Calanoid and Cyclopoid Copepods from Nearshore Epibenthic Sled Samples taken at Campbell River Estuary and Discovery Passage in 1982

T. J. Brown, C. D. McAllister, and B. A. Kask

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

March 1987

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1935

Fisheries and Oceans Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences No. 1935

March 1987

CALANOID AND CYCLOPOID COPEPODS FROM NEARSHORE EPIBENTHIC SLED SAMPLES TAKEN AT CAMPBELL RIVER ESTUARY AND DISCOVERY PASSAGE IN 1982

by

T. J. Brown, C. D. McAllister, and B. A. Kask

Department of Fisheries and Oceans

Fisheries Research Branch

Pacific Biological Station

Nanaimo, British Columbia V9R 5K6

Cat. No. Fs 97-4/1935E ISSN 0706-6473

Correct citation for this publication:

Brown, T. J., C. D. McAllister, and B. A. Kask. 1987. Calanoid and cyclopoid copepods from nearshore epibenthic sled samples taken at Campbell River estuary and Discovery Passage in 1982. Can. MS Rep. Fish. Aquat. Sci. 1935: 37 p.

ABSTRACT

Brown, T. J., C. D. McAllister, and B. A. Kask. 1987. Calanoid and cyclopoid copepods from nearshore epibenthic sled samples taken at Campbell River estuary and Discovery Passage in 1982. Can. MS Rep. Fish. Aquat. Sci. 1935: 37 p.

One hundred forty-six epibenthic sled samples were collected from 18 sites in the Campbell River estuary and Discovery Passage. The calanoid and cyclopoid copepods in the estuarine samples were dominated by Cyclops sp. Unidentified copepodites and Pseudocalanus minutus appeared numerically dominant in the few samples from the transition zone while unidentified copepodites and Cyclopina gracilis were dominant in the marine zone.

The examination of 164 wild and 191 hatchery chinook stomachs indicated a seasonal preference for calanoids which ended in June. The loss of calanoids as a major dietary item for juvenile chinook corresponded to the disappearance of Neocalanus plumchrus from the marine zone sled samples. This is in accordance with Neocalanus plumchrus' life cycle in which the stage V copepodites migrate to deeper water in June and July.

RESUME

Brown, T. J., C. D. McAllister, and B. A. Kask. 1987. Calanoid and cyclopoid copepods from nearshore epibenthic sled samples taken at Campbell River estuary and Discovery Passage in 1982. Can. MS Rep. Fish. Aquat. Sci. 1935: 37 p.

Au cours de l'échantillonnage au traîneau de 18 emplacements de l'estuaire de la rivière Campbell et du passage Discovery, on a recueilli 146 échantillons de la faune épibenthique. Parmi les Copépodes Calanoïdes et Cyclopoïdes estuariens, Cyclops sp. était l'espèce dominante tandis que dans les quelques échantillons prélevés dans la zone de transition, des Copépodes non identifiés et Pseudocalanus minutus semblaient être les plus nombreux. Dans la zone marine, des Copépodes non identifiés et Cyclopina gracilis avaient l'avantage numérique.

L'examen des contenus stomacaux de 164 saumons quinnats sauvages et 191 quinnats d'élevage a révélé une préférence saisonnière pour les Calanoïdes que a pris fin en juin. La disparition de Neocalanus plumchrus dans les échantillons recueillis au traîneau dans la zone marine coïncidait avec l'absence des Calanoïdes comme principal aliment du régime des quinnats juvéniles. Ceci correspond avec le cycle vital de cette espèce qui, au stade V, migre vers les eaux plus profondes en juin et juillet.

LIST OF TABLES

FIGURE CAPTIONS

INTRODUCTION

The Campbell River estuary lies on the eastern shore of Vancouver Island at latitude 50°03' north and longitude 125°15' west. The Campbell River and its main tributary, the Quinsam River, have a combined annual mean flow of 108 cms^{-1} and provide the main freshwater discharge to the estuary (Bell and Thompson 1977). The freshwater from the river mixes quickly into Discovery Passage which is characterized by strong tidal streams and narrow channels. The local two layered estuarine system does not exist far beyond the mouth of the river itself. The estuary is rather small, about 100 ha in area, and is confined by Tyee Spit and the tidal currents of Discovery Passage (Fig. 1). The salt wedge may retreat from the main river channel on large ebb tides but is always present in the deeper portions of the estuary (A. Ages, unpubl. data). The tides cause significant portions of the estuary to be alternately exposed to fresh, brackish and high salinity water.

In March 1981 an agreement was reached between Fisheries agencies and British Columbia Forest Products on the location of a dry land sort facility. This agreement included the clean up of the old booming ground and the construction of 4 intertidal islands within the estuary. The islands were planted with marsh grasses to increase the input of organic material into the estuarine food webs (Brownlee et al. 1984). The follow-up study began in March 1982 to assess the utilization of the new islands and marsh habitat by juvenile salmonids. The epibenthic sled (Sibert et al. 1977), which sampled the epibenthos in a layer just above the bottom in nearshore areas, was used in part of this follow-up study.

Sibert (1981), using submersible pumps, describes a dense population of potential prey organisms near the sediment-water interface. The density at the 5 cm level always exceeded the density at the 30 cm level by a factor of 2 to 20. The abundance and species composition of samples from the 5 cm pump were nearly identical to those using the epibenthic sled which sampled within 10 cm of the sediment surface (Sibert 1981). Little work has been done to relate this epibenthic population to the pelagic zooplankton as sampled by Miller plankton nets (Brown et al. in prep.).

MATERIALS AND METHODS

Twenty trips were made to the Campbell River area from March to December 1982. The juvenile salmonids were assessed using a beach seine at 47 stations in the estuary and adjacent waters (Brown et al. 1983). Samples were collected for length-weight determinations (Gordon et al. 1983; Kotyk et al. 1983) and 355 juvenile chinook salmon were analyzed for their stomach contents (Anderson and Galbraith 1984).

The study area was divided into three zones (Fig. 1). The estuarine zone was defined as the rivermouth area bounded by Tyee Spit (Fig. 2). The transition zone included the area of Discovery Passage influenced by the Campbell River, and the marine zone included the rest of Discovery Passage and Seymour Narrows (Fig. 3).

The epibenthic sled, with a mouth opening of 10 cm x 10 cm was fitted with a 100 µ net and pulled over the bottom for 5 meters. The average sample depth was 0.5 m with a volume filtered of 0.05 m^3. Duplicate samples were collected at each site and preserved in 4% formalin and rose bengal. Seven sites were sampled in the estuary, 4 in the transition and 7 in the marine zone producing 146 epibenthic zooplankton samples.

The samples were washed and then counted to major category using a dissecting microscope. When necessary the samples were split, using a Folsom plankton splitter, to yield 100 of the dominant organisms in the subsample. The counts were then multiplied by the split factor and recorded. One hundred of the calanoids and harpacticoids were retained for further identification to species where possible (Kask and Brown 1984). The calanoid species data are presented in Brown et al. 1984. This report presents further analysis of these data. The results, based on irregular sampling at some sites, must be regarded as preliminary but the data suggests many zonal differences and are presented because of the lack of information from this area.

