

AN ABSTRACT OF THE THESIS OF

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Title: VERTICAL DISTRIBUTION OF ZOOPLANKTON IN THE
OREGON COASTAL ZONE DURING AN UPWELLING EVENT

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Variations in the density and species composition of planktonic animals have been determined along transects perpendicular to the Oregon coast near the end of a prolonged and intense upwelling event. These density variations are presented as contour plots and are compared to similar plots for temperature, salinity, particulate chlorophyll and four nutrients.

Maxima of population density were consistently at 7 to 10 m depth, which was the bottom of the mixed layer, and for most species were well within 18 km of the coast. Horizontally there was a minimum of density in the region of the surface front, where the upward sloping isopycnals break the surface. The zones of dense population seaward and shoreward of the surface front differed in character. Some species were nearly exclusively found in one center or the other but not both, e. g. Acartia clausi and Centropages abdominalis in the

shoreward center and Acartia longiremis in the seaward center.

Some species were present on both sides of the front, e. g. Pseudo-
calanus. All of the life cycle stages of a given species were found to
adhere to the general pattern for that species: the sexes and stages
were not spatially isolated.

Vertical Distribution of Zooplankton
in the Oregon Coastal Zone
During an Upwelling Event

by

Anne Hutchinson Myers

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DEDICATED TO:

Jack, Hope, David, Chuck, Betsy, and Mark

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VERTICAL DISTRIBUTION OF ZOOPLANKTON IN THE OREGON COASTAL ZONE DURING AN UPWELLING EVENT

INTRODUCTION

Upwelling off the coast of Oregon generates hydrographic features which are parallel to the coast and are most pronounced within 20 km of the coast. During an upwelling event the surfaces of constant density in the nearshore region come to slope upwards toward shore. They eventually intersect the surface, forming a frontal zone, shoreward of which is a cold, nutrient-rich zone and seaward of which is a warmer, plant-rich zone (Smith et al., 1971). This arrangement of features suggests that probable effects of the abrupt hydrographic gradients on the distribution of species of zooplankton can best be studied by determining the distribution of animals along near-shore transects perpendicular to the coast. It was the purpose of this project to make such a study during an intense upwelling event.

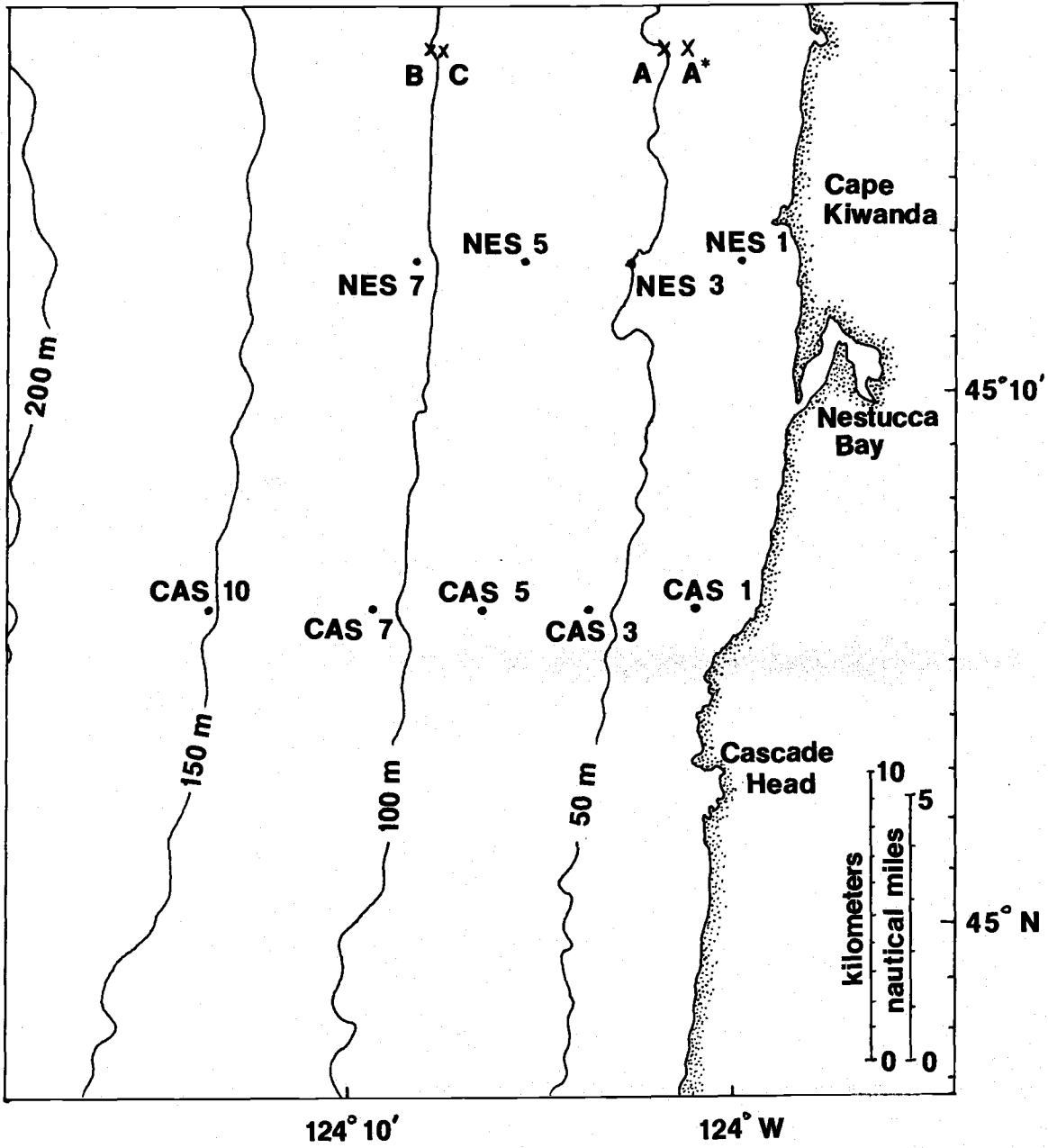
The sampling program was designed to collect physical and chemical data in conjunction with the biological samples. Emphasis was placed on a description of the relationships between patterns of distribution of zooplankton, and hydrographic, chemical and phytoplankton parameters.

Several studies of upwelling are being made concurrently at Oregon State University. The Coastal Upwelling Experiment (CUE)

is studying the hydrographic conditions which existed off the coast of Oregon during the summers of 1972 and 1973. The Sea Grant Pelagic Fisheries Environment project monitored plant nutrient concentration and primary production during these years. The Sea Grant Early Life History (ELH) project collected nearshore zooplankton samples on a year round basis from 1969 through 1972.

The ELH studies (Peterson and Miller, in press) showed a rapid change in the zooplankton populations within the first 15 km of distance from the coast, particularly during the upwelling season. The ELH samples were taken with oblique hauls with 240 μm and 505 μm mesh nets, so no determination could be made of the small-scale vertical distribution patterns. In this study vertically discrete samples were collected with 104 μm mesh nets during a single set of hydrographic conditions, intense upwelling. Figure 1 which is a map of the study area, shows the location of the sampling stations and current meters.

A series of six transects was made during the upwelling season of 1973. The results of two of these transects, made during an upwelling event, are the basis for this thesis. The other transects, from different times in the upwelling cycle, were counted by William Peterson of Oregon State University and are described in the Discussion section of this paper. At the date of completion of this thesis these results had not yet been published.



x current meters
• sampling stations

Figure 1. Map of the study area.

THE COASTAL ENVIRONMENT

The coastal environment changes with the position of the North Pacific High and the Aleutian Low pressure systems. From April through September northerly winds driven by the North Pacific High are predominant. These equatorward winds produce a southward transport of the surface water along the coast. There is an offshore component of water flow because of the earth's rotation. This offshore flow produces upwelling: colder, more saline, nutrient-rich water from depths of a few hundred meters flow toward the coast and rises to replace the surface water moved offshore.

When the southward blowing winds are strong and continuous, upwelled water appears on the surface near the shore. This is active or intense upwelling and can be termed an upwelling event. During an upwelling event the isoclines of temperature, salinity and density come to slope upward toward the shore and they eventually intersect the surface. Repeated observations have shown that isoclines frequently associated with the steepest surface in these hydrographic factors are 8-9°C, 33-33.5‰ and 25.5-26.0 σ^t (Huyer, 1974). These isoclines define a front parallel to shore during upwelling events, and are, therefore, termed a "frontal layer" by Huyer (1974). Between upwelling events the frontal layer subsides and becomes parallel to the surface or even slopes downward toward shore within about 15 km of

the coast. Seaward of 20 km from shore this frontal layer has an upward slope toward shore throughout the upwelling season. Apparently there is a slow continuous flow of cold, saline water from offshore depths toward the surface near the shore during the entire upwelling season. This water is mixed and warmed before it reaches the surface except during short periods of strong southward winds which cause upwelling events.

The samples discussed in this paper were collected at the end of an upwelling event of 20 days duration (Fig. 2), which is unusually long. The hydrographic situation during the sampling period is illustrated in Figures 3 and 4.

Current meters deployed by CUE (Pillsbury et al., 1974; and Halpern et al., 1974) were used to measure water movement during the 1973 upwelling season. For the area from which zooplankton were collected (the upper 100 m within 15 km of the shore) the major water movement was south with the fastest flowing water at the surface: 20 cm/sec in the upper 20 m. At depths below 80 m there is a slow northward return flow of 2 cm/sec.

During upwelling events the water at the depth of the frontal layers moves toward the shore at 6 cm/sec. There must also be vertical movement, but velocities that small cannot be measured with presently available current meters. Directly above the frontal layers there is little or no net onshore or offshore movement. In the

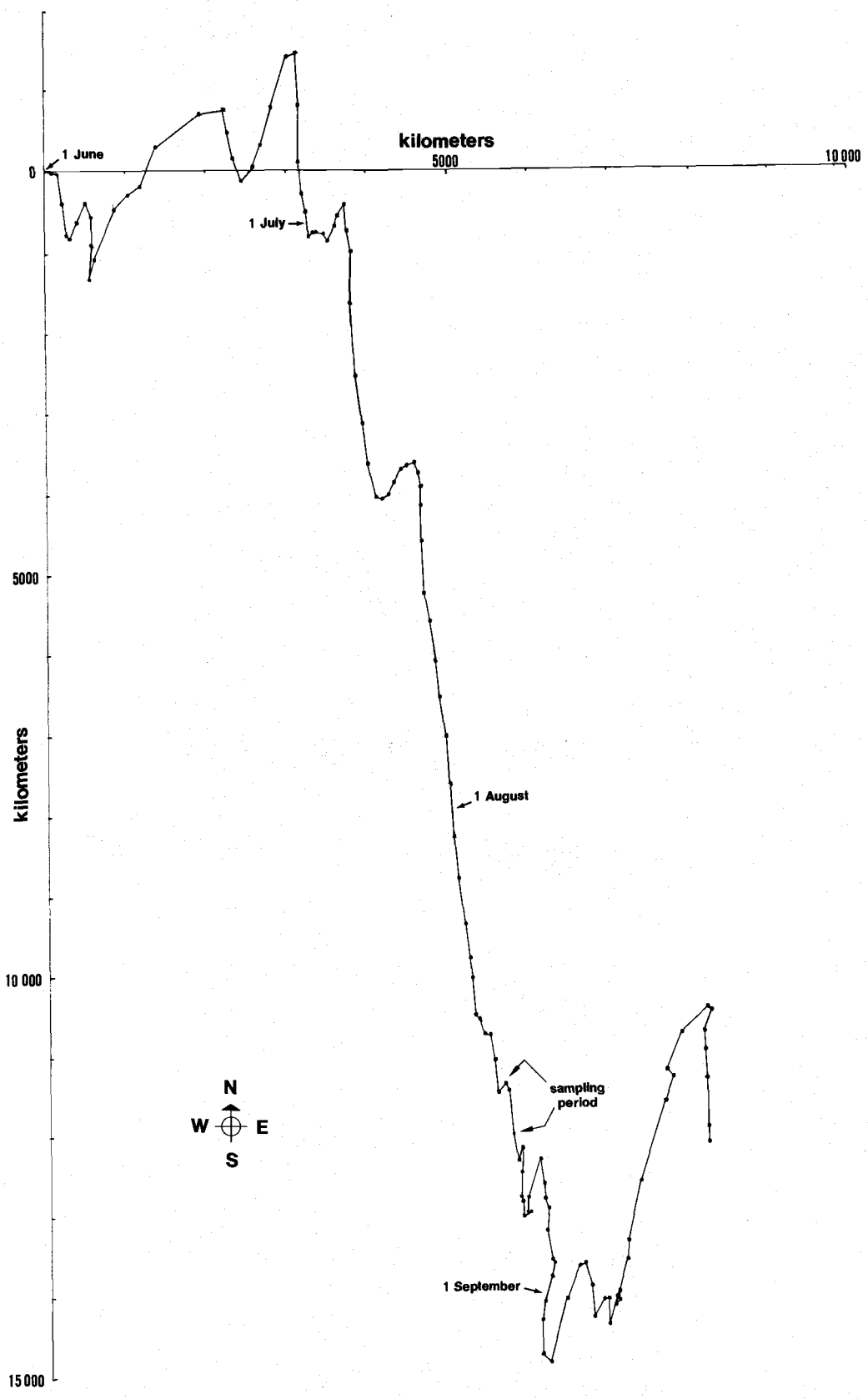


Figure 2. Progressive vector diagram of the Newport winds from June through September 1973.

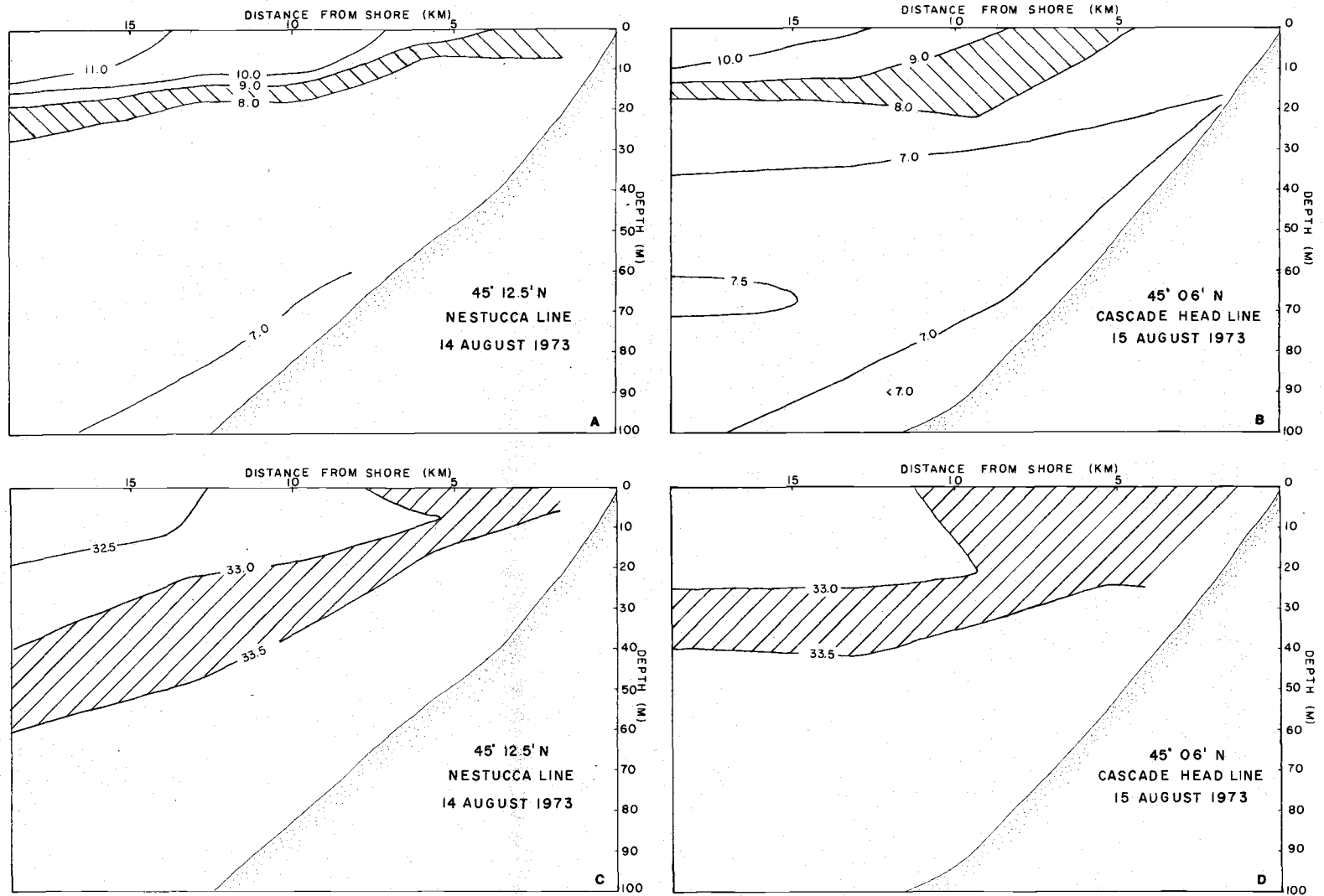


Figure 3. Temperature (a,b) and salinity (c,d) contours.

