STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
910 State Office Building
Portland, Oregon 97201

OPEN-FILE REPORT O-86-8

THE STATE OF SCIENTIFIC INFORMATION RELATING TO THE BIOLOGY AND ECOLOGY OF THE GORDA RIDGE STUDY AREA, NORTHEAST PACIFIC OCEAN: PLANKTON

By Steven G. Ellis[1] and Jonathan H. Garber[1 2]

Final Report for Contract No. 63-630-8501

Submitted to:

Oregon Department of Geology and Mineral Industries

and the

Living Resources Subgroup, Gorda Ridge Task Force

Released February 1986

[1]College of Oceanography, Oregon State University
Corvallis, Oregon 97331

[2]Oregon State University, Mark O. Hatfield Marine Science Center,
Newport, Oregon 97365

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES continued

THE STATE OF SCIENTIFIC INFORMATION RELATING TO BIOLOGY AND ECOLOGY OF THE GORDA RIDGE STUDY AREA, NORTHEAST PACIFIC OCEAN:

PLANKTON

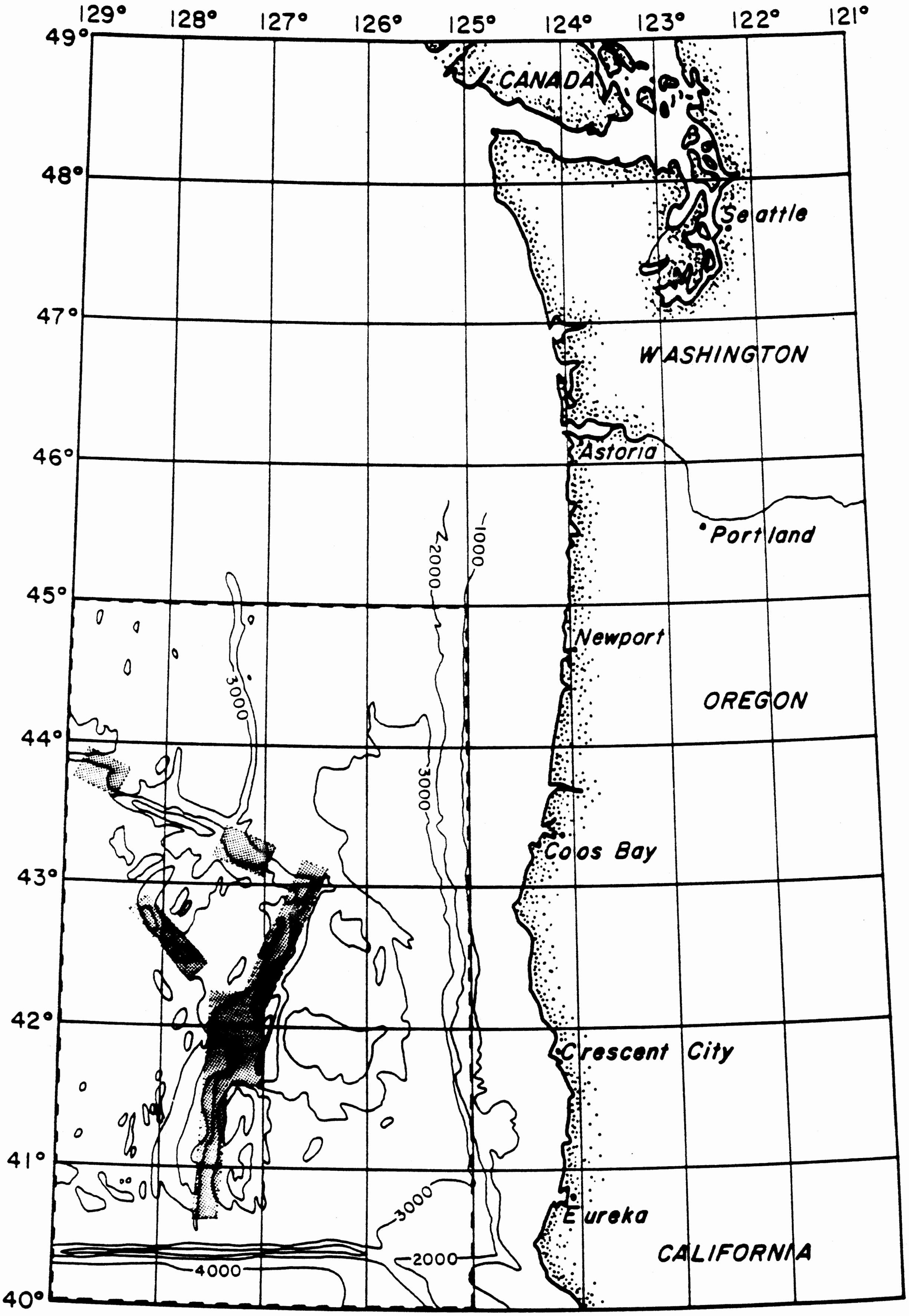
INTRODUCTION

The scope of this review of scientific reports dealing with the plankton of the Northeast Pacific ocean has been limited primarily to studies carried out in the region bounded by 40°-45° N latitude and 125°-129° W longitude (henceforth called the Study Area, Figure 1). The distributions of planktonic organisms appears limited by rather narrowly defined tolerances to physical parameters, particularly water salinity and temperature, that affect the fundamental physiological processes of growth and reproduction. The physical and chemical characteristics of water masses any great distance from the Study Area represent planktonic environments that differ markedly from those found in the Study Area itself (Kozlova and Mukhina 1967, Maruma 1967, Semina 1972, Semina and Tarkhova 1972). Extrapolation of findings of plankton studies from distant regions of the Northwest Pacific to the Study Area was therefore considered tenuous and these reports have not been included here. However, planktonic assemblages that are transported into the Study Area from adjacent regions, particularly by incursions of subarctic water masses (Pearcy 1972), have been included.