RESULTS AND DISCUSSION

ESTUARINE ZONE

Seventy samples were collected in the estuarine zone between March and December 1982 which contained 31 categories of meiofauna (Kask and Brown 1984; Fig. 2). Twelve categories of calanoids and cyclopoids were found in the estuarine zone, dominated by _Cyclops_ sp. (79.4 m^{-3} ± 26.4) followed by unidentified cyclopoids (35.1 m^3 ± 7.1) and unidentified copepodites (20.0 m^{-3} ± 5.1) ($\bar{X}$ ± 1 SE; Table 1). These 3 categories comprised 91.3% of the total copepod counts while the remaining 8.7% was composed of 9 categories. _Cyclops_ sp. was present throughout the year with a peak in May while unidentified copepodites were most important in early September (Fig. 4).

The comparison of the natural sites (3,7) with the new islands (17,18) was possible over 7 sampling periods comprising a total of 40 samples (Table 4). An analysis of the total copepod counts between the two areas indicated significantly more at the new island sites (t-test, P=0.01). The copepod counts ($\bar{X}$ ± 1 SE) for the established sites were 60.0 m^{-3} ± 12.1 compared to 328.9m^{-3}± 97.5 for the new island sites. An examination of _Cyclops_ sp. concentrations indicated a significant difference, using log transformed data (t-test, P=0.05), between the established and new island sites having 29.1 m^{-3} ± 9.5 and 204.4 m^{-3} ± 96.1 ($\bar{X}$ ± 1 SE) respectively. This data indicates that the increase in copepods at the new island sites was probably due to the presence of Cyclops sp. The source of Cyclops sp. is most likely the headwater lakes of the Campbell River.

There is a pronounced salt wedge in the sea plane channel and log pond and a tidally dependent salt wedge in the new islands and river channel (Fig. 2) (A. Ages, unpubl. data). Despite the marine influence in the estuary, the surface waters sampled by the sled were dominated by freshwater, as indicated by the mean surface salinity of 1.6°/₀₀ ± 0.6 ($\bar{X}$ ± 1 SE; Table 5).

The examination of gut contents of 110 wild and 88 hatchery juvenile chinook salmon from the estuary zone showed that calanoids and cyclopoids were numerically important in their diets (new islands wild chinook, 54.1%; established sites wild and hatchery chinook, 63.3 and 95.4% respectively; Anderson and Galbraith 1984). The combination of Neocalanus plumchrus, Pseudocalanus sp. and Metridia pacifica made up 75.9% and 89.3% of the wild and hatchery chinook calanoid diet (Fig. 7, 8). This indicates that the estuarine chinook did consume copepods but ate organisms mainly of marine origin and not the freshwater cyclopoid, Cyclops sp. dominant in the estuarine sled samples.

TRANSITION ZONE

Four stations were sampled in the transition zone (Fig. 2) producing 12 samples containing 13 categories of copepods (Table 2). Five categories made up 93.2% of the total counts. Unidentified copepodites dominated the transition zone (556.7 m^{-3} ± 237.7) followed by Pseudocalanus minutus (540.0 m^{-3} ± 394.1), Oithona sp. (388.3 m^{-3} ± 239.5) and Neocalanus plumchrus (280.0 m^{-3} ± 197.6) ($\bar{X}$ ± 1 SE). The high concentration of Pseudocalanus minutus observed at one location on April 5 (Fig. 5) was not found in similar concentrations in the estuarine or marine zones. This high population is difficult to explain due to the poor sample coverage within the transition zone. The tidal circulation and exchange from the salt wedge (13.8°/₀₀; Table 5) in this area would seem to preclude the in situ production of a local dominant species at the one location and date where Pseudocalanus was abundant.

A comparison of 40 wild and 71 hatchery chinook stomach contents (Figs. 9, 10) from the transition zone to the sporadic sled samples was not possible. The major copepod concentrations occurred on April 5 at which time no juvenile chinook were examined. A comparison of the transition chinook stomachs to the marine zone copepods (Fig. 6) indicated the preference for Neocalanus plumchrus which corresponded to this calanoid's seasonal peak abundance (April-June; Fulton 1973). The unidentified copepodites, Oithona sp. and Oncaea sp. were also present in high numbers but were not consumed by the juvenile chinook.

MARINE ZONE

Seven stations were sampled in the marine zone (Fig. 3) producing 64 samples and 21 categories of copepods (Table 3). Of the 21 categories, 6 made up 94.1% of the population. The dominant categories were unidentified copepodites, Cyclopina gracilis, Oithona sp. and Neocalanus plumchrus ($957.5\ m^{-3} \pm 155.9$, $884.7\ m^{-3} \pm 298.1$, $440.6\ m^{-3} \pm 72.1$ and $439.1\ m^{-3} \pm 163.4$ respectively) ($\bar{X} \pm 1$ SE). Unidentified copepodites, Oithona sp. and Oncaea sp. were present throughout the sampling period (March to September) while Neocalanus plumchrus occurred in large numbers in May and June. Cyclopina gracilis was dominant in July and August (Fig. 6).

Stations 27 and 31 were the only sites with sufficient samples for between station comparisons in the marine zone. There were 10 periods of coincident sampling producing 40 samples and 21 categories of copepods (Table 6). An examination of the top six categories, which represented >90% of the total counts, showed only one category that was significantly different between the two sites (t-test, p=0.01). The presence of Cyclopina gracilis in high numbers at station 31 could be due to the difference in habitat and reduced currents along the beach compared to station 27. The low numbers of Neocalanus plumchrus at station 31, although not significantly different from station 27, may reflect dilution by the intense mixing in Seymour Narrows and grazing by predators during transport from the southern populations. Strong currents and tidal mixing in Discovery Passage preclude the local production of pelagic zooplankton. The majority of the plankton observed is indicative of the production in the northern part of the Strait of Georgia.

Fourteen wild and 32 hatchery chinook from the marine zone were examined for gut contents (Figs. 11, 12; Anderson and Galbraith 1984). The hatchery chinook consumed mainly Neocalanus plumchrus. The number of wild fish examined from the marine zone was insufficient to show any trends. Those that were examined consumed mainly Calanus pacificus and Calanus marshallae, but in small numbers.

ZONAL COMPARISONS

The mean concentrations of copepods for the estuarine zone, as sampled by the epibenthic sled, was $147.4\ m^{-3} \pm 28.2$ (Table 1) while the transition and marine zones had $2186.5\ m^{-3} \pm 1194.0$ (Table 2) and $3538.1\ m^{-3} \pm 419.7$ ($\bar{X} \pm 1$ SE) (Table 3) respectively. A comparison of the calanoid and cyclopoid concentrations in the three zones were significantly different (t-test, p=0.01).

High freshwater flow and tidal flushing may prevent local planktonic production in the estuary, except perhaps in the log pond and seaplane channel (Fig. 2) (Hara et al., in prep.). The observed plankton most likely results from the transport of zooplankton from the headwater lakes of the Campbell River or via the tidal salt wedge. The estuarine zone, despite marine influence, lacked calanoids and cyclopoids in the surface waters. The lack of copepods and low surface salinities indicates the poor exchange with the marine waters intruding on each tidal cycle and the surface waters.

The transition zone zooplankton counts, although significantly different from the marine zone, contained too few samples to determine local population estimates. The estuarine zone was dominated by the freshwater cyclopoid Cyclops sp. which occurred rarely in the transition zone and not in the marine zone. Unidentified copepodites and Pseudocalanus minutus appeared numerically dominant in the transition zone while unidentified copepodites and Cyclopina gracilis were dominant in the marine zone.

Unidentified copepodites, Oithona sp. and Oncaea sp. were present in the top six categories from all three zones while unidentified cyclopoids and Pseudocalanus minutus were present in the estuarine and transition top six categories. Neocalanus plumchrus was present in the major categories of the transition and marine zones while Cyclops sp. was found mainly in the estuary. Cyclopina gracilis and Paracalanus parvus were present only in the marine zone's top six categories.