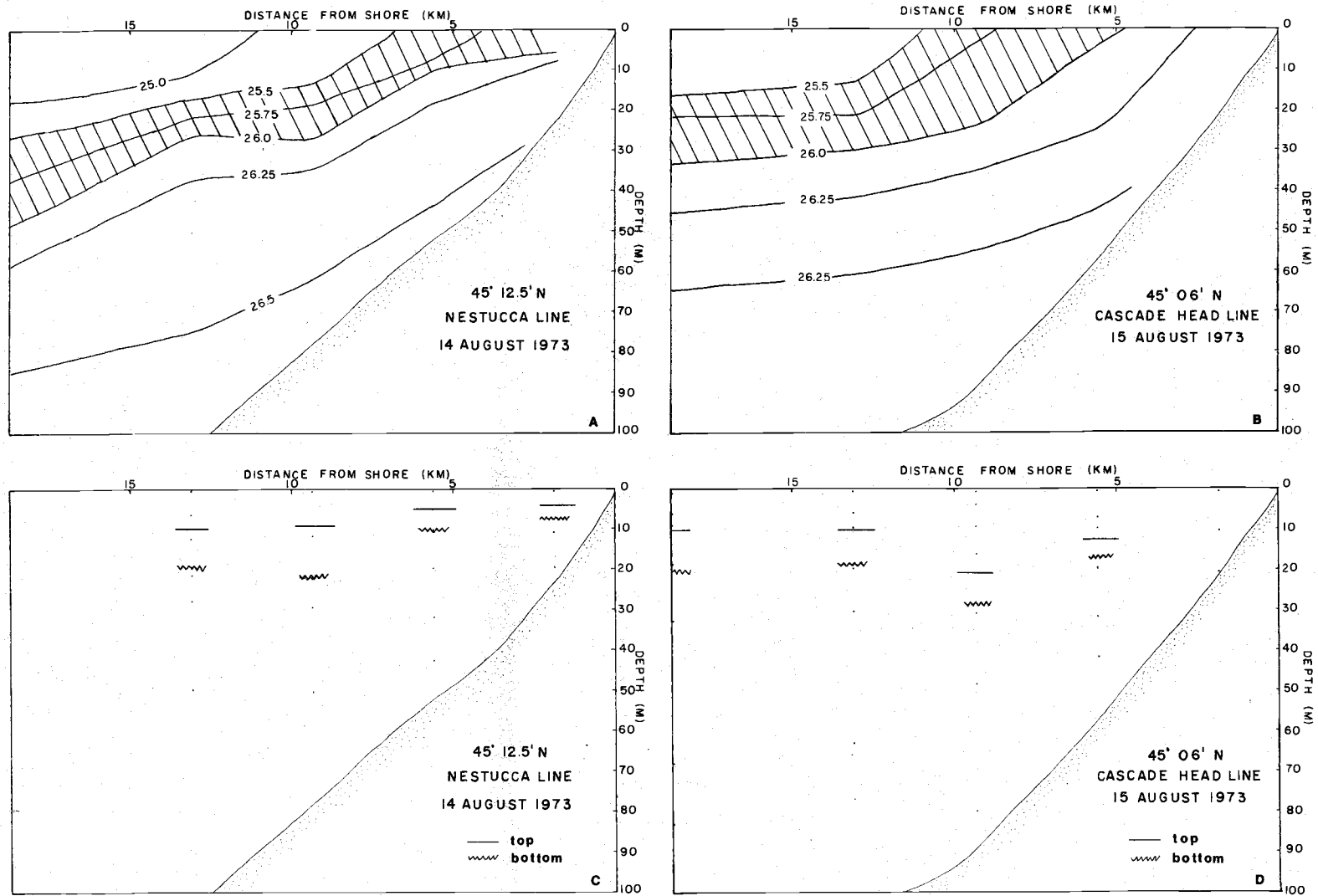


Figure 4. Density contours (a, b) and depth of the thermocline (c, d).

upper 15 m there is offshore movement at 8 cm/sec. Figure 5 shows the sum of the on-offshore water movement in kilometers for the entire upwelling event preceding the biological sampling.

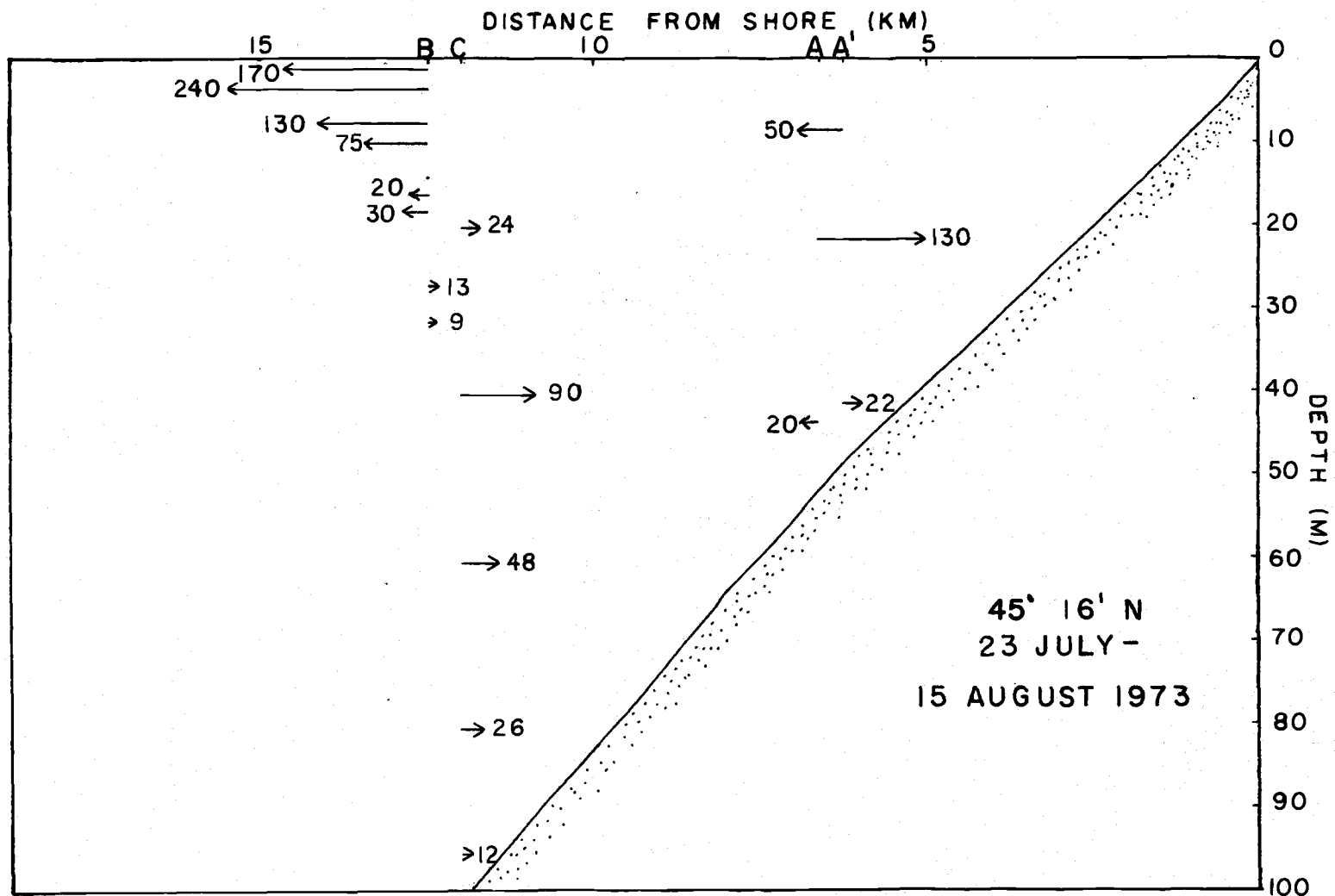


Figure 5. Horizontal east-west components of current velocity expressed as kilometers/24 days.

MATERIALS AND METHODS

This study was timed and positioned to use current meter data collected by CUE-II (Coastal Upwelling Experiment, Phase II, Pillsbury *et al.*, 1974; Halpern *et al.*, 1974). An array of current meters located north $45^{\circ}16'N$ (Fig. 1) of the zooplankton sampling transects recorded current data throughout the 1973 upwelling season.

Zooplankton were collected along transects perpendicular to the Oregon coast on six dates during the summer of 1973. This paper reports the findings of two of the transects: the Nestucca line ($45^{\circ}12.5'N$) on 14 August and the Cascade Head line ($45^{\circ}06'N$) on 15 August. The results of two other transects are also discussed. Stations were labelled by distance from the shore in nautical miles and were NES 1, 3, 5 and 7 and CAS 1, 3, 5, 7 and 10. These stations were approximately 2, 5, 9, 12 and 18 kilometers from the shore.

The zooplankton samples were collected with opening and closing 12.7 cm Clarke-Bumpus nets (Paquette and Frolander, 1957). The NITEX nets were 62 cm long with $104\ \mu m$ apertures. The cod ends were stainless steel cups with brass mesh screen on the laterally positioned filtering windows. Flow meters were located in the mouth of each frame.

Physical and chemical oceanographic data were obtained using

the pumping and STD system developed by the Pelagic Fisheries Environment Project at OSU. Sensors attached to the end of the hose provided temperature, salinity and depth data (Bisset-Berman STD). Fluorescence readings were taken at sea from water pumped continuously through a Turner model 111 equipped with a large volume flow-through door. Readings were calibrated against independent particulate chlorophyll samples to obtain chlorophyll A in $\mu\text{g/l}$, or mg/m^3 . Particulate chlorophyll was determined by standard spectrophotometric techniques (Strickland and Parsons, 1972). Oxygen was also measured directly in the flowing water stream by a gold and zinc electrode pair, based on the expendable bathyoxymeter (Jeter et al., 1972), which was previously calibrated with Winkler titrations (Strickland and Parsons, 1972). Independent measurements by the two methods indicated reliability to 0.25 ml/l with 90% confidence limits. Water samples were pumped from discrete depths and stored in 60 ml plastic bottles. The frozen samples were stored two months before nutrient analysis was carried out. Phosphate, nitrate, silicate and ammonia were measured by a Technicon autoanalyzer using standard techniques (Callaway et al., 1972). David Menzies of Oregon State University provided the physical and chemical data.

In the laboratory, zooplankton samples were poured into 500 ml pharmaceutical graduates and allowed to settle for several hours. Large medusae and ctenophores were removed before reading the

settled volume. The total volume was then adjusted to ten times the settled volume. Aliquots for sampling were then removed from this volume with a 1 ml stempel pipette, after the animals were suspended by agitation with a small spatula. At least three aliquots were drawn from each sample. Animals were enumerated with the aid of a binocular dissecting scope at 25X. After counting the subsamples, the entire sample was examined for rare species not found in the subsamples.

All adult copepods were identified to species and sex. See Table III for the species list. All copepodites were identified to species, and counted by stages for the most common species: Calanus pacificus, Pseudocalanus sp., Acartia clausi, and A. longiremis. Copepod nauplii (Table IV) were divided into Calanus sp. and other copepod nauplii (probably Acartia sp.). Eggs counted as small eggs were probably Pseudocalanus sp.

Two morphs of the genus Metridia were seen and were separated on the basis of the shape of the prosome in lateral view. The Metridia pacifica type is more robust and has a steeply sloping forehead, while the M. lucens type has a much less sloping forehead. Detailed morphological study of the two types has not been done. Very tiny Oncaea were divided into sp. A and sp. B on the basis of size, approximately 0.5 mm and 0.3 mm total length, respectively. These animals were so small and so infrequently seen that no attempt was

TABLE I. Time, depth and volume of Nestucca transect samples, 45°12.5'N, 14 August 1973.

Station	Time	Sampled Depth (m)	# of sub-samples	Volume filtered (m ³)	Settled Volume/vol. filtered	Correction Factor
NES 1	1035	1	9	1.6	2.5	3.4
	1035	11	3	1.2	4.2	27.7
	1035	20	3	1.1	0.9	31.2
NES 3	1323	1	3	9.1	0.9	1.8
	1350	5	8	7.2	2.8	2.6
	1323	10	3	11.1	1.8	4.5
	1323	20	6	9.5	1.1	1.7
	1350	32	9	11.7	0.3	1.0
	1350	42	*	9.9	0.3	0.1
	1350	42	*	9.9	0.3	0.1
NES 5	1540	1	8	1.9	4.2	3.9
	1540	12	3	3.7	5.4	17.9
	1540	22	4	3.9	2.6	6.4
	1622	29	3	5.5	0.9	2.4
	1622	50	4	5.3	1.9	2.3
	1622	50	4	5.3	1.9	2.3
NES 7	1906	1	3	6.1	4.1	13.6
	1936	7	3	3.4	4.4	14.8
	1906	12	3	3.3	4.5	15.0
	1906	22	3	7.8	1.7	4.3
	1936	28	3	7.9	1.8	5.9
	1936	50	4	8.6	1.2	2.9

* Total sample counted.

TABLE II. Time, depth and volume of Cascade Head transect samples, 45°06'N, 15 August 1973

Station	Time	Sampled Depth (m)	No. of sub-samples	Volume filtered (m ³)	Settled vol/vol filtered	Correction Factor
CAS 1	0818	1	3	12.7	3.1	10.5
	0852	10	3	0.5	10.0	34.7
	0852	21	3	1.1	2.7	15.7
CAS 3	1011	1	3	9.8	1.0	3.4
	1033	7	3	6.1	4.9	16.5
	1011	10	3	12.4	2.4	8.0
	1011	20	3	11.8	0.8	2.8
	1033	32	3	10.3	1.0	3.2
	1033	42	3	10.3	0.5	1.6
CAS 5	1206	1	3	8.8	0.6	1.9
	1235	4	3	8.7	1.7	5.7
	1206	9	3	4.9	2.0	6.7
	1206	16	3	6.0	1.7	5.6
	1235	31	3	10.4	1.4	4.8
	1235	48	3	10.0	0.5	2.0
	1300	80	3	12.5	0.6	2.1
CAS 7	1427	1	3	9.3	2.2	7.2
	1451	6-0	3	4.1	4.9	16.3
	1427	9	3	4.9	4.1	13.5
	1427	20	3	12.1	1.7	5.5
	1521	30	3	8.2	1.0	3.2
	1521	63	3	8.3	0.7	2.4
	1521	77	3	0.9	1.1	5.5
CAS 10	1751	1	3	10.9	1.4	4.6
	1819	6	3	10.4	2.4	8.0
	1751	9	3	4.3	7.0	23.1
	1751	18	3	7.4	2.0	6.8
	1849	33	3	7.0	2.1	7.1
	1849	68	3	6.7	0.7	7.5
	1849	83	3	6.3	1.0	3.2

TABLE III. A species list of copepods seen in the samples.

