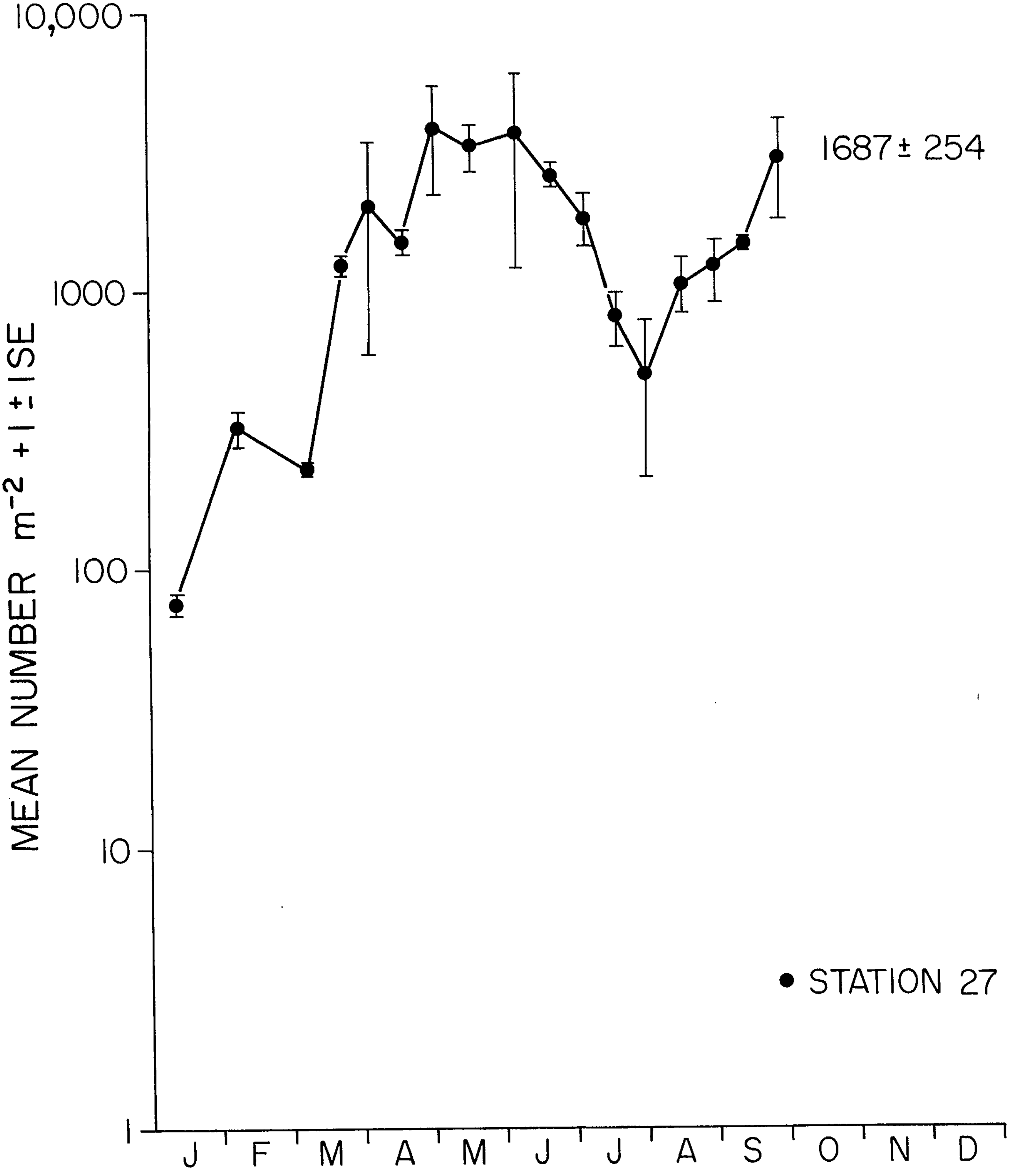

10,000
1000
100
10
1
MEAN NUMBER m-2 + 1 ± 1SE
1687 ± 254
● STATION 27
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 11b. Campbell River marine zone 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for station 31.