The examination of 164 wild and 191 hatchery juvenile chinook from March to September 1982 indicated a seasonal preference for calanoids which ended in June. Pseudocalanus sp. was consumed in the estuarine zone by wild chinook while Neocalanus plumchrus was utilized by wild and hatchery chinook in the estuarine and transition zones and hatchery chinook in the marine zone. Insufficient wild chinook were examined from the marine zone to indicate diet preferences.

The loss of calanoids from juvenile chinook diets corresponds to the disappearance of Neocalanus plumchrus from the marine zone sled samples. This is in accordance with their life cycle in which growth from nauplii stages to stage V copepodite takes place in surface waters (Fulton 1973). In June the stage V copepodites migrate to deeper water and would be unavailable to the epibenthic sled and the juvenile chinook (Fig. 6). The concentrations of calanoid and cyclopoid copepods in the marine zone after June were high (7125 m^{-3}) (mainly Cyclopina gracilis, unidentified copepodites and Paracalanus parvus, Fig. 6) yet they were not utilized by the juvenile chinook as a major dietary item.

The ranking of organisms by frequency of occurence does not reflect the importance of the different prey items as fish food. For instance, one large amphipod may occupy as much space in the gut as 10-20 harpacticoids. The use of zonal means was necessary due to sporadic sampling but hides the local populations which sometimes dominate the zone.

The data presented in this report along with other work on the Campbell River estuary (Anderson and Galbraith 1984; Cross 1985; Goodman and Vroom 1974; Macdonald et al. 1985; Brown et al. In prep.) indicate that juvenile chinook consume a wide variety of prey species. When calanoids were consumed, in high numbers, both the wild and hatchery chinook utilized mainly Neocalanus plumchrus. Further studies and a more complete sample series from the transition zone, along with an extensive fish analysis from the marine zone, are necessary to confirm these preliminary findings.

ACKNOWLEDGEMENTS

We would like to thank R. F. Clarke for the calanoid and cyclopoid identifications for the epibenthic sled samples.

REFERENCES

Anderson, E. P. and M. Galbraith. 1984. Stomach contents of juvenile chinook salmon from the Campbell River estuary March-November 1982. Contract report in partial fulfillment of DSS File Number 03SB.FP957-2-7474: 30 p. plus appendix.

Bell, L. M. and J. M. Thompson. 1977. The Campbell River estuary status of enviornmental knowledge to 1977. Report of the estuary working group, Special Estuary Series No. 7: 346 p.

Brown, T. J., C. D. McAllister, C. D. Levings, and M. Kotyk. 1983. Salmonid catch-data from Campbell River and Discovery Passage, 1982. Can. Data Rep. Fish. Aquat. Sci. 416: 97 p.

Brown, T. J., R. F. Clarke, and B. A. Kask. 1984. Meiofauna sled samples from Campbell River estuary and Discovery Passage 1982 - Calanoid copepod species identification. Can. Data Rep. Fish. Aquat. Sci. 483: 22 p.

Brown, T. J., C. D. McAllister, and B. A. Kask. In prep. Plankton samples in Campbell River and Discovery Passage in relation to juvenile chinook diets. Can. MS Rep. Fish. Aquat. Sci.

Brownlee, M. J., E. R. Mattice, and C. D. Levings. 1984. The Campbell River estuary: a report on the design, construction and preliminary follow-up study findings of intertidal marsh islands created for purposes of estuarine rehabilitation. Can. MS Rep. Fish. Aquat. Sci. 1789: 211 p.

Cross, S. F. 1985. Analysis of 1984 chinook fry and smolt samples from Campbell River estuary and Discovery Passage. Contract Report by EVS Consultants in partial fulfillment of DSS File No. 03SB.FP597-4-0457.

Fulton, J. 1973. Some aspects of the life history of Calanus plumchrus in the Strait of Georgia. J. Fish. Res. Board Can. 30(6): 811-815.

Goodman, D. and P. R. Vroom. 1974. An assessment of the impact of the proposed marina development on the fisheries resources of the Campbell River estuary. Env. Can. Tech. Rept. Ser. PAC/T-74-13, 25 p.

Gordon, D. K., M. Kotyk, T. Brown, C. D. Levings, and C. D. McAllister. 1983. Data record on coded wire tags recovered from juvenile chinook at Campbell River estuary and Discovery Passage, 1982. Can. Data Rep. Fish. Aquat. Sci. 403: 57 p.

Hara, Y., C. D. McAllister, A. Otsuki, and H. Seki. Unpublished manuscript. Spring bloom of phytoplankters in the brackish intermediate watermass of the Campbell River estuary.

Kask, B. A. and T. J. Brown. 1984. Meiofauna sled samples from Campbell River Estuary and Discovery Passage 1982. Can. Data Rep. Fish. Aquat. Sci. No. 476: 157 p.

Kotyk, M., B. D. Chang, T. J. Brown, C. D. Levings, and C. D. McAllister. 1983. Length and weight data for unmarked juvenile salmon sampled in the Campbell River estuary and Discovery Passage, 1982. Can. Data Rep. Fish. Aquat. Sci. 408: 61 p.

Macdonald, J. S., G. M. Kruzynski, I. K. Birtwell, K. D. Seaman, L. Del Mistro, and M. Kotyk. 1985. Juvenile salmonid and plankton samples from an inner and an outer estuarine station in the Campbell River estuary, British Columbia, 1984. Can. Data Rep. Fish. Aquat. Sci. 520: 27 p.

Sibert, J. R. 1981. Intertidal hyperbenthic populations in the Nanaimo estuary. Marine Biology 64: 259-265.

Sibert, J., B. A. Kask, and T. J. Brown. 1977. A diver-operated sled for sampling the epibenthos. Fish. Mar. Serv. Tech. Rep. 738: 19 p.

Table 1. Calanoid and cyclopoid species found in the Campbell River estuarine zone epibenthic sled samples, 1982, for stations 1, 2, 3, 7, 13, 17, and 18 in mean numbers m^{-3}.

Date	Total calanoids	*Cyclops* sp.	Unid. cyclopoids	Unid. copepodites	*Oithona* sp.	*Oncaea* sp.	*Pseudocalanus minutus*
820323	50.0	30.0	13.3	0	3.3	0	0
820405	166.7	30.0	46.7	43.3	6.7	10.0	23.3
820413	206.7	63.3	100.0	33.3	3.3	3.3	0
820428	100.0	10.0	10.0	20.0	30.0	20.0	10.0
820505	482.5	405.0	60.0	10.0	0	2.5	0
820517	46.7	26.7	16.7	0	0	3.3	0
820526	110.0	30.0	65.0	15.0	0	0	0
820606	30.0	6.7	13.3	3.3	0	0	0
820616	143.3	80.0	30.0	16.7	0	6.7	0
820629	160.0	100.0	0	30.0	10.0	0	10.0
820709	80.0	0	10.0	60.0	0	0	0
820721	90.0	20.0	60.0	0	10.0	0	0
820804	60.0	20.0	0	30.0	0	0	0
820910	220.0	0	10.0	170.0	30.0	0	0
820929	50.0	0	30.0	0	10.0	0	10.0
821109	110.0	105.0	5.0	0	0	0	0
821214	50.0	0	35.0	15.0	0	0	0
$\bar{X}$	147.4	79.4	35.1	20.0	3.7	2.9	2.9
1 SE	28.2	26.4	7.1	5.1	1.4	0.9	1.2
% of total*		53.9	77.7	91.3	93.8	95.7	97.7

*The remaining 2.3% is composed of six species.