<u>Aetidius pacificus</u> Brodskii
<u>Acartia clausi</u> Giesbrecht
<u>Acartia longiremus</u> Lilljeborg*
<u>Calanus cristatus</u> Kroyer
<u>Calanus marshallae</u> Frost*
<u>Calanus plumchrus</u> Marukawa
<u>Calanus tenuicornis</u> Dana
<u>Centropages abdominalis</u> Sato
<u>Epilabidocera longipedata</u> Sato
<u>Eucalanus bungii</u> Giesbrecht
<u>Lubbockia</u> cf. <u>squillimana</u> Claus
<u>Metridia lucens</u> Boeck
<u>Metridia pacifica</u> Brodskii
<u>Microcalanus pusillus</u> Sars
<u>Microsetella rosea</u> Dana
<u>Oithona similis</u> Claus*
<u>Oithona spinirostris</u> Claus
<u>Oncaea borealis</u> Sars
<u>Oncaea</u> sp. A
<u>Oncaea</u> sp. B
<u>Euchaeta japonica</u> Marukawa
<u>Pseudocalanus</u> sp. *
<u>Racovitzanus antarcticus</u> Giesbrecht
<u>Scolecithricella minor</u> Brady
<u>Tortanus discaudatus</u> , Thompson and Scott

*Seen in more than 20 of the 50 samples

TABLE IV. A list of the planktonic taxa seen in the samples.

Coscinodiscus sp.*
 tintinnid
 dinoflagellate
 foraminiferan
 radiolarian
 medusae
 ctenophore
 annelid
Limacina helicina Phipps
 bivalve mollusc veliger*
 gastropod veliger*
Evadne nordamani Loven
Podon leukarti Sars
 ostracod
 copepod nauplius (probably Acartia sp.)*
Calanus sp. nauplius
Calanus sp. egg*
 small egg (probably Pseudocalanus sp.)*
 barnacle nauplius A*
 barnacle nauplius B
 barnacle cypris
 isopod
 amphipod egg
Parathemisto pacifica
 euphausiid egg*
 euphausiid nauplius*
 euphausiid calyptopis
 euphausiid furcilia
 decapod prezoaea
 decapod zoea
 echinoderm pluteus larva
Oikopleura sp.
Sagitta elegans Verrill*
Eukrohnia hamata Mobius
 fish egg
Artemia sp. A (cottid fish larvae)
 fecal pellets

 *Seen in more than 20 of the 50 samples.

made to identify them.

Amphipods and chaetognaths were identified to species and counted by sex or size categories. Other holoplanktonic taxa were grouped in general categories, e. g. euphausiid furcilia, decapod zoea, barnacle nauplii. Barnacle nauplii were divided into type A, the one seen most commonly near shore, and type B, a more oceanic nauplius common in deep water collections. Phytoplankton and protozoa were also grouped in general categories, e. g. Coscinodiscus sp., dinoflagellates, radiolarians.

Sample counts were multiplied by appropriate factors (Table I and II) to obtain an estimate of the number of individuals in a m³ of water filtered. All abundance data is listed in Appendix A.

A progressive vector diagram (PVD) was drawn by a computer routine from daily mean components of hourly wind data collected by the National Weather Service using a recording anemometer located on the south jetty of Yaquina Bay, Newport, Oregon. William Gilbert of the Oregon State University School of Oceanography provided the data.

RESULTS

Contour plots of data from the transect lines were chosen to display the nutrient levels and density of all biological categories which made up at least 10% of a contourable fraction of the samples. All biological categories are listed in Appendix A as number/m³.

Inorganic Factors

The hydrographic results are presented in Figures 3 and 4. The highest values of silicate, phosphate and nitrate (Figs. 6 and 7) were in the water along the bottom. The pattern of nutrient isoclines were very similar to those of salinity and density. Values for these nutrients were very similar between the two transects. Nitrate values were lower at the surface offshore at Nestucca than at Cascade Head.

Oxygen (Fig. 8) had the reverse relationship to the hydrographic isoclines with the lowest values along the bottom, increasing toward the surface, seaward of the front. The highest values were near the surface seaward of the front at Nestucca.

Ammonia values (Fig. 8) were also lowest along the bottom but remained low at the surface out to 15 km. The highest values were at 10-15 m depth seaward of the front. Nestucca had the highest values. There appears to be an anomalous reading on this transect

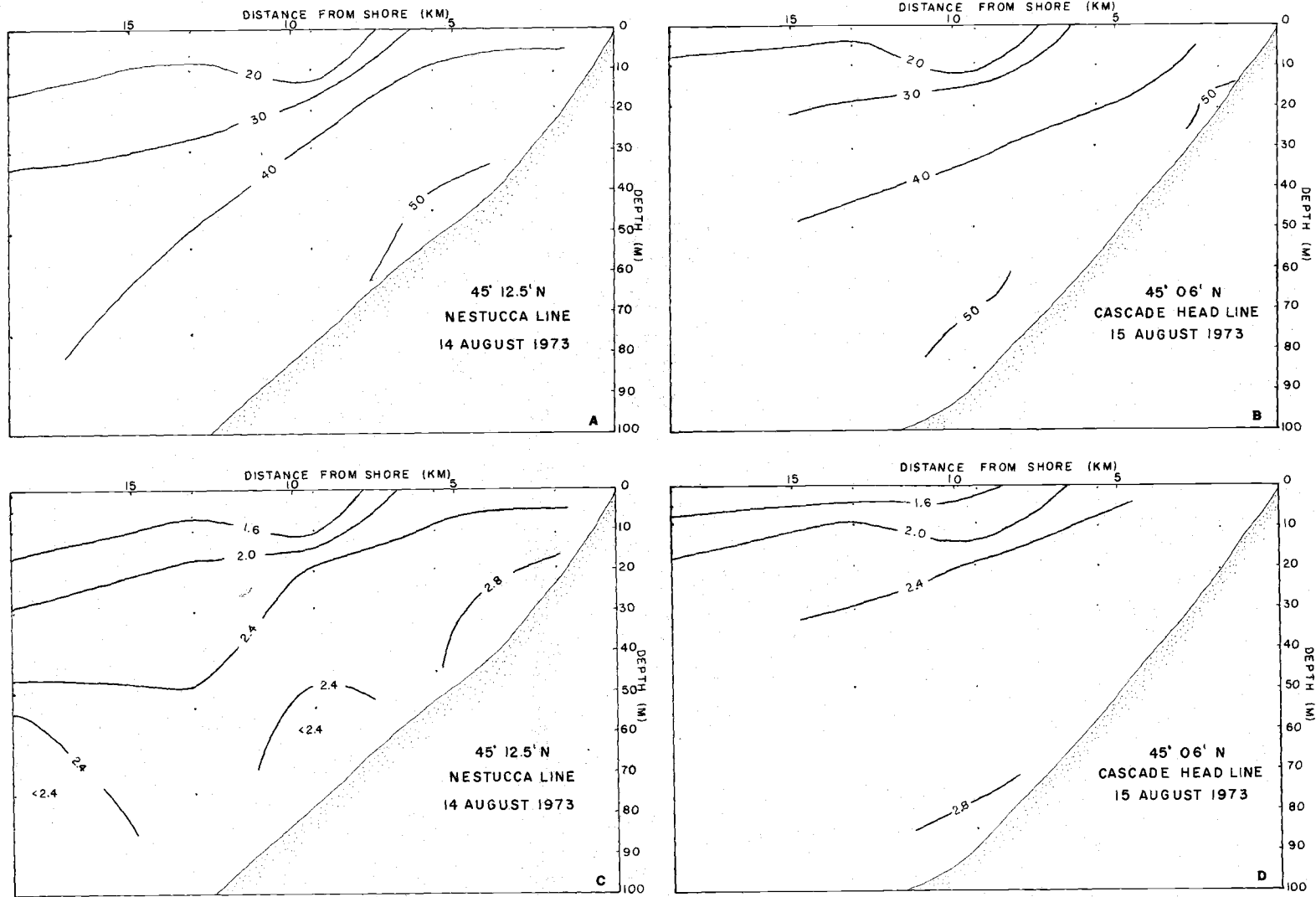


Figure 6. Silica $\mu\text{M}/\text{l}$ (a, b) and phosphate $\mu\text{M}/\text{l}$ (c, d) contours.

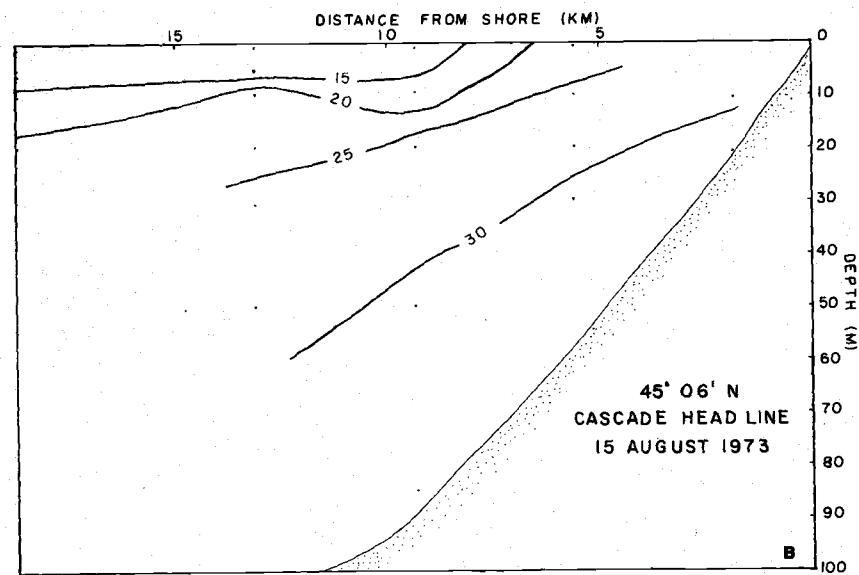
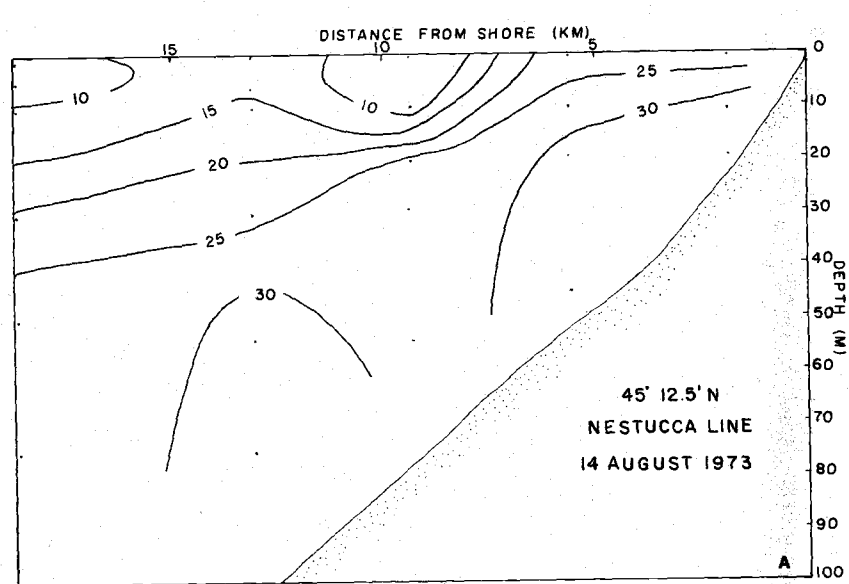


Figure 7. Nitrate $\mu\text{M}/\text{l}$ (a,b) contours.

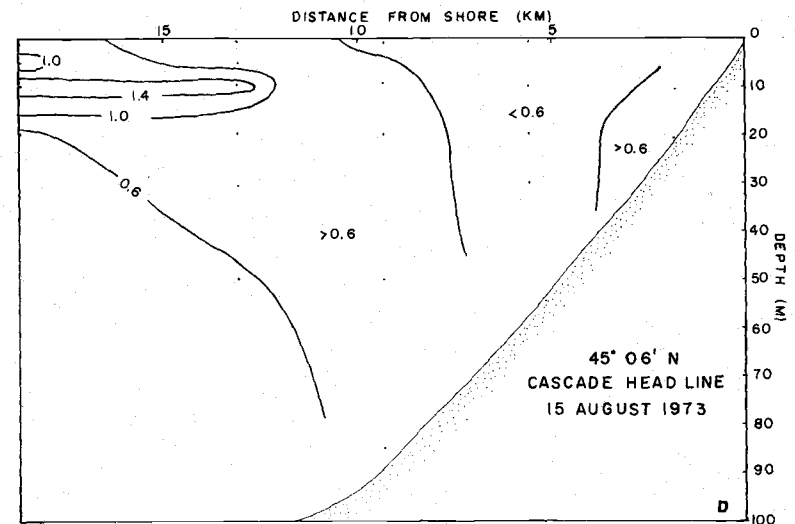
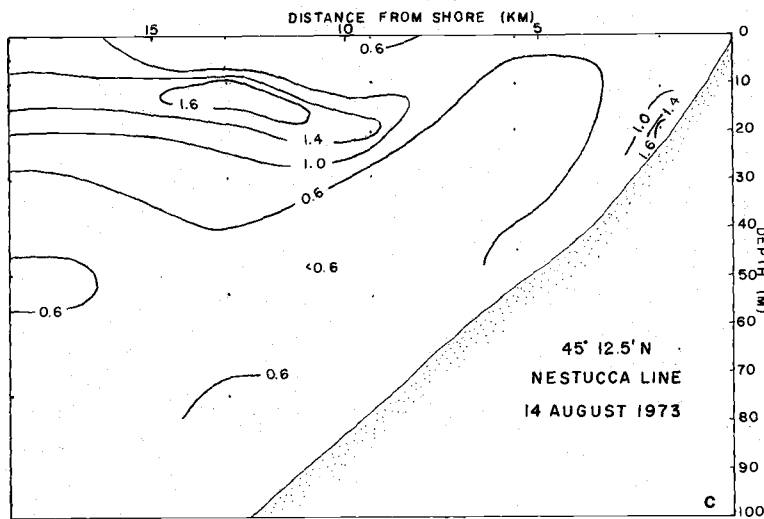
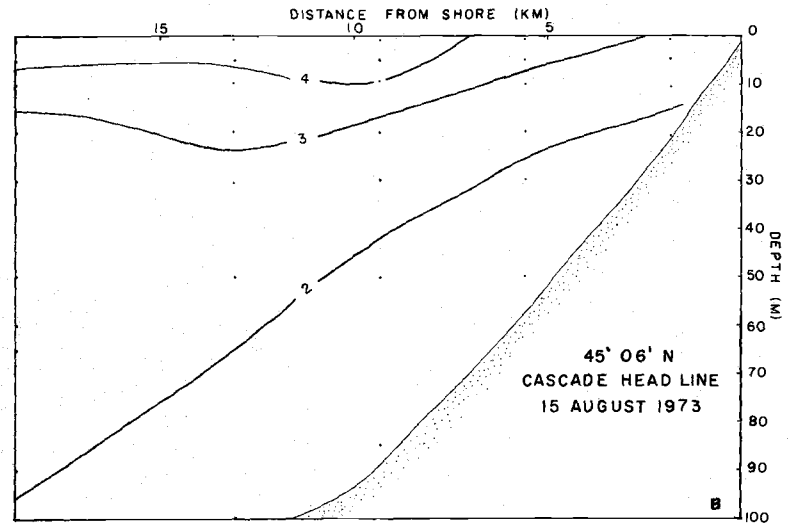
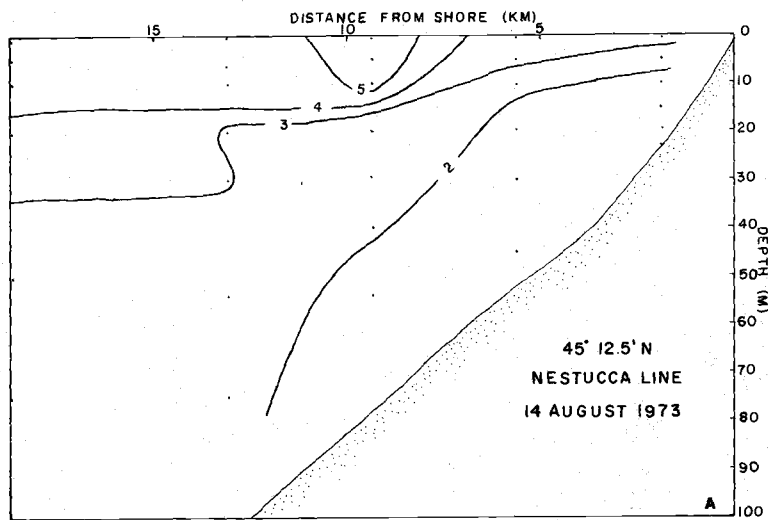


Figure 8. Dissolved oxygen ml/l (a, b) and ammonia $\mu\text{M}/\text{l}$ (c, d) contours.