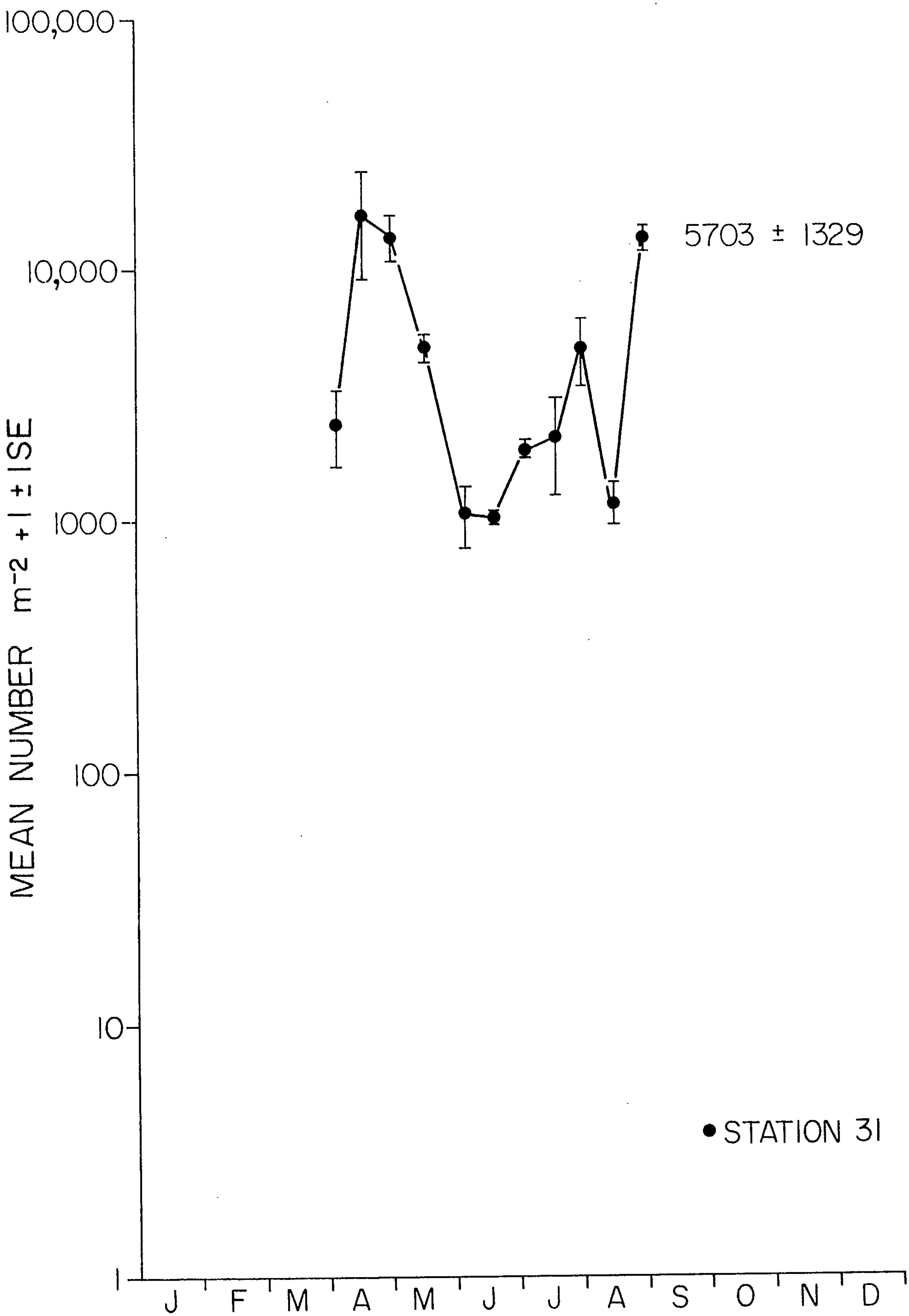

100,000
10,000
1000
100
10
1
MEAN NUMBER m⁻² + 1 ± 1SE
5703 ± 1329
STATION 31
J F M A M J J A S O N D

Fig. 12. Campbell River marine zone 1982-1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.