Table 2. Calanoid and cyclopoid species found in the Campbell River transition zone epibenthic sled samples, 1982, for stations 4, 5, 20, and 34 in mean numbers m^{-3}.

Date	Total calanoids	Unid. copepodites	*Pseudo-calanus minutus*	*Oithona* sp.	*Neo-calanus plumchrus*	*Oncaea* sp.	Unid. cyclopoid
820323	50.0	0	0	0	0	0	0
820405	10830.0	1950.0	3190.0	2160.0	1650.0	1570.0	80.0
820413	490.0	210.0	50.0	130.0	30.0	30.0	20.0
820709	20.0	0	0	0	0	0	20.0
820721	40.0	0	0	40.0	0	0	0
820818	1720.0	1180.0	0	0	0	40.0	280.0
$\bar{X}$	2186.5	556.7	540.0	388.3	280.0	273.3	66.7
1 SE	1194.0	237.7	394.1	239.5	197.6	194.4	39.6
% of total*		25.5	50.2	67.9	80.7	93.2	96.3

*The remaining 3.7% is composed of seven species.

Table 3. Calanoid and cyclopoid species found in the Campbell River marine zone epibenthic sled samples, 1982, for stations 23, 24, 25, 27, 31, 32 and 281 in mean numbers m^{-3}.

Date	Total calanoids	Unid. copepodites	*Cyclopina gracilis*	*Oithona* sp.	*Neocalanus plumchrus*	*Oncaea* sp.	*Paracalanus parvus*
820323	1330.0	400.0	0	785.0	0	15.0	0
820405	3170.0	765.0	0	1240.0	300.0	820.0	0
820413	1190.0	280.0	0	565.0	25.0	250.0	0
820428	3940.0	845.0	0	1345.0	85.0	655.0	0
820505	6875.0	1630.0	0	565.0	1450.0	2775.0	0
820517	1910.0	380.0	0	910.0	400.0	100.0	0
820526	5110.0	540.0	0	420.0	2450.0	1360.0	0
820606	2635.0	25.0	0	95.0	2465.0	5.0	0
820616	990.0	375.0	0	135.0	20.0	190.0	0
820629	1625.0	1015.0	0	130.0	5.0	85.0	215.0
820709	3280.0	1023.0	1903.0	13.0	0	13.0	177.0
829721	5055.0	355.0	4055.0	215.0	0	175.0	135.0
820804	2110.0	440.0	1405.0	50.0	0	100.0	55.0
820818	5947.0	1535.0	3880.0	7.0	0	160.0	395.0
820910	7125.0	4300.0	1.0	925.0	20.0	125.0	1530.0
820929	1320.0	640.0	0	190.0	10.0	120.0	350.0
$\bar{X}$	3538.1	957.5	884.7	440.6	439.1	432.8	173.1
1 SE	419.7	155.9	298.1	72.1	163.4	129.2	52.0
% of total*		27.1	52.1	64.5	76.9	89.2	94.1

*The remaining 5.9% is composed of 15 species.

Table 4. Total calanoid and cyclopoid copepods and *Cyclops* sp. concentrations in mean numbers m^{-3} for the natural sites (3,7) and the new island sites (17,18).

Date	Sled no.	Total copepods 3	7	17	18	*Cyclops* sp. 3	7	17	18
820323	1	20.0	40.0	140.0	-	20.0	40.0	80.0	-
	2	20.0	20.0	60.0	-	20.0	0	20.0	-
820405	1	60.0	60.0	360.0	-	0	60.0	0	-
	2	160.0	120.0	240.0	-	0	120.0	0	-
820413	1	80.0	-	300.0	100.0	20.0	-	100.0	20.0
	2	40.0	-	520.0	200.0	20.0	-	160.0	60.0
820503	1	60.0	160.0	300.0	1340.0	60.0	20.0	200.0	1340.0
	2	220.0	60.0	260.0	1460.0	180.0	20.0	200.0	1280.0
820517	1	-	0	-	80.0	-	0	-	40.0
	2	-	40.0	-	100.0	-	40.0	-	40.0
820526	1	0	-	-	360.0	0	-	-	120.0
	2	40.0	-	-	40.0	0	-	-	0
820605	1	20.0	20.0	-	40.0	0	0	-	0
	2	20.0	60.0	-	20.0	20.0	0	-	20.0
$\bar{X}$ ± 1 SE		60.0±12.1		328.9±97.5		29.1±9.5		204.4±96.1	

Table 5. Temperature (°C) and salinity (°/..) for the estuarine, transition and marine zones during the epibenthic sled sampling 1982 ($\bar{X}$ ± 1 SE).

	Estuarine	Transition	Marine
n	25	5	23
Temperature	10.1 ± 0.9	9.7 ± 2.3	10.7 ± 0.4
Salinity	1.6 ± 0.6	13.3 ± 5.3	27.9 ± 0.5

Table 6. A comparison of stations 27 and 31 for 10 coincident samples collected in 1982 comparing the top six categories in numbers m^{-3}.

	Total copepods		Unidentified copepodites		*Cyclopina gracilis*		*Oithona* sp.		*Neocalanus plumchrus*		*Oncaea* sp.		*Paracalanus parvus*	
Date	27	31	27	31	27	31	27	31	27	31	27	31	27	31
820405	4580	2000	740	600	0	0	1820	760	460	300	1420	300	0	0
	3960	2140	880	840	0	0	1720	660	140	300	1220	340	0	0
820426	5900	480	1400	160	0	0	2080	100	120	20	1340	80	0	0
	8480	900	1520	300	0	0	3020	180	200	0	1120	80	0	0
820526	6940	3340	280	560	0	0	280	340	5080	40	720	2220	0	0
	6500	3660	640	680	0	0	260	800	4560	120	640	1860	0	0
820616	800	1440	360	460	0	0	60	240	40	0	20	580	0	0
	1040	680	280	400	0	0	120	120	40	0	40	120	0	0
820628	1340	1520	880	960	0	0	140	80	0	0	20	120	0	320
	1320	2320	640	1580	0	0	120	180	0	20	80	120	280	260
820708	2480	6720	2020	0	0	6400	0	0	0	0	0	0	420	0
	3760	5120	2800	0	0	4700	80	0	0	0	80	0	640	0
820719	720	10180	200	480	320	9060	140	320	0	0	40	0	20	0
	840	8480	120	620	380	6460	40	360	0	0	220	440	80	440
820803	940	5120	580	320	80	4640	20	80	0	0	60	80	200	0
	460	1920	300	560	20	880	20	80	0	0	100	160	20	0
820817	5080	8000	4140	640	240	6880	0	0	0	0	240	0	420	160
	4360	13120	3320	160	160	11840	40	0	0	0	240	480	520	480
820908	8160	4700	4640	2840	80	0	740	580	0	0	80	100	2220	1180
	8760	6880	4500	5220	0	0	1520	860	80	0	260	60	1980	740
$\bar{X}$	3821	4436	1514	869	64	2543	611	287	536	40	397	357	340	197
1 SE	644	783	341	269	26	839	201	65	329	21	110	135	142	71
t	0.606		1.486		2.954		1.535		1.504		0.230		1.012	
Significance	ns		ns		0.01		ns		ns		ns		ns	