(perhaps caused by a bit of detritus) near the bottom at 2 km. A scatter plot of ammonia against total numbers of copepods had no discernable pattern. However, comparison of the contour diagrams shows the high ammonia values are associated with high animal density seaward of the frontal layers, whereas low ammonia values are associated with high animal density shoreward of the front. This set of relationships is particularly strong at Cascade Head.

Chl-A distribution (Fig. 9) was similar at each transect: very low below 20 m and near to shore, and highest at 10 km, above and seaward of the frontal layer. The transects differed in that the highest value at Nestucca was at the surface while at Cascade Head it was at 10 m.

Biological Factors

Coscinodiscus sp. (Fig. 9), the only phytoplankton group counted, were the most numerous at 5 m depth near the surface front. They are not considered to be a major species nearshore during upwelling (David Menzies, personal communication), and are included here only because they were large enough (150 μm) to be caught by the 104 μm mesh net.

The various life stages of copepods constituted at least 90% by number of all samples but two (Tables V and VI). The numerical dominance by copepods agrees with the ELH data (Peterson and

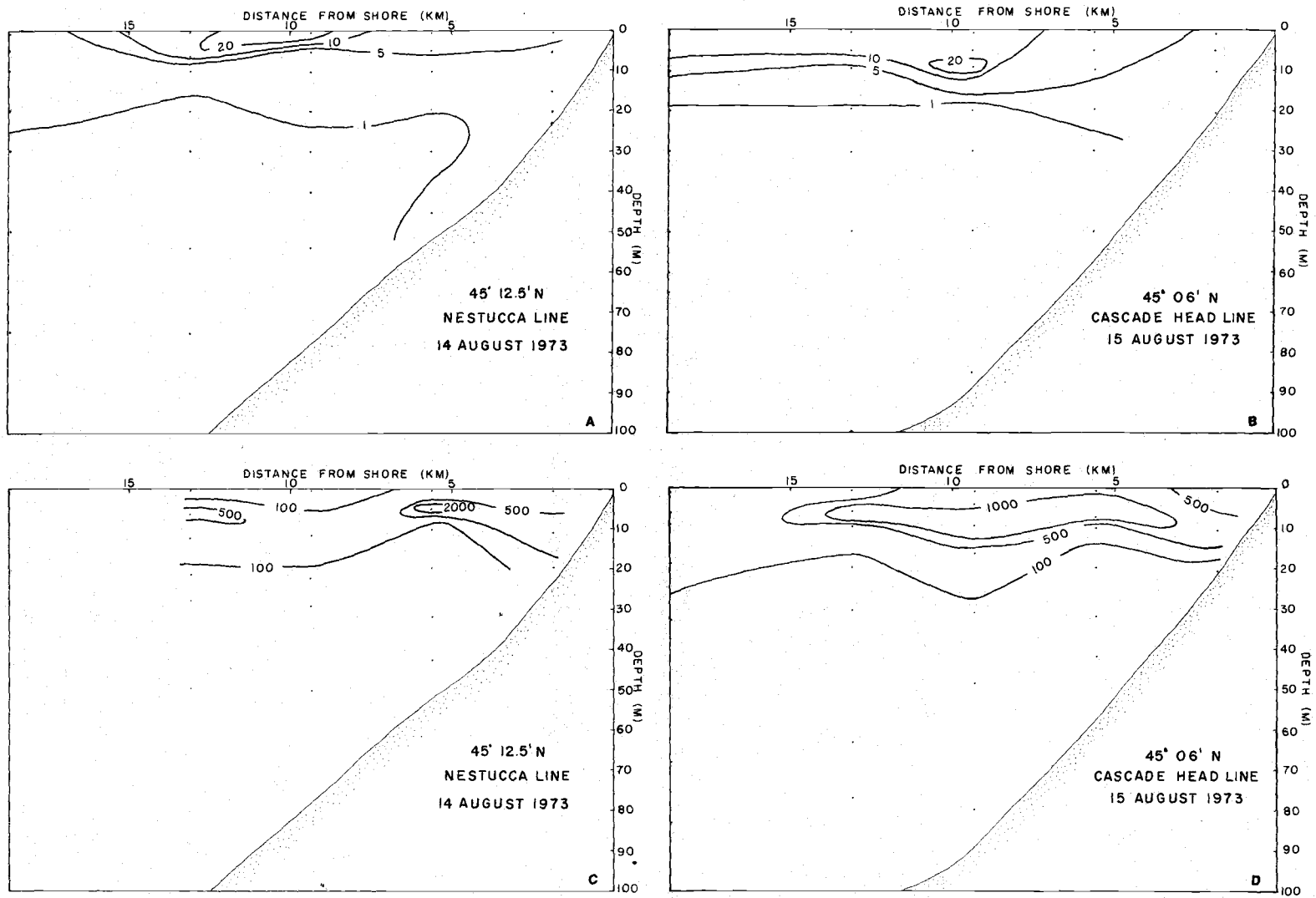


Figure 9. Chlorophyll A $\mu\text{g/l}$ (a, b) and *Coscinodiscus* sp. numbers/ m^3 (c, d) contours.

TABLE V. Zooplanktonic taxa as percentages of the sampled population for groupings which constitute at least 10% of any sample. Nestucca line, 14 August 1973.

	NES 1			NES 3					NES 5					NES 7						
	1m	11m	20m	1m	5m	10m	20m	32m	42m	1m	12m	22m	29m	50m	1m	7m	12m	22m	28m	50m
All copepod stages	94.2	98.4	97.2	89.9	94.6	96.8	99.5	96.2	93.0	97.0	97.4	99.4	98.9	93.6	98.7	98.4	98.2	98.5	99.3	96.3
Copepods and copepodites	30.7	68.2	62.1	49.0	26.0	50.2	27.0	53.0	89.1	27.2	78.4	79.0	63.7	55.8	82.9	75.6	80.7	71.9	73.2	78.2
<u>Pseudocalanus</u> sp.	6.0	62.4	49.0	11.2	11.5	35.2	23.3	44.9	51.2	7.4	56.4	56.9	32.6	22.1	51.0	44.6	33.9	40.4	42.9	20.4
<u>Acartia longiremis</u>	7.9	2.3	6.3	26.8	10.1	4.5	0.5	1.3	4.7	18.0	17.1	11.6	7.3	8.7	27.3	24.9	36.6	9.9	9.7	27.6
<u>Acartia clausi</u>	15.8	3.1	5.8	3.6	0.9	3.0	0.2	0.0	0.8	0.4	0	0	0	0	0	0	0	0	0	0
<u>Oithona similis</u>	0.4	0.4	0.8	7.1	2.6	5.3	2.0	5.7	29.7	0.7	3.6	5.7	18.6	23.2	4.0	5.1	9.3	15.4	11.5	23.6
<u>Calanus</u> sp.	0	0	0.1	0.4	0.9	1.3	0.9	0.7	0.8	0.7	1.3	4.6	5.1	0.2	0.4	0.2	0.9	6.2	8.8	3.2
Other species	0	0.1	0	0	0	0	0.1	0.4	1.7	0	0	0.1	0.1	1.6	0.1	0.8	0	0	0.3	3.5
Copepod eggs and nauplii	63.5	30.2	35.1	40.9	68.6	46.6	72.5	46.2	3.9	69.8	19.0	20.4	35.2	37.8	15.8	22.8	17.5	26.6	26.1	18.1
small (<u>Pseudocalanus</u>) eggs	44.5	7.5	1.3	28.2	12.4	21.4	70.9	41.9	0.8	14.7	5.5	15.1	25.7	27.1	0.2	1.7	1.4	9.5	5.2	1.4
intermediate (<u>Calanus</u>) eggs	2.5	0.1	0.3	0.6	9.5	0.1	0	0	1.1	0	1.2	1.4	2.6	3.0	1.9	2.4	1.6	2.2	1.8	5.5
<u>Acartia</u> nauplii	3.8	0.6	1.8	1.0	1.5	0.1	0.0	0.2	0.1	6.2	1.9	0.9	4.0	3.2	1.1	1.9	0.8	2.3	1.7	0
<u>Calanus</u> nauplii	12.8	22.0	31.7	11.1	45.1	25.0	1.5	4.2	1.9	48.9	10.4	3.0	2.9	4.5	12.6	16.8	13.7	12.6	17.5	11.2
All other taxa	5.8	1.6	2.8	10.1	5.4	3.2	0.5	0.8	7.0	3.0	2.6	0.6	1.1	6.4	1.3	1.6	1.8	1.5	0.7	3.7

TABLE VI. Zooplankton taxa as percentages of the sampled population for groups which constitute at least 10% of any sample. Cascade Head line, 15 August 1973.

	CAS 1			CAS 3				CAS 5						CAS 7					CAS 10											
	1m	10m	21m	1m	7m	10m	20m	32m	42m	1m	4m	9m	16m	31m	48m	80m	1m	6m	9m	20m	30m	63m	77m	1m	6m	9m	18m	33m	68m	83m
All copepod stages	98.9	98.7	94.9	95.2	97.6	97.8	92.8	96.1	96.5	81.6	98.9	98.6	94.9	98.9	96.2	95.7	99.0	97.6	98.6	98.6	95.3	96.9	82.9	97.2	98.0	98.5	98.1	97.5	95.9	98.2
Copepods and copepodites	56.7	44.8	83.4	33.6	44.8	58.6	73.7	71.0	87.8	12.7	33.6	43.8	35.2	84.0	66.6	68.7	73.7	22.9	84.3	90.2	86.4	74.3	63.4	70.2	78.9	86.5	82.5	87.0	85.7	82.4
<u>Pseudocalanus</u> sp.	26.7	35.4	72.0	7.6	23.1	45.2	46.9	53.3	49.3	0.3	0.3	4.6	11.5	30.9	8.5	9.6	11.2	0.3	63.5	27.1	42.1	7.4	18.3	6.9	19.9	23.6	31.7	10.1	8.0	8.3
<u>Acartia longiremis</u>	11.3	3.6	2.1	0.2	16.2	5.2	2.5	2.6	5.8	12.4	32.3	33.9	15.4	30.2	29.8	20.6	60.3	21.1	17.9	42.5	23.1	36.9	24.4	46.5	44.3	49.4	26.0	60.7	12.4	6.8
<u>Acartia clausi</u>	10.8	4.1	4.3	24.2	0.2	1.0	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>Oithona similis</u>	0.6	0.2	3.1	0.4	3.3	6.0	19.3	10.2	28.2	0	0.9	4.6	7.4	19.6	24.7	20.6	2.1	1.5	1.7	18.4	18.1	25.7	14.6	16.6	13.0	12.1	20.6	13.5	49.0	44.9
<u>Calanus</u> sp.	4.0	0.7	0.2	1.0	1.9	1.0	2.5	2.4	1.0	0	0.1	0.6	0.9	2.9	3.6	10.7	0.1	0	1.2	2.1	2.6	1.9	6.1	0.2	1.7	1.2	4.1	2.7	9.1	11.6
Other species	0	0	0.5	0	0.1	0.1	0.6	2.5	3.4	0	0.1	0.1	0	0.2	0.9	7.1	0	0	0	0.2	0.5	2.4	0	0	0	0.1	0.1	0	7.2	10.7
Copepod eggs and nauplii	42.2	53.9	11.5	61.6	52.8	39.2	19.1	25.1	8.7	68.9	65.3	54.8	59.7	14.8	29.6	27.0	25.3	74.7	14.3	8.4	8.9	22.6	19.5	27.0	19.1	12.0	15.6	10.5	10.2	15.8
small (<u>Pseudocalanus</u>) eggs	1.2	26.7	1.8	1.6	7.2	30.2	1.0	7.6	0.4	3.7	0	0.7	0.1	3.6	1.1	0.4	0	0	3.3	0.7	0.4	3.5	1.2	0.5	0.6	2.9	3.6	1.8	1.1	3.9
intermediate (<u>Calanus</u>) eggs	10.5	2.6	0.7	23.4	7.0	0.5	2.0	4.0	0	51.4	6.4	3.2	14.6	1.3	9.9	7.8	4.1	3.4	0.8	0.5	1.2	5.8	2.4	6.0	1.1	0.8	3.1	2.5	3.0	2.4
<u>Acartia</u> nauplii	5.0	3.3	1.2	16.1	4.4	0.3	0.4	0.9	7.3	7.2	47.8	1.6	1.0	0.3	0	0	15.7	7.0	0.3	0.3	0	0.3	4.9	1.6	1.5	0.2	0.8	0	0	0.3
<u>Calanus</u> nauplii	25.5	21.3	7.9	20.5	34.3	8.2	15.8	12.6	1.0	6.6	11.1	49.3	44.1	9.6	18.6	18.9	5.5	64.3	9.9	6.9	7.3	13.0	11.0	19.0	15.9	8.1	8.2	6.3	6.1	9.2
All other taxa	1.1	1.3	5.1	4.8	2.4	2.2	7.1	3.9	3.5	18.4*	1.1	1.4	5.1	1.3	3.0	4.3	1.0	2.4	1.4	1.4	4.7	3.2	17.1#	2.8	2.0	1.5	1.9	2.5	4.1	1.8

* euphausiid eggs 17.5

euphausiid eggs 12.2

TABLE VII. Rare species list by water type affinity and with code for rare species contour.

Code		Reference
Offshore Oregon		
A	<u>Calanus tenuicornis</u>	Peterson, 1972; Mullin, 1969
B	<u>Eucalanus bungii</u>	Peterson, 1972
C	<u>Metridia lucens</u>	Peterson, 1972
D	<u>Racovitzanus antarcticus</u>	Peterson, 1972
E	<u>Limacina helicina</u>	McGowan, 1960
Open-ocean Boreal		
F	<u>Aetidius pacificus</u>	Brodsky, 1950
G	<u>Calanus cristatus</u>	Brodsky, 1950
H	<u>Calanus plumchrus</u>	Brodsky, 1950
I	<u>Metridia pacifica</u>	Brodsky, 1950
J	<u>Microcalanus pusillus</u>	Brodsky, 1950
K	<u>Microsetella rosea</u>	Marlowe, 1974
L	<u>Oncaea borealis</u>	Marlowe, 1974
M	<u>Euchaeta japonica</u>	Brodsky, 1950
N	<u>Scolecithricella minor</u>	Brodsky, 1950
O	<u>Eukrohnia hamata</u>	Alvarino, 1965
Neritic Boreal		
X	<u>Epilabidocera longipeda</u>	Peterson, 1972
Y	<u>Tortanus discaudatus</u>	Brodsky, 1950

Miller, in press). Five species of copepods made up more than 75% of the adult copepod and copepodite population. They are Pseudocalanus sp., Acartia longiremis, A. clausi, Oithona similis and Calanus sp. which agrees completely with the ELH data on major species. Apparently, the data from the two sampling programs is comparable although mesh and mouth sizes of the nets differed. In many of the samples there were no other copepod species present. The major exceptions were that Centropages abdominalis occurs in nearshore surface samples, and a variety of rare species occur in samples from near the bottom. These rare copepod species were less than 2% of the total catch in 43 of the 50 samples.