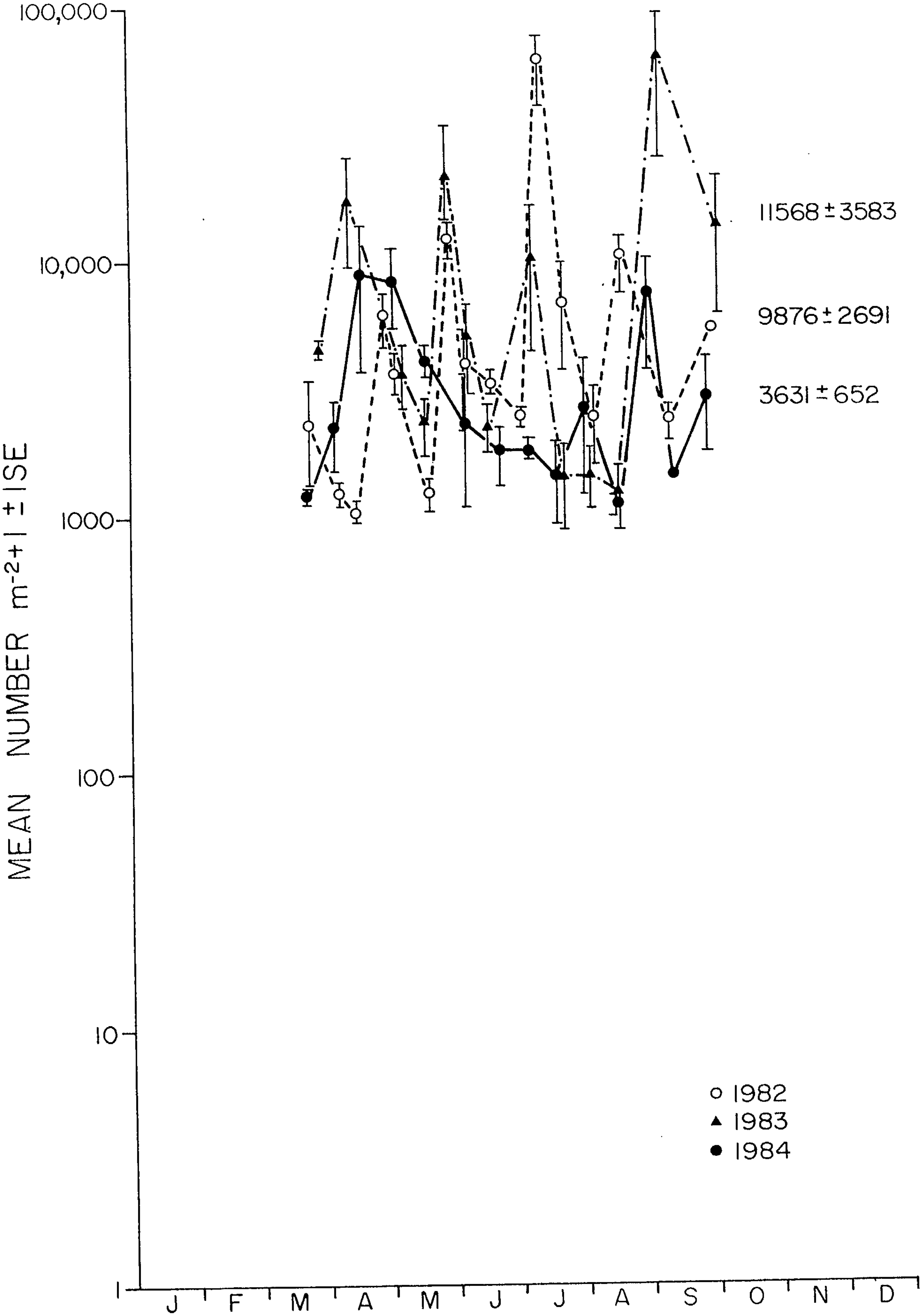
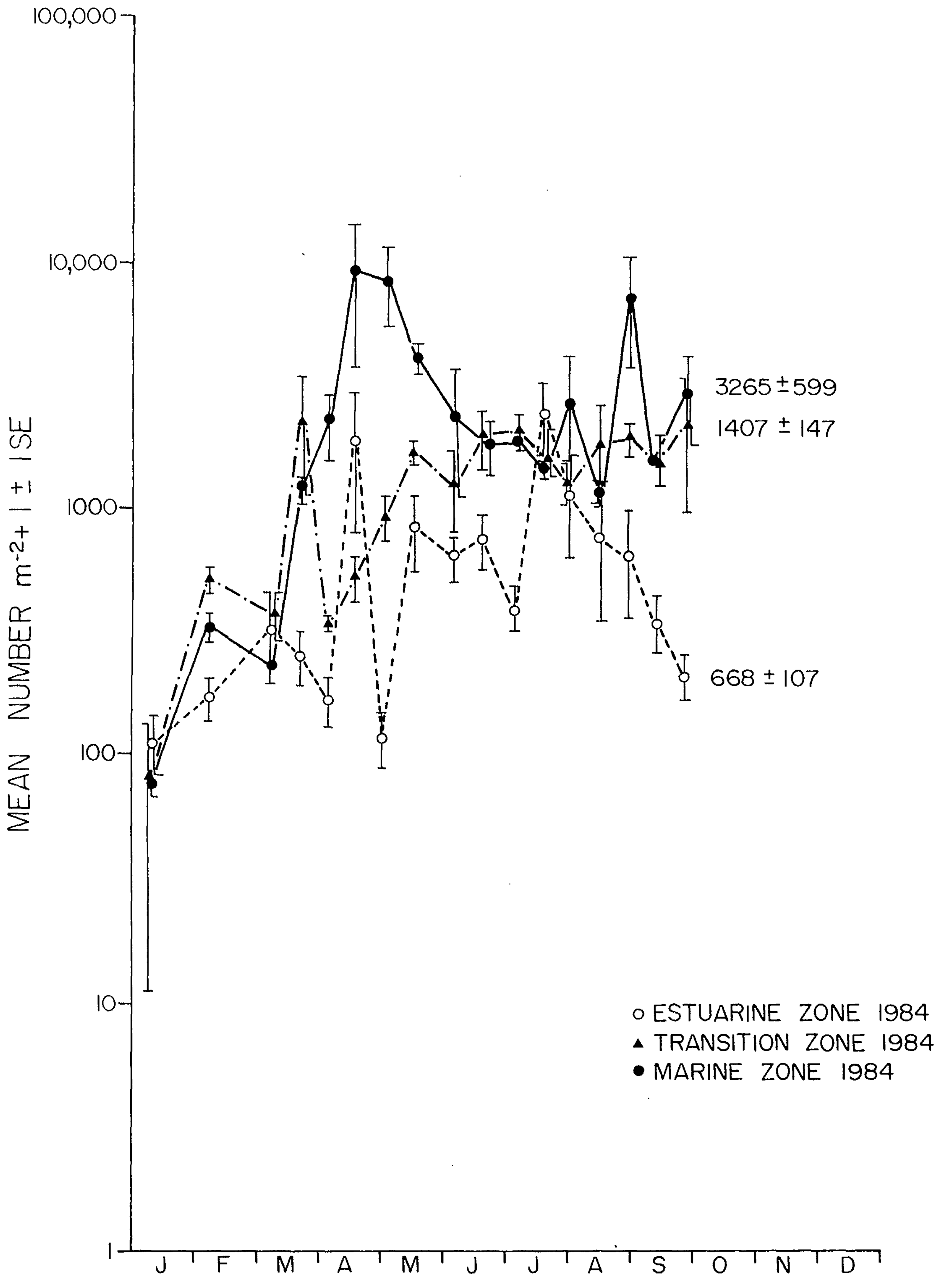

100,000
10,000
1000
100
10
1
MEAN NUMBER m-2+1 ± 1SE
11568 ± 3583
9876 ± 2691
3631 ± 652
1982
1983
1984
J
F
M
A
M
J
J
A
S
O
N
D

Fig. 13. Campbell River zonal comparison 1984. Total mean epifauna $m^{-2}+1 \pm 1SE$ by date for all stations combined.


100,000
10,000
1000
100
10
1
MEAN NUMBER m-2+ I ± ISE
J F M A M J J A S O N D
3265 ± 599
1407 ± 147
668 ± 107
○ ESTUARINE ZONE 1984
▲ TRANSITION ZONE 1984
● MARINE ZONE 1984