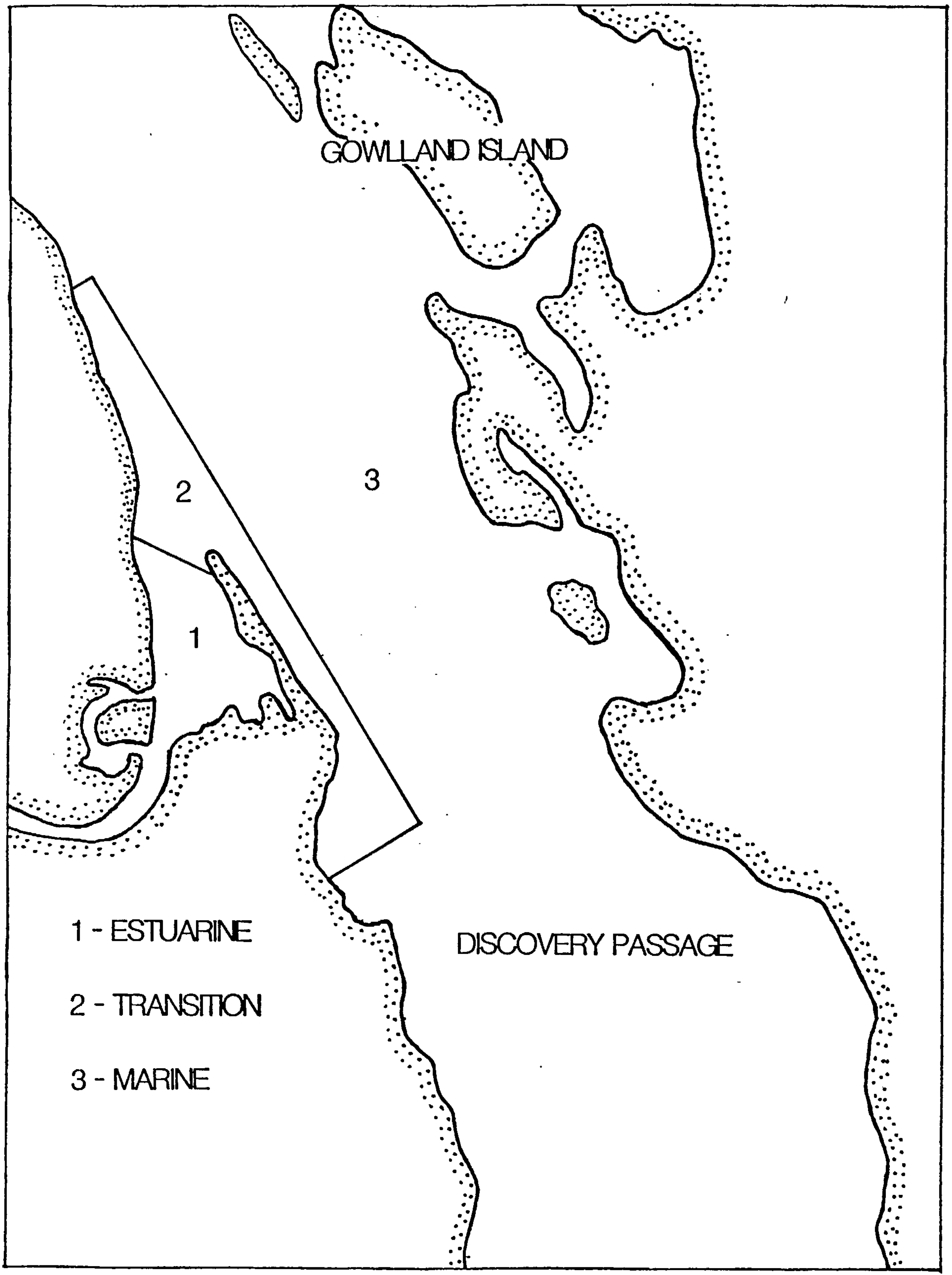

Fig. 1. Estuarine, transition, and marine zone locations.

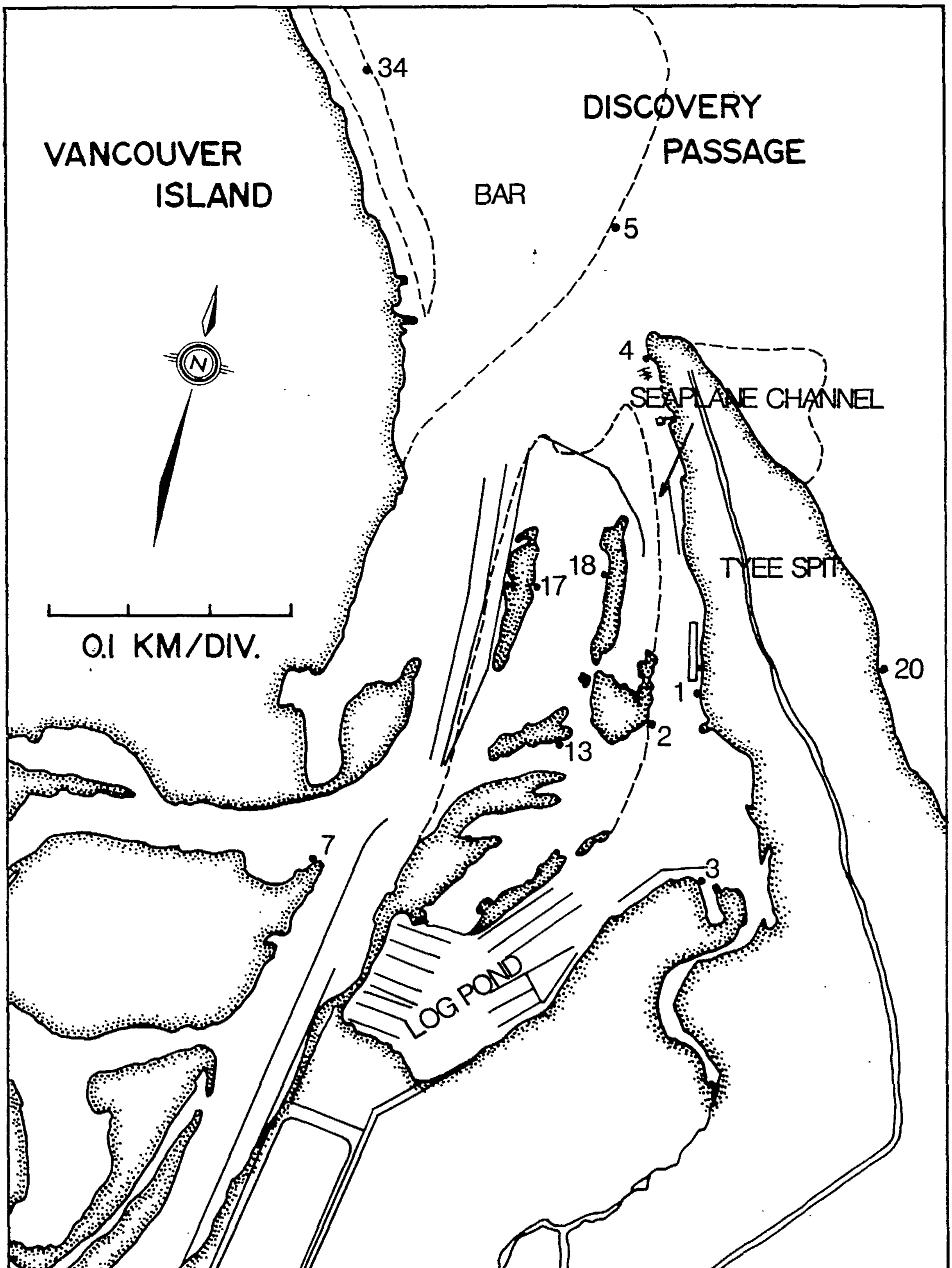

Fig. 2. Estuarine and transition zone station locations.