Adult copepods were counted by sex and immature forms according to stage. Density in numbers per m^3 is listed in Appendix A. Adult and copepodite counts were summed to make the contour plots. Concordance tests (Tate and Clelland, 1957) indicated at the 0.005 level for Pseudocalanus sp. and Acartia longiremis that no information would be lost by summing. Members of a particular species did not separate spatially by age classes but were found in mixed groups. Eggs and nauplii of these species (which were sufficiently abundant for estimation) did have different population centers than the older stages and they are plotted and discussed separately.

All copepod stages including eggs and nauplii were summed to

draw contours A and B of Figure 10. The relationship of copepod population centers to the hydrography is very striking: copepods are most abundant at the bottom of the mixed layer, and their abundance is greatly reduced within the frontal layers. The same relationship is even stronger for the copepod and copepodite population excluding eggs and nauplii (Fig. 10C, D); most copepods were located on either side of the front at 10-15 m depth. The adult and copepodite populations were nearly equal in size on both sides of the front and at both transects, but Cascade Head did have a larger population spread over a larger area. Eggs and nauplii were present at densities of about $10,000/m^3$ in all centers of copepod density which appear in the data, except inshore at Cascade Head where their densities reached $30,000/m^3$.

The numerically dominant animal was Pseudocalanus sp. It is ranked first among copepods in 26 of 50 samples and second or third in 19 of the remaining 24 samples. The Pseudocalanus sp. (Fig. 11) contours are very similar to the total copepod and copepodite contours because they strongly influence them. Pseudocalanus sp. were most numerous at approximately 10 m depth and show a strong hiatus in the frontal layers. Pseudocalanus sp. populations show a marked decrease seaward of 15 km. On the Nestucca transect the seaward population is larger than the shoreward population; on the Cascade Head transect they are of equal size.

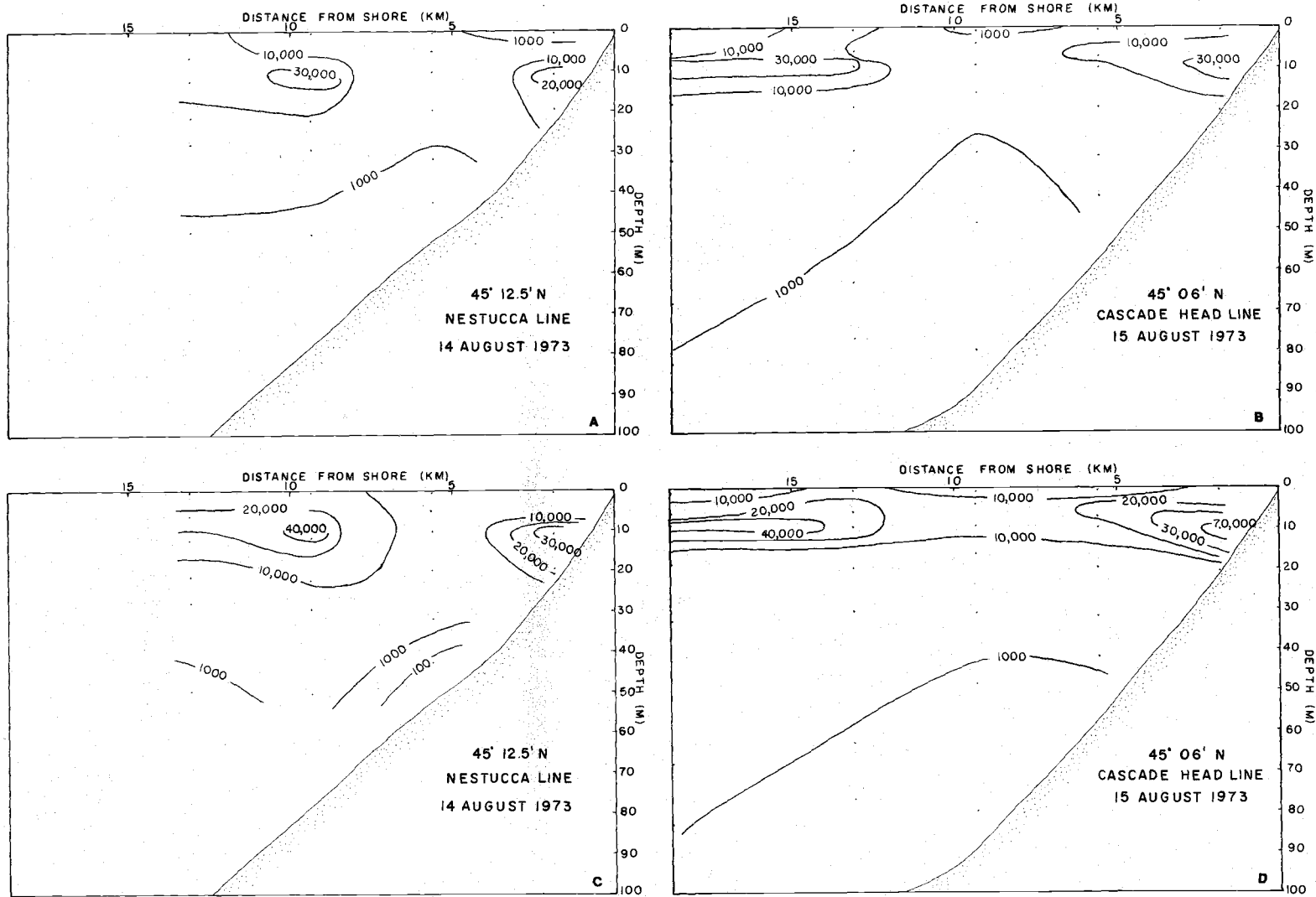


Figure 10. Sum of all copepod stages number/m³ (a, b) and sum of all copepodites number/m³ (c, d) contours.

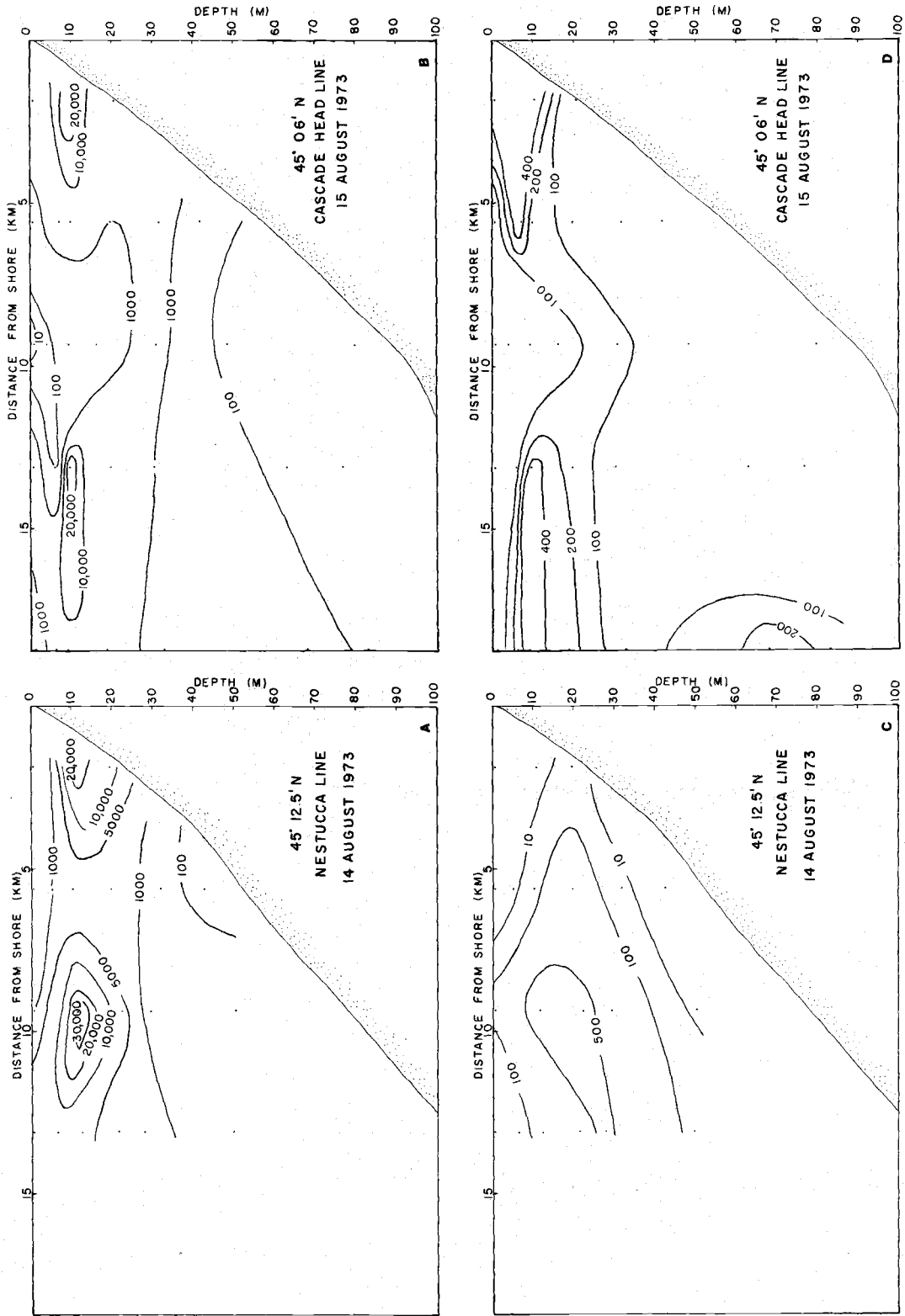


Figure 11. *Pseudocalanus* sp. copepodites number/m³ (a, b) and *Calanus marshallae* copepodites number/m³ (c, d) contours.

Calanus marshallae (Fig. 11) had distinct centers on either side of the front at Cascade Head but not at Nestucca, where there was no population center shoreward of the surface front. At all stations the population centers were near 10 m depth.

There were some species which were consistently centered either shoreward or seaward of the front. Acartia longiremis (Fig. 12) was the most numerous of these species. Its population centers were just seaward of the front and at approximately 10 m depth. At 7 nautical miles on the Cascade Head transect, the population center was at the surface. This was one of only two population centers found located at the surface in this study (the other was Calanus nauplii on the Nestucca transect). Acartia clausi was found shoreward of the front, very few individuals were found seaward of the front. Both transects were similar.

For the species discussed above there is also some data on pre-copepodite forms: the nauplii and eggs. The eggs counted as small round eggs are mostly believed to be Pseudocalanus sp. eggs (William Peterson, personal communication). Unlike the copepodites which were remarkably similar between transects, there was little correlation between the two transects for these small eggs (Fig. 13). Both population centers were shoreward of the front, but the populations were at different depths, differed in density, and in their position relative to the frontal layers. The small population

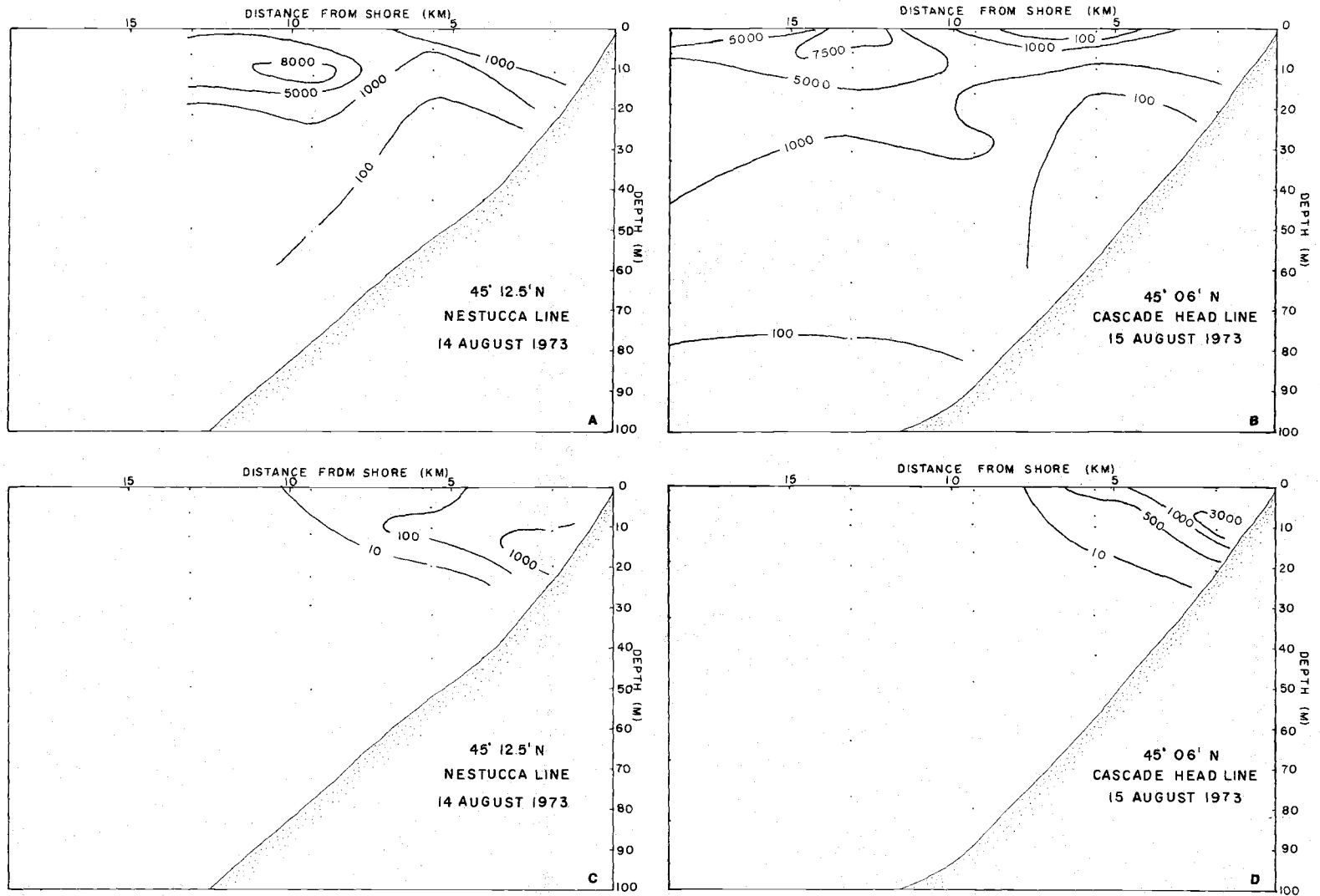


Figure 12. *Acartia longiremis* copepodites number/m³ (a, b) and *Acartia clausi* copepodites number/m³ (c, d) contours.

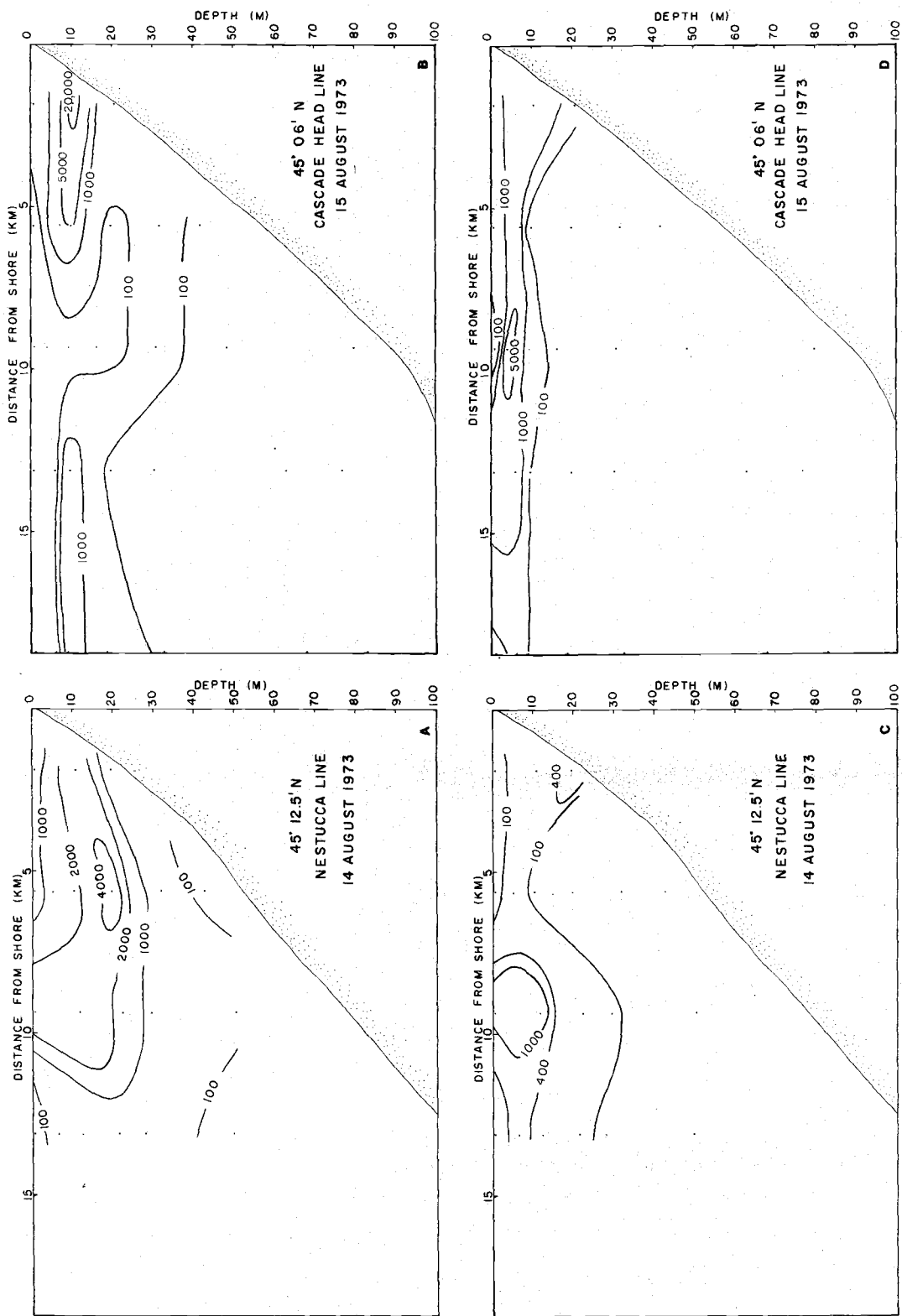


Figure 13. Small (*Pseudocalanus* sp.) eggs number/ m^3 (a, b) and *Acartia* sp. nauplii number/ m^3 (c, d) contours.

center on the Nestucca transect was located directly below the surface front. The nearshore population of small eggs on the Cascade Head transect corresponded with the nearshore population of Pseudocalanus sp. copepodites but none of the other small egg populations corresponded with the Pseudocalanus sp. copepodite population.

Acartia nauplii (Fig. 13) were probably mostly Acartia longiremis rather than Acartia clausii, which has shorter appendages. Although the Acartia longiremis copepodite population was similar in size between transects, the Cascade Head naupliar population is larger than the Nestucca population. The population centers for both copepodites and nauplii were in similar positions seaward of the surface front.

Calanus nauplii (Fig. 14) were also enumerated. They had a hiatus in the frontal layers and population centers at about 10 m depths. On the Nestucca transect the seaward population center extended to the surface. The positions of the Calanus nauplii and the Calanus copepodites were very dissimilar on the Nestucca transect but similar on the Cascade Head transect.

Eggs counted as intermediate rounds (Fig. 14) are Calanus marshallae eggs (William Peterson, personal communication). Location and numbers of the eggs showed little relationship between transects or to the nauplii and copepodites on the same transect.

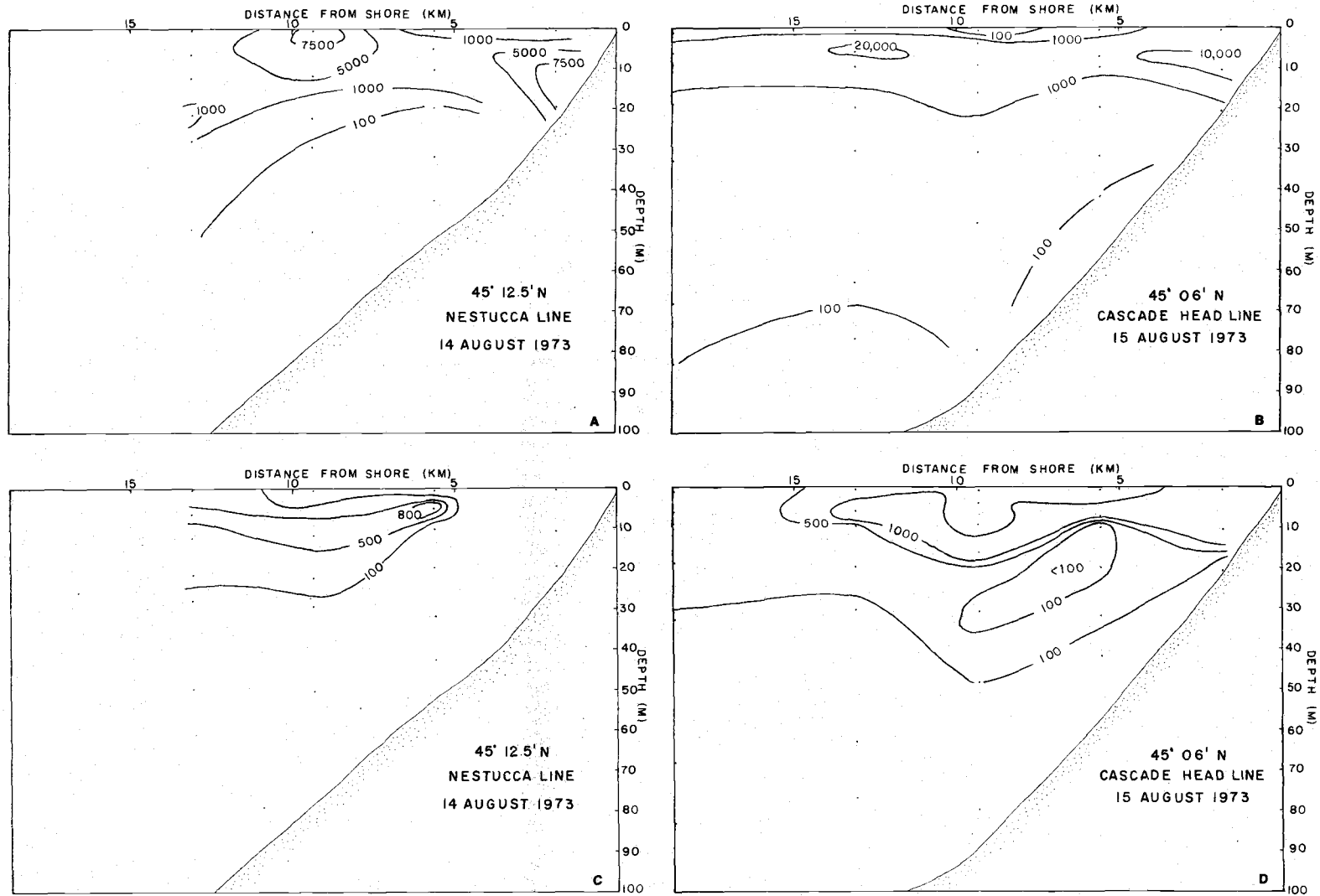


Figure 14. *Calanus* sp. nauplii number/ m^3 (a, b) and *Calanus* sp. eggs number/ m^3 (c, d) contours.

There is a correlation between location and numbers of adult female Calanus marshallae (see Appendix A for numbers) and the eggs. The largest density of females ($150/m^3$) was found on the Cascade transect at the surface at the one nautical mile station. A decreasing female population ($10/m^3$) was found seaward. These females may correspond with the 100 nauplii/ m^3 contour, which extended 7 km farther seaward than the female population. On the Nestucca transect females were species found in the sample not abundance of a single species. The number of deepwater species were summed to make the contours. The neritic boreals are shown by letter designation but are not included in the contours. The Nestucca line clearly shows that the offshore species were near the bottom and were closest to the surface in the upward flowing frontal layers. The Cascade Head transect is not as clear. There are high numbers of offshore species near the bottom and they do approach the surface in the frontal layers but the picture is not consistent. There are also low numbers near the bottom and in the frontal layers. The neritic boreal species, indicated by X and Y, are all found near the surface.

The populations of bivalve mollusc veligers, gastropod veligers, barnacle nauplii A, euphausiid eggs and euphausiid nauplii were also examined for patterns. They were not present in enough samples or in great enough abundance (always less than $600/m^3$) to generate any useful contour patterns (see Appendix A for abundance). Some

generalizations can be made: populations were low in the frontal layers (except barnacle nauplii) and decreased with depth and with distance offshore. Population centers were at 10 m depth.

DISCUSSION AND CONCLUSIONS

Steele (1961) pointed out that causal relationships between nutrients, plants and animals are often obscure because of time changes (for example, lag between plant and animal growth) and because of spatial changes (such as flow outward from an upwelling region). In order to seek causal relationships Steele suggested sampling on successive days or at distances of a few kilometers, and he recommended choosing areas of large hydrographic changes over short distances. The sampling scheme used in the summer of 1973 followed these suggestions. Five to eight sampling stations were located on transects of 10-40 km length across a region of major hydrographic changes, the Oregon coastal upwelling zone. Transects were sampled in July (one transect), in August (three transects), and in September (two transects). Transects within each set were made on successive days but were not at the same latitude.

Each set of transects was made during different parts of the upwelling cycle, when hydrographic conditions were quite different. This study presents the results of two of the August transects, made during active upwelling, for which extensive hydrographic, nutrient and Chl-A data are available. Data from other transects are discussed as well. The samples were counted by William Peterson (unpublished data).

Summary of Conclusions for Transects During an
Active Upwelling Period

On both transects of this study, zooplankton were found on either side of the surface front (Figs. 10-16). Centers of both populations were located at approximately 10 m depth. For the offshore station 10 m is near the bottom of the mixed layer. At the inshore station the water was mixed to the bottom (Cascade Head) or the mixed layer was very shallow (5 m at Nestucca). A few taxa did have offshore populations which extended to the surface (Acartia longiremis copepodites at Cascade Head, Fig. 12, and Acartia and Calanus nauplii at Nestucca, Fig. 13 and 14). Abundances were very high at the station closest to the shore (2 km) and may have continued high shoreward. At Nestucca most of the taxa with offshore population centers decreased in samples collected farther to the west. The sampling did not continue far enough west at Cascade Head to find a seaward decrease in the density of Calanus marshallae copepodites (Fig. 11). Acartia longiremis (Fig. 12) and Pseudocalanus (Fig. 11) sp. copepodites did decrease at the seaward end of the Cascade Head transect.

Since 95% of the zooplankton were copepods, this discussion is primarily about that group. However, patterns were examined for all taxa which were found in at least 20 of the 50 samples; the taxa are indicated on Table IV. All the distributions resembled the contoured and described patterns with a few exceptions. Barnacle nauplii had a

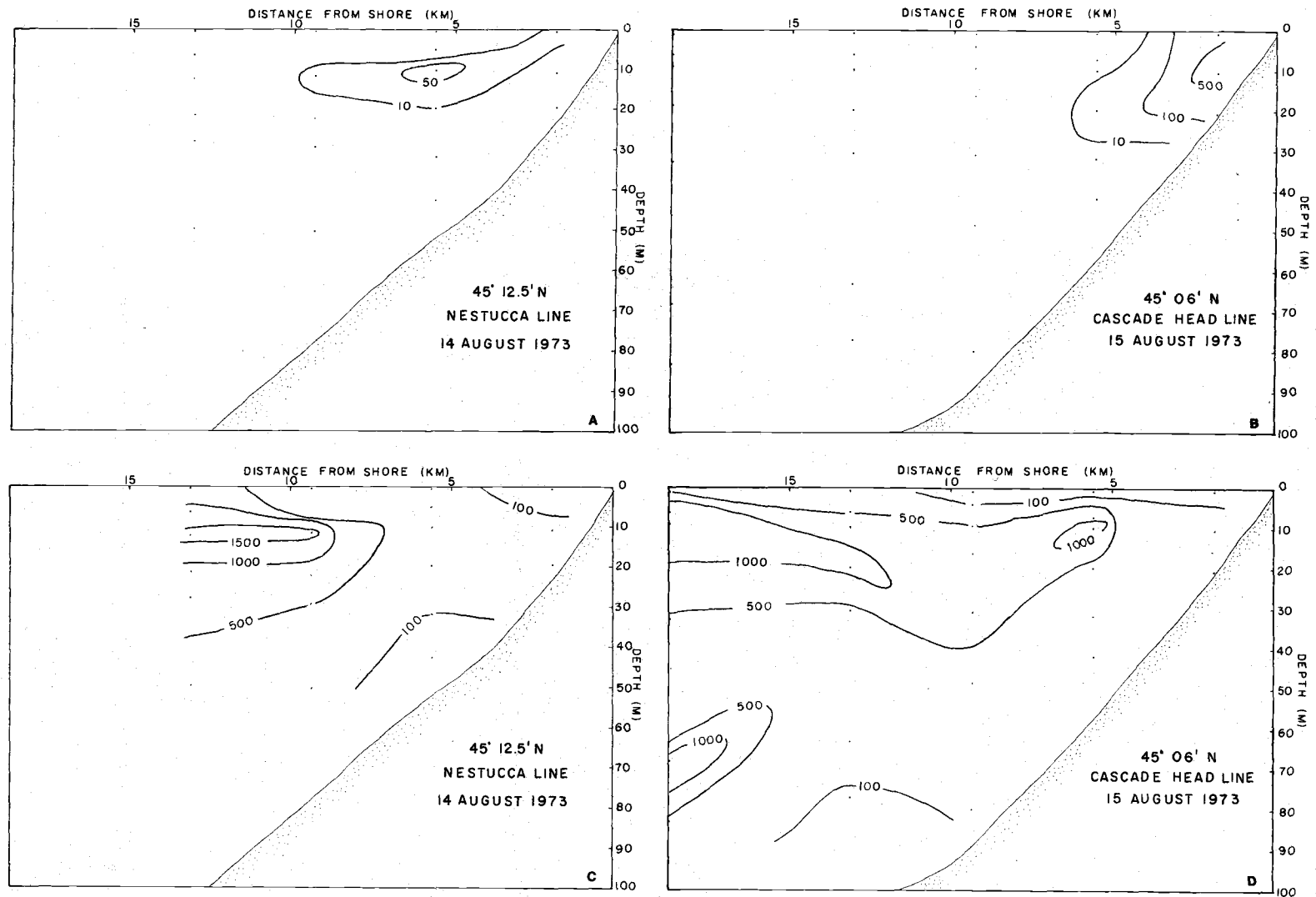


Figure 15. *Centropages abdominalis* copepodites number/m³ (a, b) and *Oithona similis* number/m³ (c, d) contours.