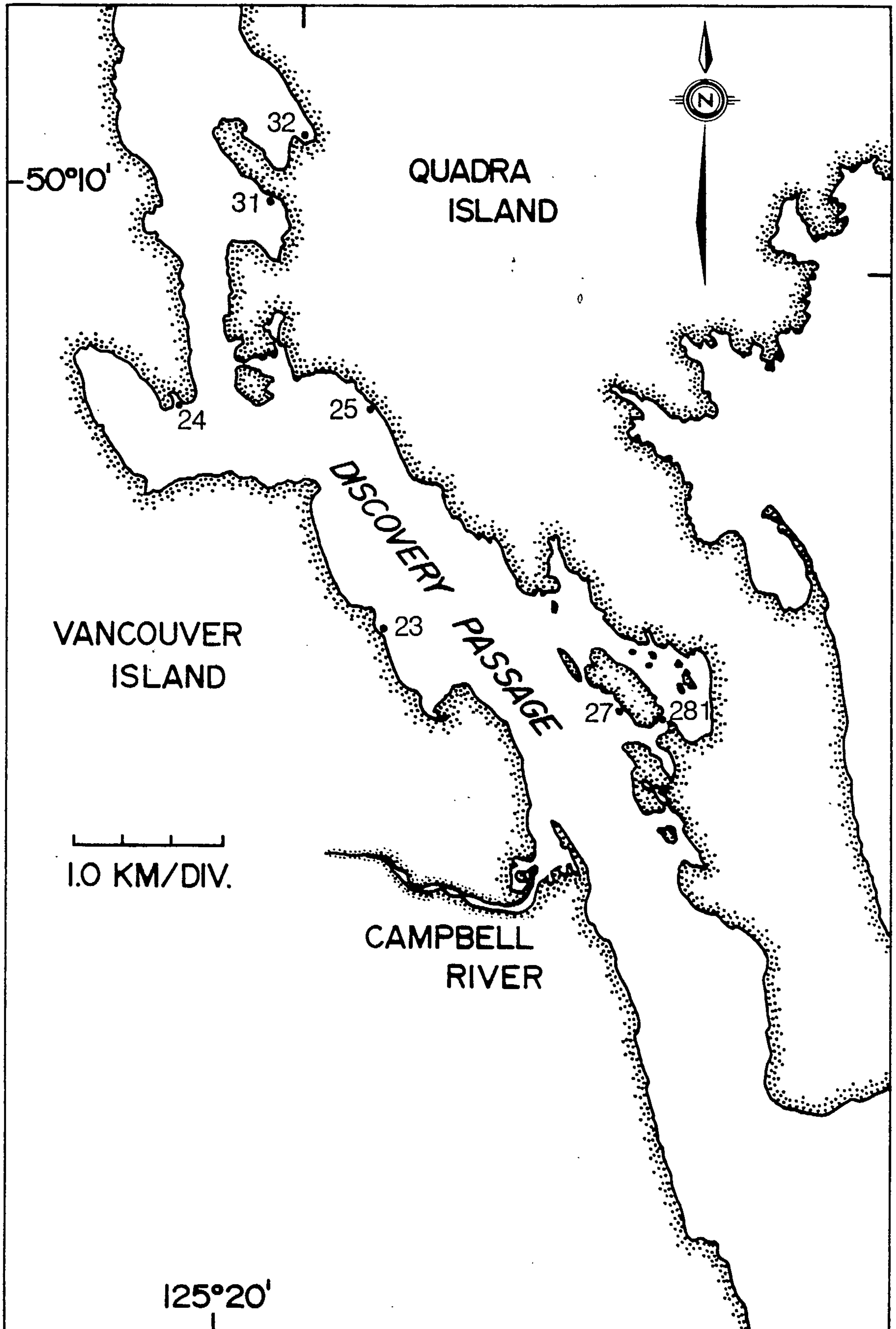

Fig. 3. Marine zone station locations.

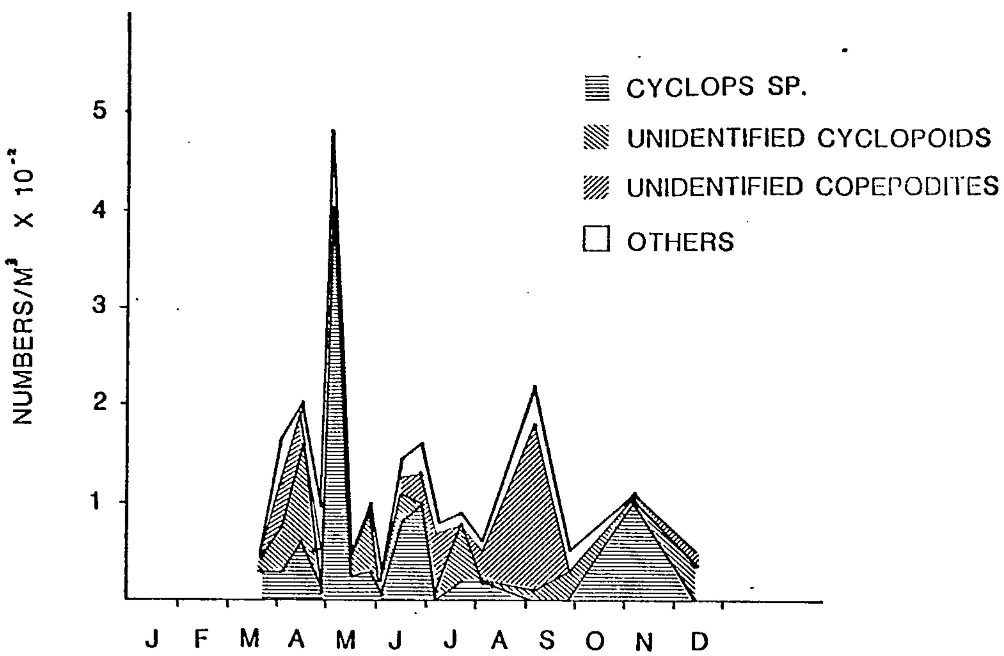

Fig. 4. The estuarine zone calanoid and cyclopoid species concentrations in mean numbers m-3 for the 1982 epibenthic sled samples.

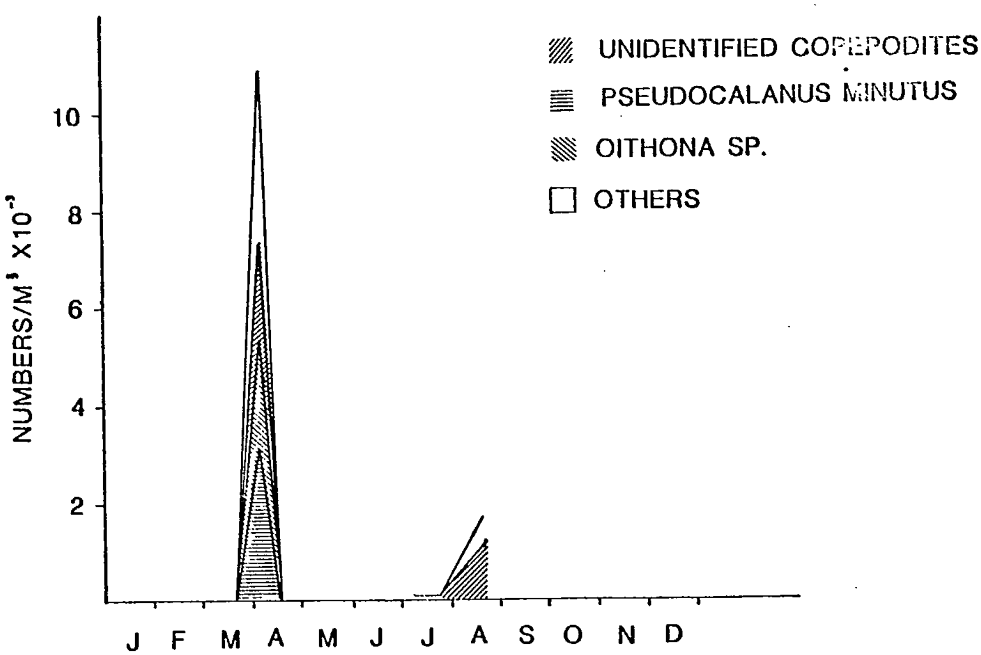

Fig. 5. The transition zone calanoid and cyclopoid species concentrations in mean numbers m^{-3} for the 1982 epibenthic sled samples.