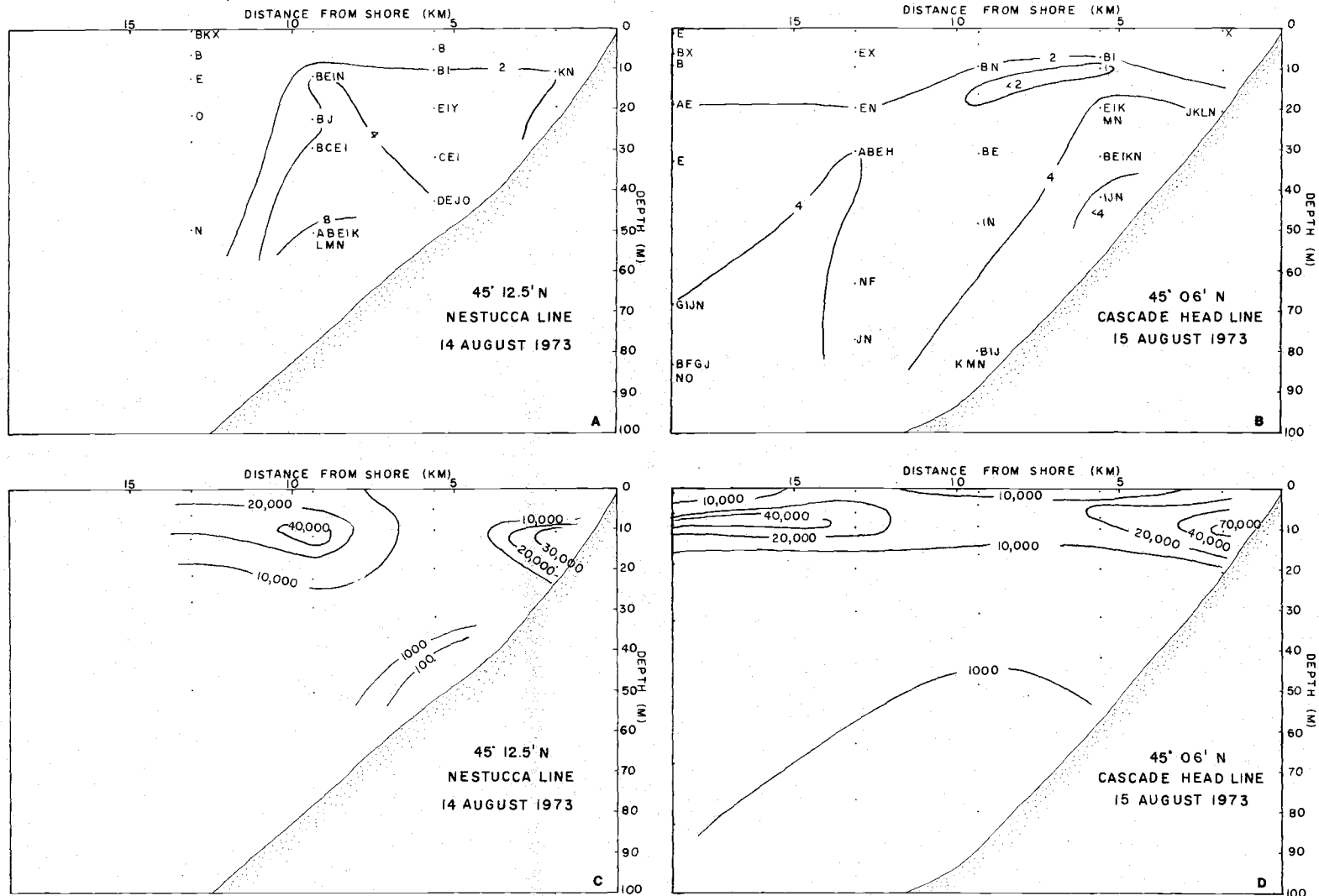


Figure 16. Number of offshore species/sample and location of rare species (see Table VII for code) (a, b) and all zooplankton number/m³ (c, d) contours.

population center in the frontal layers and the Sagitta elegans population seaward of the front was well below 10 m depth (> 30 m).

Within any single vertical series of samples more than 95% of the zooplankton were clustered at 10 m depth, except the series taken through the surface front (Fig. 16). These samples were taken during one day, but there is no evidence of typical diel migration (William Peterson, unpublished data), so animals would not be expected to change depth importantly during this time.

The third transect of the August set (Peterson, personal communication), also during active upwelling, was along the Newport hydrographic line on August 16. The surface front was located at 14-20 km. Most of the zooplankton were shoreward of the front with the largest number at the station closest to the coast. The phytoplankton as measured by Chl-A were highest at the 7 and 10 nautical mile station (14 and 20 km). Nutrient measurements were not made. The plankton pattern differed from the Cascade and Nestucca transects in some respects: there was not a large seaward population of phytoplankton or zooplankton, and phytoplankton were most abundant in the surface front. Like the two previous transects zooplankton density is greater near the shore where Chl-A was very low.

Interpretation of Plankton Distribution Patterns
During Active Upwelling

The location of an individual plankton organism is in all likelihood determined largely by water movement. The currents of the upwelling zone were examined to determine if they could be a factor in producing the patterns. Throughout the upwelling season there is major water movement at velocities which would transport plankton considerable distances. The flow is predominantly south, which would not affect the distribution in a vertical section perpendicular to the coast. The velocities are about 700 km/month (23 cm/sec) in the upper 10 m within 15 km of the coast. Flow decreases with depth, but is still 500 km/month (16 cm/sec) at 20 m depth.

During active upwelling water flows along the frontal layers to the surface and then westward. The westward component of flow is 150 km/month (5 cm/sec) or 5 km/day. The newly upwelled water is relatively devoid of plankton, and several days are required before abundant phytoplankton develop in the nutrient-rich upwelled water. Therefore, the maximum of plant density is not in the upwelling band, but several day's equivalent of flow to the west. Farther west the phytoplankton abundance is reduced, possibly by zooplankton grazing. West of the maximum, phytoplankton appear to be nutrient limited (Figs. 6 and 7) and densities are lower. The westward flow also explains the location of the Chl-A maximum within the surface front

at Newport. At all locations the band of upwelling water is broad, extending shoreward from the surface front to within about 3 km of the coast. At Newport the surface front was 10 km farther to sea than on the other two transects, so that water reaching the surface at the shoreward edge of the band results in a phytoplankton population right in the surface front, 14 km from shore.

There is not a corresponding increase in zooplankton located to the west of the area of greatest phytoplankton density. The transit time through the regions of high phytoplankton density is only about two days. Zooplankton cannot reproduce quickly enough to respond to this short-lived food supply. An herbivore in the surface flow would have dense concentrations of food available for a very short time until the current removed it from the upwelling zone.

Zooplankton below the surface flow can probably take advantage of sinking and mixing of food from the high phytoplankton abundance above them and maintain their horizontal position relative to the front and the shore. The surface flow measured by the current meters was not deep, there was a level of no onshore-offshore motion just below 10 m depth (Fig. 5). High Chl-A does extend to 10 m on the Cascade Head transect. It does not at Nestucca but there is some evidence that it may have done so shortly before the sampling date, since oxygen was high and nutrients were low at this depth.

Studies in deeper (> 200 m) waters indicate that several

congeners (Calanus pacificus, helgolandicus and Pseudocalanus minutus copepodites and nauplii) of major Oregon coastal species have their greatest abundance at the same depth as the Chl-A maximum (Anderson et al., 1972; Mullin and Brooks, 1972). Active aggregation, greater egg production, greater juvenile survival or a combination of these are suggested as reasons for the correlation of zooplankton with phytoplankton.

The seaward zooplankton population in this study correlates with the Chl-A maximum given that a zooplankton population cannot maintain its geographic position in the surface flow. Both zooplankton and phytoplankton were scarce below 12 m, but only phytoplankton were abundant above 10 m. This suggests that greater egg production and greater juvenile survival in a region of high food availability may be more important than active aggregation in determining the depth of greatest zooplankton abundance. Herbivores actively selecting the Chl-A maximum will be above 10 m and shortly removed from the area of greatest food abundance by the westward flow. Zooplankton might actively choose depth using a physical cue, such as the thermocline or light intensity, which would locate them at the bottom of the surface flow.

Less is known about the currents acting on the shoreward population center. Most current meters cannot presently be used in depths less than 30 m or so because it is too shallow to successfully

filter out wave and bottom effects. Drogues and drift bottles have been used to study nearshore water movements for periods of several days. Upwelling velocities probably decrease from the surface front to the shore (Stevenson et al., 1974). Drogues and drift bottles in this "euneritic" zone are carried south at the same velocity as that measured by current meters in deeper water (600 km/month) (Holton and Elliot, 1973; Miller, unpublished data). An offshore component of flow or Ekman layer was not seen, on the contrary, drogues and drift bottles ultimately are caught in the surf zone, indicating a small component of onshore flow. This seems then to be a stable region where zooplankton populations may grow up close to the nutrient rich upwelling water. Stable is used here in the sense of maintaining horizontal position with relation to the shore.

At the time of sampling there was very low Chl-A at the nearshore stations. Nutrients did not show a decrease, nor oxygen an increase, indicating low phytoplankton levels. Although high ammonia levels correlated with high zooplankton populations at the offshore stations, ammonia levels were low inshore, suggesting that zooplankton were not excreting. Lack of excretion usually means that energy supplied by ingestion is less than energy required for respiration and growth. It is not understood why the "euneritic" zone would be stable enough for a large zooplankton population to be present but not contain a sizable phytoplankton population although illumination

may be a factor. The near shore nutrient sampling indicates that nutrients are available. Although nutrient rich water does not flow into the "euneritic" zone, there should be mixing and diffusion into the layer. There is fog along the coast during active upwelling due to the cold water at the surface. Reduced radiation for periods of more than a few days can have a significant effect on phytoplankton density (Steele, 1961).

Summary and Interpretation of Plankton Distribution Patterns During Non-Active Upwelling

Samples were collected with a pump along two transects near Wecoma Beach (45°00.5'N) and Nestucca on September 11 and 12, respectively (William Peterson, unpublished data). There had been no northerly winds for one week and winds had not been strong for the three previous weeks. Zooplankton density was greater than during August sampling but there were no population centers. Different species seemed to occupy different depths in the upper 20 m. Abundances were highest nearshore (within 15 km of the coast) and decreased offshore. Chl-A levels were high (10-25 µg/l) in the upper 10 m from 5 km seaward. The highest Chl-A measured during the summer was 60 µg/l on September 11 at Wecoma Beach.

The physical stability of the system due to lack of upwelling may have contributed greatly to the growth of the bloom. When upwelling

is not active, the frontal layers subside near the coast to a horizontal position and there is no surface front. Water continues to upwell (Huyer, 1974), much more slowly and nutrients reach the surface mostly by mixing and diffusion. Water along the coast is warmer and fog is not present. Phytoplankton grow near the coast as there is westward component of flow (Pillsbury et al., 1974; Halpern et al., 1974) to carry nutrients and plankton seaward.

Summary and Interpretation of Plankton Distribution Patterns During the Initiation of Active Upwelling

A zooplankton collection was made on the Nestucca transect on July 29 (William Peterson, unpublished data), seven days after the wind had begun to blow from the north (Fig. 2). Animals were most abundant (approximately 12,000 copepodites/m³) 2 km from shore at 10 m depth and 20 km from shore at the surface. There were 5,000-10,000 copepodites/m³ in a band at 10 to 20 m depth stretching from the nearshore (2 km) to the offshore (20 km) station except for a hiatus 7 km from shore particularly evident below 20 m. Chl-A and primary productivity data were collected on Cascade Head and Nestucca transects on July 30 and 31 (Kitchen et al., 1975; David Menzies, unpublished data). These values were maximum 3 km from the coast. There was a second Chl-A maximum at the surface at 12 km considered to be in the Columbia River plume from its

correlation with low salinity.

When a new upwelling event is initiated by steady southward blowing winds after a period of calm or northward blowing winds there is a transition period while the pycnocline upwarps to the surface. Ten days may be required for pycnocline at 50 m depth to penetrate the surface (O'Brien and Hurlburt, 1972). At the end of July temperature and salinity values indicated that a surface front had not yet been formed but that the frontal layers were approaching the surface 7 km from shore. Drogue studies suggest that when the frontal layers upwarp there is a divergence in the east-west direction above the warp (Stevenson et al., 1974).

Plankton as Indicators of Water Movement

Rare species may be good indicators of the source of upwelling water. Species characteristically found more than 20 km offshore could have been carried along the nearshore bottom and up toward the surface in the upwelling water. The surface southward flow apparently carried boreal neritic species into the study area. These species were only found near the surface. The rare species could be used as an indicator of water source and movement as they agree very well with the physical data. Sampling at depths of more than 80 m should produce southern fauna as current meters (Huyer, 1973; Pillsbury et al., 1974) indicate a northward flowing current at 100 m. Plankton

may be used to test and even suggest hypotheses about the physics of upwelling even though plankton are non-conservative.

Summary of Hypothetical Processes Generating Plankton Distribution Patterns During the Upwelling Season

During active upwelling there are two zooplankton populations: an offshore population below the offshore transport layer and below but probably fed by a phytoplankton population, and an inshore population with no measurable food supply. Nutrients are supplied to the offshore area by upwelling. Light may be limiting nearshore because of coastal fog.

During non-active upwelling there are phytoplankton blooms and high zooplankton density throughout the 20 km nearshore area. The members of the inshore zooplankton population presumably eat at this time. Lack of both fog and offshore water transport (physical stability) are probably of major importance.

During initiation of active upwelling the upwarping frontal layers push plankton on or offshore separating the zooplankton into the two populations of active upwelling. Phytoplankton productivity remains at high levels during the settling up period of about one week.

Future Work

The few transects of this study suggest distribution patterns

which are related to the upwelling regime. More transects must be made to test the generality of the patterns and their physical correlation. Collecting samples with pumps rather than nets should allow faster, more reliable collecting. A budgetary approach to zooplankton populations in the upwelling zones could be particularly informative. Studies of light, nearshore currents and primary productivity are especially needed in the "euneritic" zone.

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APPENDIX

APPENDIX OF DATA

Zooplankton data for Nestucca line, 14 August 1973 and Cascade Head line, 15 August 1973. All data are in number of animals/m³. An 's' means that an animal was seen only in the scan of the sample after subsampling and abundance was low but undetermined.