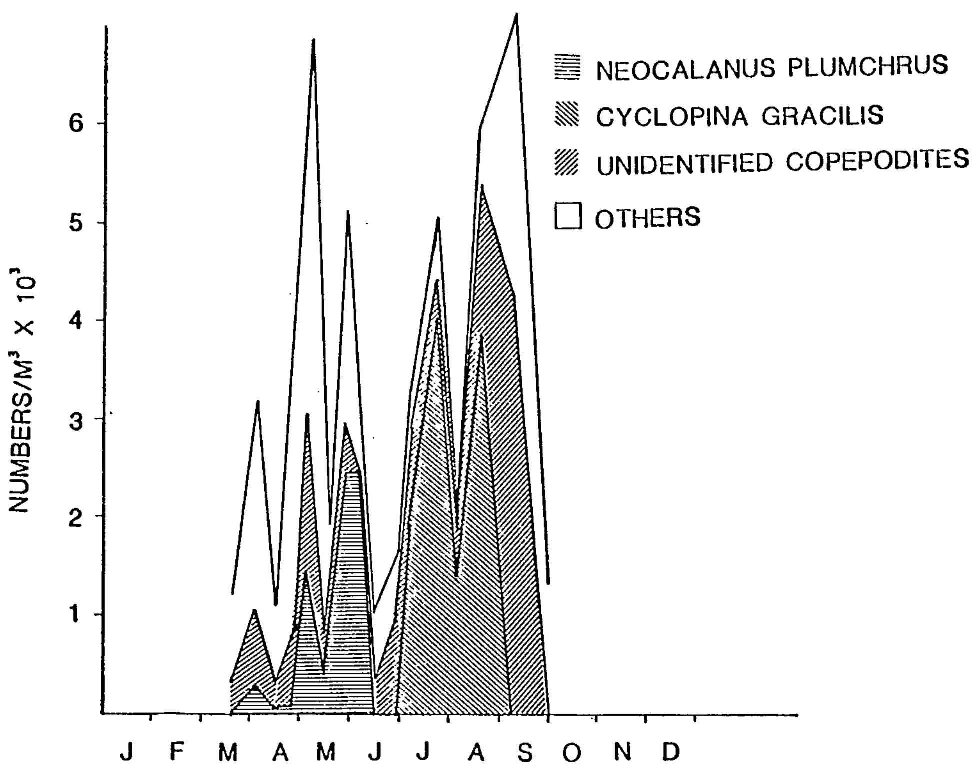

Fig. 6. Marine zone calanoid and cyclopoid species concentrations in mean numbers m^{-3} for the 1982 epibenthic sled samples.

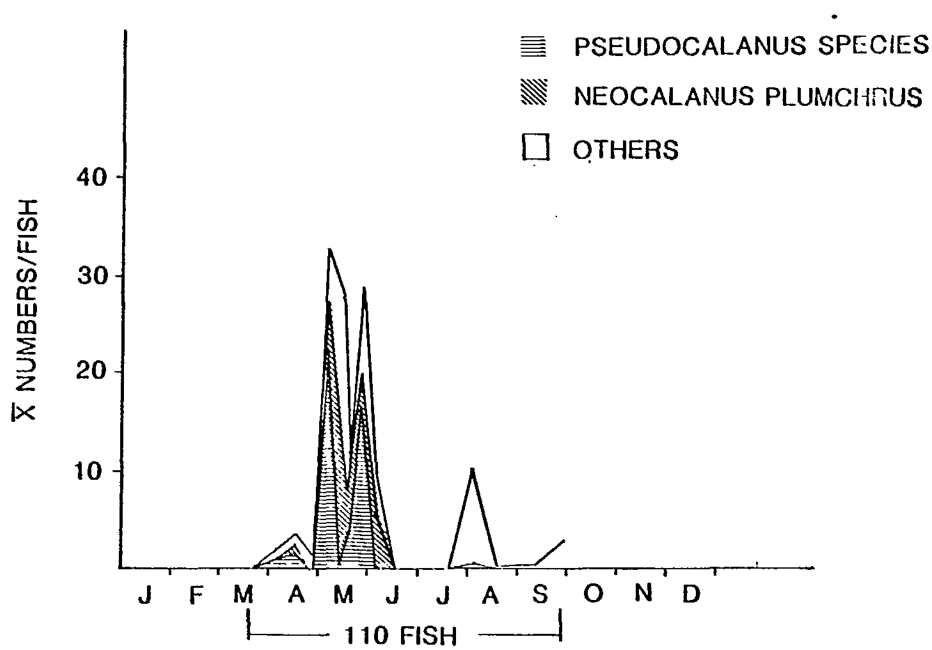

Fig. 7. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by wild chinook in the estuarine zone during 1982.

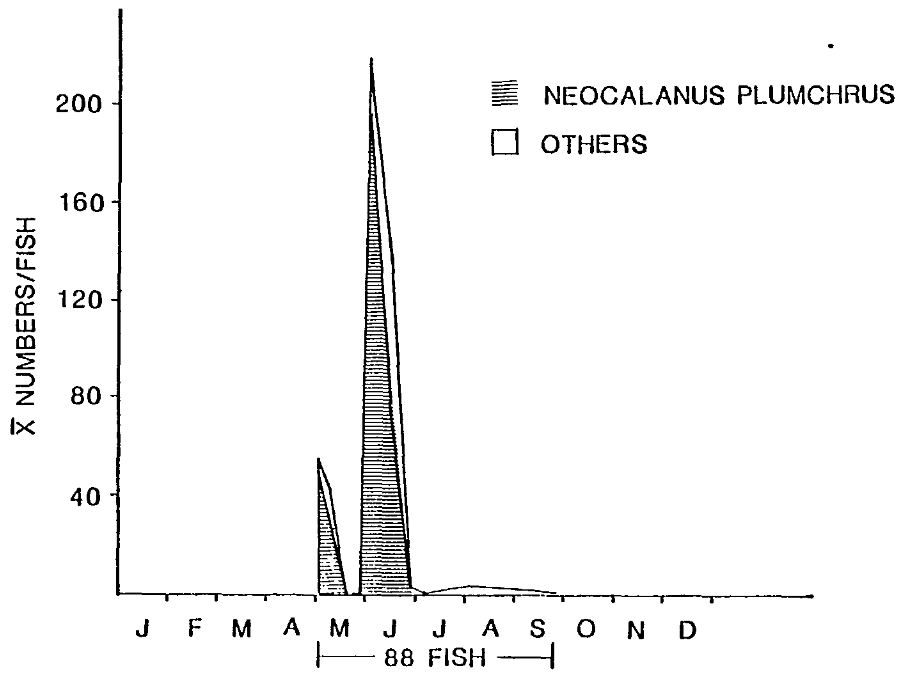

Fig. 8. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by hatchery chinook in the estuarine zone during 1982.