	NES 1			NES 3					NES 5					NES 7						
	1m	11m	20m	1m	5m	10m	20m	32m	42m	1m	12m	22m	29m	50m	1m	7m	12m	22m	28m	50m
<u>Acartia clausi</u>																				
Total	288	1050	1375	75	83	239	10	1	1	58	0	0	0	0	0	0	0	0	0	0
I	27	28	0	20	10	18	0	0	0	12	0	0	0	0	0	0	0	0	0	0
II	7	0	0	18	5	36	0	0	0	8	0	0	0	0	0	0	0	0	0	0
III	10	28	0	6	10	36	0	0	0	8	0	0	0	0	0	0	0	0	0	0
IV	31	0	94	6	3	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	3	28	125	9	13	41	0	1	0	0	0	0	0	0	0	0	0	0	0	0
♀	209	884	719	13	36	54	9	0	1	27	0	0	0	0	0	0	0	0	0	0
♂	0	83	437	4	5	23	2	0	0	4	0	0	0	0	0	0	0	0	0	0
<u>Acartia longiremis</u>																				
Total	144	774	1500	557	919	365	30	23	4	2744	8340	1425	193	127	4523	5355	6627	450	547	279
I	21	194	125	35	62	14	4	0	0	276	376	51	17	0	652	413	915	4	30	3
II	21	28	125	30	52	32	0	0	<1	202	734	45	2	0	964	590	1035	4	6	0
III	24	0	94	22	78	23	0	0	1	424	1181	77	2	0	504	738	765	26	6	0
IV	27	83	94	33	112	50	4	2	1	412	1271	396	5	0	217	590	630	0	12	3
V	27	28	94	53	197	108	2	0	1	280	895	38	10	5	285	620	930	73	18	0
♀	14	166	63	294	369	54	18	21	1	1069	2398	575	89	103	1019	1195	1109	214	285	264
♂	0	277	906	90	49	86	4	0	<1	82	1486	243	67	19	883	1210	1244	128	190	9
<u>Calanus marshallae</u>																				
Total	0	0	31	7	78	131	56	11	1	105	644	569	135	2	68	44	165	282	499	32
I	0	0	0	2	8	32	2	s	<<1	4	215	20	10	0	14	s	s	98	232	3
II	0	0	0	0	26	59	25	5	<<1	4	179	147	55	0	41	44	15	81	143	3
III	0	0	0	6	29	27	16	7	<<1	43	197	173	19	2	s	s	45	47	60	3
IV	0	s	0	0	5	s	2	s	<<1	35	54	128	41	s	s	s	s	34	30	17
V	0	s	31	0	10	5	4	s	0	20	s	64	7	s	14	s	45	17	6	s
♀	0	0	0	0	s	9	9	s	0	s	s	38	2	s	0	0	60	4	30	6
♂	0	0	0	0	s	s	s	0	0	0	s	0	s	0	0	0	0	0	0	0
<u>Pseudocalanus sp.</u>																				
Total	110	21291	11591	231	1044	2834	1459	769	39	1123	27561	6966	863	323	8449	9575	6147	1841	2425	206
I	48	6244	4405	112	166	347	16	17	4	315	6067	128	55	23	2404	2567	1754	497	814	41
II	27	5394	3717	39	31	379	44	11	2	283	9450	275	87	19	3192	3393	2384	591	589	38
III	7	2932	1312	0	39	351	77	35	6	222	6550	473	123	47	1141	1785	900	214	297	12
IV ♀	0	2739	812	6	68	297	142	79	7	43	1557	153	65	26	720	502	615	248	291	15
IV ♂	0	636	188	4	10	104	77	32	2	70	1594	70	41	12	353	398	105	17	101	6
V ♀	3	719	219	2	94	221	159	67	2	31	430	58	51	35	204	428	60	69	65	9
V ♂	7	609	156	4	39	180	81	37	2	40	376	64	19	12	136	177	45	9	18	3
♀	14	692	63	59	447	820	752	421	10	82	1307	569	318	122	217	251	270	163	226	17
♂	3	1356	719	7	151	135	112	70	4	39	233	58	104	28	82	74	15	34	24	67

	NES 1			NES 3					NES 5					NES 7						
	1m	11m	20m	1m	5m	10m	20m	32m	42m	1m	12m	22m	29m	50m	1m	7m	12m	22m	28m	50m
<u>Calanus tenuicornis</u>																				
♂	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
<u>Centropages abdominalis</u>																				
♀	3	s	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0
♂	0	s	s	0	s	5	5	0	<<1	0	0	0	0	0	0	0	0	0	0	0
	7	s	0	0	s	5	4	0	0	0	18	0	0	0	0	0	0	0	0	0
<u>Epilabidocera longipedata</u>																				
♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0
<u>Eucalanus bungii</u>																				
immature	0	0	0	0	s	0	0	0	0	0	0	s	0	s	s	s	0	0	0	0
♀	0	0	0	0	0	s	0	0	0	0	s	0	s	0	0	0	0	0	0	0
<u>Euchaeta japonica</u>																				
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0
<u>Metridia lucens</u>																				
♀	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0
♂	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<u>Metridia pacifica</u>																				
♀	0	0	0	0	0	s	s	s	0	0	0	0	s	0	0	0	0	0	0	0
♂	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0
<u>Metridia sp.</u>																				
immature	0	0	0	0	0	0	0	4	1	0	0	0	s	5	0	162	0	0	0	35
<u>Microcalanus pusillus</u>																				
immature	0	0	0	0	0	0	0	0	2	0	0	6	0	0	0	0	0	0	0	0
♀	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
♂	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<u>Microsetella rosea</u>																				
	0	28	0	0	0	0	0	0	0	0	0	0	0	12	s	0	0	0	0	0
<u>Oithona similis</u>																				
immature	7	83	125	28	47	135	28	34	11	47	1092	256	2	164	353	782	1109	471	488	140
♀	0	55	0	0	164	221	82	56	10	54	501	422	267	129	285	310	540	210	159	90
♂	0	0	63	119	26	72	14	7	2	8	143	26	222	47	27	0	45	21	12	9
<u>Oithona spirostris</u>																				
immature	0	0	0	0	0	0	2	4	<1	0	0	0	0	0	0	0	s	0	0	0
♀	0	0	0	0	0	0	4	3	1	0	0	6	0	2	0	0	0	0	6	s
<u>Oncaea borealis</u>																				
	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
<u>Oncaea sp. A</u>																				
♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0
<u>Oncaea sp. B</u>																				
	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
<u>Racovitzanus antarcticus</u>																				
immature	0	0	0	0	0	0	0	0	<<1	0	0	0	0	0	0	0	0	0	0	0
<u>Scolecithricella minor</u>																				
immature	0	s	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	s
♀	0	0	0	0	0	0	0	0	0	0	18	0	s	0	0	0	0	0	0	0
♂	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0
<u>Tortanus discaudatus</u>																				
♂	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0

	CAS 1			CAS 3					CAS 5						CAS 7					CAS 10											
	1m	11m	21m	1m	7m	10m	20m	32m	42m	1m	4m	9m	16m	31m	48m	80m	1m	6-0m	9m	20m	30m	63m	77m	1m	6m	9m	18m	33m	68m	83m	
<u>Aetideus pacificus</u>	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	s	0	0	0	0	0	s	0	0	0	0	0	0	0	0	s
immature	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	s	0	0	0	0	0	s	0	0	0	0	0	0	0	0	s
♀	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	s	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0
<u>Calanus cristatus</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	s
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>Calanus plumchrus</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
<u>Calanus tenuicornis</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	
♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	
♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	
<u>Centropages abdominalis</u>	221	417	63	3	0	0	31	3	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
immature	74	34	s	s	0	8	3	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	
♀	158	104	47	s	0	s	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
♂																															
<u>Epilabidocera longipedata</u>	11	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
immature	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	s	0	0	0	0	0	
♀																															
<u>Eucalanus bungii</u>	0	0	0	0	s	0	0	s	0	0	0	s	0	s	0	s	0	0	0	0	0	s	0	0	s	23	0	0	0	0	
immature	0	0	0	0	0	0	0	0	0	0	0	s	0	5	0	0	0	0	0	0	0	0	0	0	s	s	0	0	0	0	
♀	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	s	s	0	0	0	0	
♂	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Euchaeta japonica</u>	0	0	0	0	0	0	s	0	s	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
immature	0	0	0	0	0	0	s	0	s	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Lubbockia cf. squillimana</u>	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Metridia lucens</u>	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
♀																															
<u>Metridia pacifica</u>	0	0	0	0	s	s	3	0	s	0	0	0	0	0	s	s	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0
immature	0	0	0	0	0	0	s	0	s	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
♀	0	0	0	0	0	0	s	0	s	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
♂	0	0	0	0	0	0	s	0	s	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Metridia sp. immature</u>	0	0	0	0	0	0	3	52	26	0	6	7	0	0	8	9	0	0	0	0	0	17	0	0	0	0	0	0	90	45	
<u>Microcalanus pusillus</u>	0	0	16	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	s	0	0	0	0	0	8	3	
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Microsetella rosea</u>	0	0	16	0	0	0	3	3	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Oithona similis</u>	32	139	126	3	313	394	238	239	241	0	69	236	291	532	39	75	223	326	461	475	259	121	33	279	982	3264	603	185	562	302	
immature	42	35	126	10	478	515	113	74	131	0	23	236	201	244	76	36	72	147	136	337	175	82	33	206	575	1366	325	199	577	127	
♀	0	0	47	0	17	72	40	10	42	0	6	27	22	43	18	13	0	16	54	39	23	31	0	0	80	255	163	43	157	35	
♂																															
<u>Oithona spinirostris</u>	0	0	0	0	0	16	0	0	8	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	25	
immature	0	0	0	0	0	8	0	0	0	0	0	0	0	5	0	s	0	0	0	0	3	2	0	0	0	0	7	0	30	0	
♀																															
<u>Oncaea borealis</u>	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<u>Oncaea sp. B</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
<u>Racovitzanus antarcticus</u>	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
immature																															
<u>Scolecithricella minor</u>	0	0	0	0	0	0	3	23	10	0	0	0	0	0	0	0	0	0	0	11	0	0	s	0	0	0	0	0	0	10	
immature	0	0	0	0	0	0	3	0	s	0	0	0	0	0	0	s	0	0	0	0	0	2	0	0	0	0	0	0	15	0	
♀	0	0	0	0	0	0	0	0	5	0	0	s	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	8	6	
♂	0	0	s	0	0	0	0	0	5	0	0	s	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	8	6	

	NES 1			NES 3						NES 5					NES 7					
	1m	11m	20m	1m	5m	10m	20m	32m	42m	1m	12m	22m	29m	50m	1m	7m	12m	22m	28m	50m
fecal pellets	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0
<i>Coscinodiscus</i> sp.	244	498	437	129	2207	41	0	0	1	0	358	32	5	5	41	487	180	81	60	0
tintinnids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0
dinoflagellates	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	15	0	0	0	0
foraminiferae	0	0	0	0	0	s	2	0	0	0	18	0	0	0	0	30	0	0	0	0
medusae	0	0	0	0	s	2	s	0	<<1	4	s	6	0	s	s	s	15	s	0	0
ctenophores	0	0	0	0	0	0	0	0	0	s	0	s	s	0	14	0	s	0	0	0
annelids	3	138	188	0	0	s	s	2	0	0	18	0	s	0	0	0	0	0	0	0
<i>Limacina helicina</i>	0	0	0	0	0	0	s	s	2	0	18	0	s	0	0	0	15	0	0	0
bivalve mollusc veligers	21	553	188	2	8	108	4	1	1	19	680	0	s	0	14	30	105	21	6	0
gastropod veligers	10	138	31	2	13	23	7	2	<<1	4	107	26	2	49	54	89	60	4	0	3
<i>Evadne nordamani</i>	0	s	31	6	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0
<i>Podon leukarti</i>	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ostracod	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0
copepod nauplii	69	194	437	20	140	9	2	4	<<1	944	949	109	106	47	177	398	150	107	95	0
<i>Calanus</i> sp. nauplii	233	7497	7498	230	4091	2014	96	71	1	7442	5101	364	77	66	2078	3600	2489	574	987	113
small egg	809	2573	312	586	1127	1725	4446	717	1	2238	2685	1847	679	396	41	369	255	432	291	15
intermediate egg	45	28	63	13	865	5	0	0	1	0	573	173	70	45	312	516	285	98	101	55
barnacle nauplii A	38	194	0	92	200	36	2	2	0	58	18	0	0	0	54	74	0	0	0	0
barnacle nauplii B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	12	0
barnacle cypris	0	0	0	0	0	0	0	0	<<1	0	0	0	s	s	0	0	0	s	0	0
isopods	0	0	0	4	0	0	2	0	<<1	0	0	0	0	0	0	0	0	0	0	0
<i>Parathemisto pacifica</i>	0	0	0	0	s	s	s	0	0	0	s	s	s	s	s	s	s	s	s	s
euphausiid eggs	3	55	0	72	78	9	5	3	1	342	304	38	17	21	68	133	90	17	12	15
euphausiid nauplii	7	0	94	7	55	9	4	1	1	16	90	0	0	0	14	0	0	0	0	17
euphausiid calyptopis	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0
euphausiid furcilia	0	0	0	0	0	s	s	0	0	s	0	0	0	2	0	0	0	0	0	s
decapod prezoa	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
decapod zoea	0	s	63	0	s	s	s	2	0	0	0	s	0	21	0	0	0	0	0	s
echinoderm pluteus larvae	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sagitta elegans</i>	0	28	31	0	s	5	9	1	0	4	s	s	7	s	s	s	0	4	12	s
<i>Eukrohnia hamata</i>	0	0	0	0	0	0	0	0	<<1	0	0	0	0	s	0	0	0	4	0	0
fish eggs	17	0	0	26	49	0	0	0	<<1	4	0	0	0	0	0	0	0	0	0	0
<i>Artemia</i> sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	6	0

	CAS 1			CAS 3					CAS 5					CAS 7					CAS 10											
	1m	10m	21m	1m	7m	10m	20m	32m	42m	1m	4m	9m	16m	31m	48m	80m	1m	6-0m	9m	20m	30m	63m	77m	1m	6m	9m	18m	33m	68m	83m
fecal pellets	0	0	0	0	0	s	0	0	0	0	0	0	0	s	0	s	0	0	0	11	s	0	0	0	0	23	34	0	0	0
<u>Coccinodiscus</u> sp.	295	729	47	962	1779	169	3	0	0	953	683	1720	464	24	2	6	187	1465	380	17	16	2	0	92	112	278	122	50	0	0
tintinnids	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dinoflagellates	0	0	0	3	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
foraminiferae	0	0	0	7	0	0	6	10	2	6	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0
radiolarians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
medusae	s	0	s	0	0	0	0	s	s	0	0	0	0	s	0	0	0	s	s	s	s	0	0	s	s	s	0	0	0	0
ctenophores	0	0	0	0	0	0	0	s	s	0	6	0	6	0	0	0	s	s	s	s	0	0	0	s	s	s	0	0	0	0
annelids	s	0	63	0	0	s	s	0	7	0	s	0	11	0	0	s	0	0	27	0	0	0	0	0	0	0	0	0	0	0
<u>Limacina helicina</u>	0	0	0	0	0	0	s	3	0	0	0	0	0	s	0	0	0	16	0	6	3	0	0	5	0	0	7	7	0	0
bivalve mollusc veligers	32	104	267	0	0	81	62	0	3	0	0	7	22	19	0	0	0	0	163	33	29	2	6	5	104	93	7	0	0	0
gastropod veligers	11	69	79	0	s	48	20	7	3	0	0	7	0	10	2	6	0	0	27	0	16	0	6	5	0	0	7	0	8	0
<u>Evadne nordamani</u>	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>Podon leukarti</u>	11	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ostracod	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s
copepod nauplii	643	2326	110	524	1087	48	9	29	0	89	5167	175	67	14	0	0	2213	2296	108	17	0	2	22	46	184	93	41	0	0	3
<u>Calanus</u> sp. nauplii	3255	15104	755	666	8501	1352	321	397	107	81	1200	5308	3049	403	175	113	778	21050	3861	419	185	118	49	554	2004	3264	432	199	165	99
small egg	158	1898	173	51	1779	4973	20	239	15	45	0	74	6	149	10	2	0	0	1273	44	10	31	6	14	80	1157	190	57	30	41
intermediate egg	1338	1840	63	762	1730	81	40	126	7	632	689	344	1007	53	94	47	584	1123	312	33	29	53	11	174	144	324	163	78	82	25
barnacle nauplii A	21	556	47	44	132	64	0	3	3	0	0	14	207	0	0	0	0	537	81	0	0	0	0	9	0	0	0	0	0	0
isopods	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
amphipod eggs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	3
<u>Parathemisto pacifica</u>	11	0	0	0	s	s	s	s	0	0	s	0	s	s	s	s	s	s	s	3	s	0	s	s	s	s	s	0	3	
<u>Streetsia challengeri</u>	0	0	0	0	0	0	0	0	s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0	0	0	0
euphausiid eggs	42	0	0	85	379	40	31	26	13	215	109	94	95	14	18	9	115	98	203	39	58	19	55	46	88	463	54	43	37	3
euphausiid nauplii	0	0	16	0	17	0	11	3	23	0	0	20	0	0	4	22	49	14	s	0	2	6	9	40	0	7	0	23	6	
euphausiid calyptopsis	0	0	0	0	0	s	0	0	0	0	s	0	0	0	0	0	0	81	s	0	0	0	0	0	8	s	0	0	0	0
euphausiid furcilia	0	0	0	0	s	0	s	s	s	0	s	s	s	s	4	2	0	s	s	s	s	s	0	0	8	23	s	7	15	s
decapod prezoaea	0	0	0	0	0	0	s	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
decapod zoea	s	s	s	0	s	s	3	s	s	0	0	s	0	0	s	s	0	0	s	s	0	0	0	0	0	0	0	0	0	0
<u>Oikopleura</u> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	s	0
<u>Sagitta elegans</u>	s	35	s	3	17	40	9	13	s	0	0	s	6	s	4	4	0	s	s	s	3	s	0	s	s	s	s	s	23	3
<u>Eukrohnia hamata</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s
fish eggs	0	35	16	3	0	32	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	s	0	0