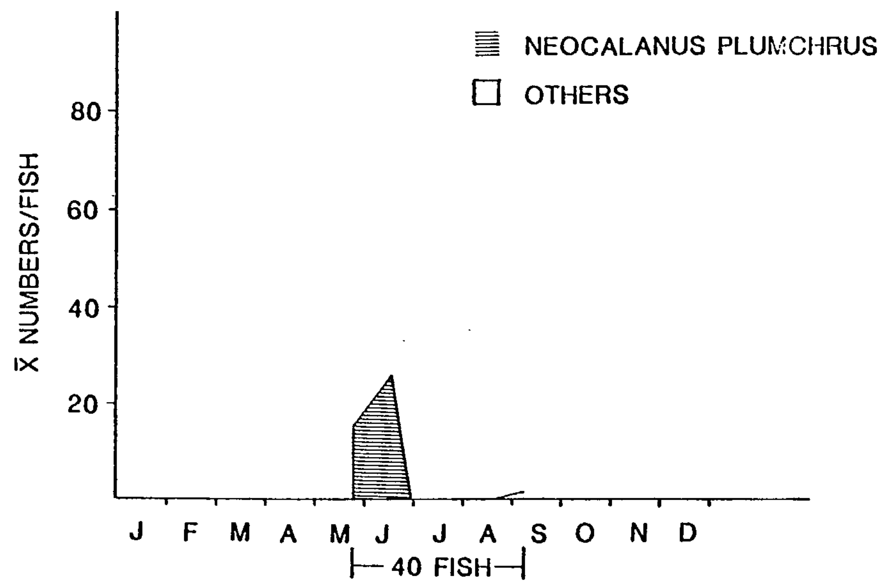

Fig. 9. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by wild chinook in the transition zone during 1982.

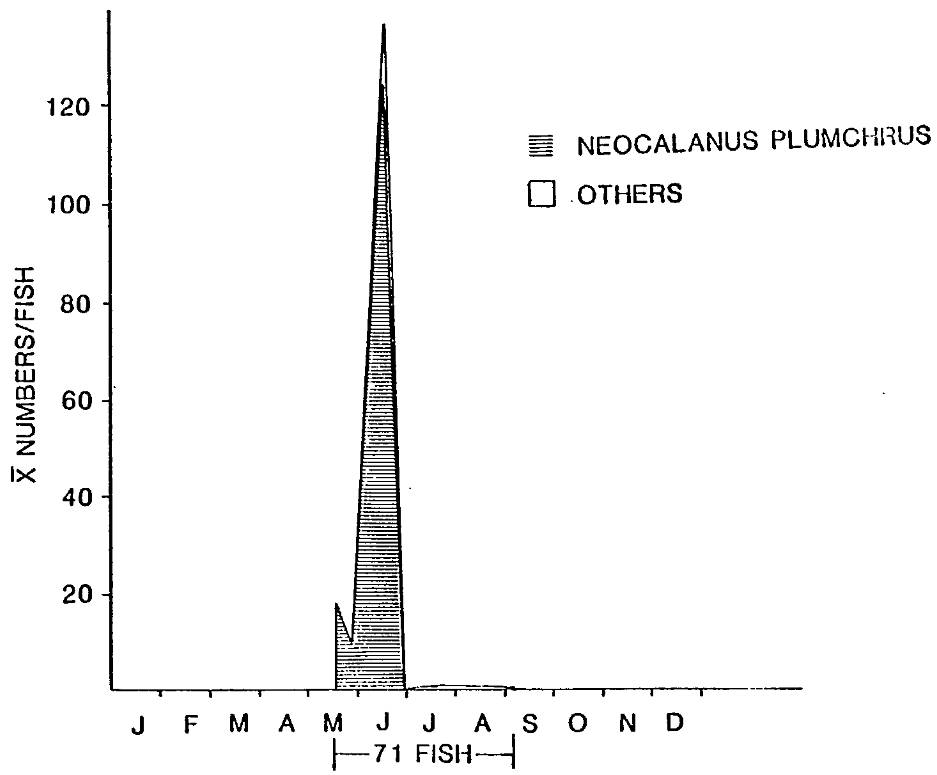

Fig. 10. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by hatchery chinook in the transition zone during 1982.

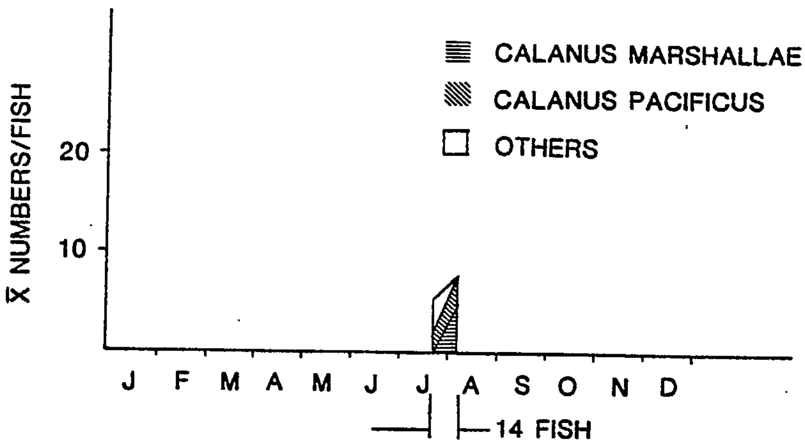

Fig. 11. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by wild chinook in the marine zone during 1982.

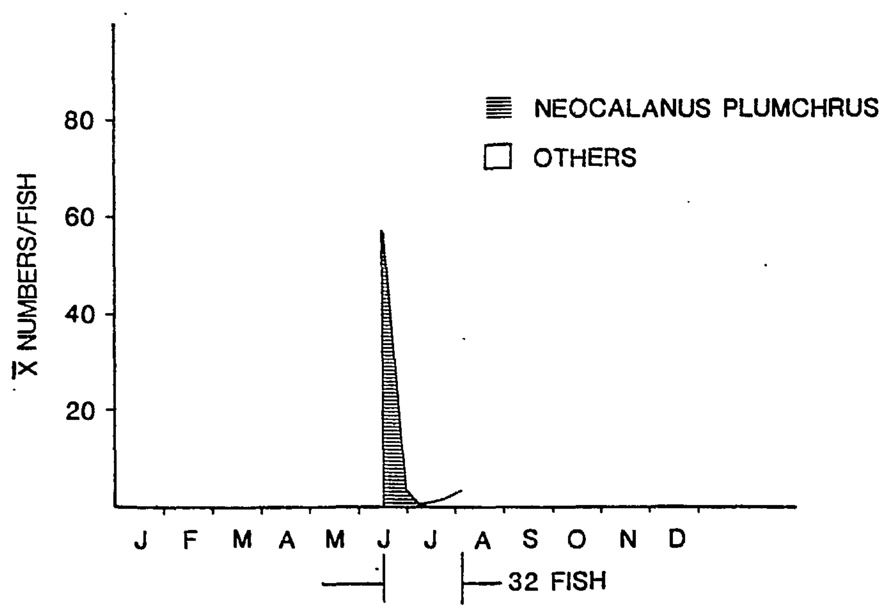

Fig. 12. The calanoid and cyclopoid concentrations, in mean numbers per fish, consumed by hatchery chinook in the marine zone during 1982.