The works by Anderson (1964, 1972) and Small and Curl (1972) are key references that provide basic information on phytoplankton within the Study Area. Anderson's (1964, 1972) reports described the hydrography, nutrient chemistry, seasonal patterns of phytoplankton biomass and productivity, and significance of the subsurface chlorophyll maximum in the northern region of the Study Area. One of the few phytoplankton species lists for the Study Area is given in Anderson (1972). Small and Curl (1972) provide additional information on seasonal distributions of chlorophyll a along cruise transects off Newport, OR (44° 39' N), Coos Bay, OR (43° 20.5' N) and Brookings, OR (42° 00' N), thus encompassing a large portion of the northern region of the Study Area.

Lists of zooplankton species found within the Study Area were found in reports by Pearcy (1972), Laurs (1967), Peterson (1972) and Hubbard (1966). Pearcy's (1972) work contains the most extensive list of zooplanktonic organisms in the region, and describes seasonal catch variations, vertical distributions and migrations of major zooplanktonic groups found off the central and northern Oregon coast. This work also provides the only information available to date on plankton of mesopelagic depths of the region. Laurs (1967) describes seasonal abundances and trophic interactions of several important components of the plankton from a study carried out in the Study Area between 1962 and 1964. Peterson (1972) reported seasonal abundances, spatial distributions, and vertical migrations of copepods in the northern region of Study Area. Hubbard's (1966) report remains a key work on the abundance and distribution of salps (Salpidae) from four offshore transects between Newport and Brookings, OR, which were carried out between 1961 and 1964.

Figure 1. GORDA RIDGE STUDY AREA shown inside dashed line. (Rectangular blocks encompass about 2.6 million acres).



PLANKTON

The short list of key reports given above on the distribution and abundance of planktonic organisms in the Study Area illustrates two major findings of this survey: (1) most studies of the plankton of the Study Area are now ten to twenty years old; and (2) we were unable to locate any works dealing with functional aspects of the planktonic community, such as feeding ecology, secondary production, and reproduction. Good general reviews of these topics can be found in Raymont's (1980, 1983) monographs.

SPECIES COMPOSITION AND DISTRIBUTION

The surface circulation patterns in and around the Gorda Ridge are such that plankton with affinities to subarctic, transitional, and central or equatorial water masses occur within the Study Area (Pearcy 1972). It is therefore necessary to briefly describe the surface current patterns that transport such disparate planktonic assemblages into the Study Area.

Surface currents within the lease area are generally weak (less than 30 cm/sec) and variable in speed and direction (Barnes and Paquette 1957). The surface circulation is dominated by the southward-flowing California Current. The origin of this current is the wind-driven Subarctic Current which flows east across the North Pacific north of the Study Area. The Subarctic current splits into two branches approximately 500 km east of the North American continent. One branch flows north and away from the Study Area, while the other branch, the California Current, flows south through the Study Area (Burt and Wyatt 1964). Although the California Current has no well-defined western boundary it is thought to extend westward at least 800-1000 km from the coast (Favorite et al. 1976). During spring and summer the influence of this current extends to the coastline, but during fall and winter it is displaced along the coast by the northerly-flowing Davidson Current (Burt and Wyatt. 1964). The width of the Davidson Current varies, but its main flow occurs within 160 km of the coast off Oregon (Wyatt et al. 1972).

The current patterns described above indicate the general mechanism by which plankton having both northerly and southerly affinities can be transported into the region of the Gorda Ridge. Subarctic forms can be carried by the southward flowing California Current into the Study Area, while during fall and winter species characteristic of regions to the south can be transported into the Study Area by the northward-flowing Davidson Current. Other species of plankton found within the Study Area are endemic to the transitional water mass encompassing the region between the subarctic water to the north and the equatorial and central water masses to the south.

A list of plankton species found within the Study Area was compiled from reports that, taken together, provided good coverage of the entire Study Area. Although the majority of data is from the northern half of the lease area, several studies were conducted along the Brookings transect (42° N) which crosses the Gorda Ridge (Cross 1964, Cross and Small 1967, Hubbard

1967, Laurs 1967, Lee 1972, Small and Cross 1972). In addition, several reports of plankton distributions in the atlases assembled during the California Cooperative Oceanic Fisheries Investigation (CalCOFI) cover the southern portion of the Gorda Ridge from roughly 40° N to 42° N (Alvarino 1965, Bowman and Johnson 1973, Brinton 1967, 1973, Fleminger 1964, 1967, McGowan 1967). A list of the references to major taxonomic groups of the plankton is given in Table 1. A more complete list of the planktonic species found within the Study Area is presented in Appendix 1.

Phytoplankton Abundance and Primary Productivity

In terms of algal numbers and biomass the phytoplankton community within the Study Area is dominated by diatoms (Kilburn 1961, Semina and Tarkhova 1972). According to Semina and Tarkhova (1972) diatoms are the major component of the phytoplankton community of the North Pacific for the region extending south to approximately 35° to 40° N latitude. South of this latitudinal boundary diatoms are replaced by peridinians as the main components of the phytoplankton. Marumo (1967) further divided the species of diatoms found in the North Pacific into four communities, and classified the region which includes the Gorda Ridge Study Area as a Rhizosolenia community.

Several estimates of the abundance of phytoplankton, either in terms of cell numbers of chlorophyll a are available for the Gorda Ridge Study Area. As mentioned above diatoms are the dominant component of the phytoplankton (in terms of cell numbers or biomass) throughout the year in this region of the Northeast Pacific (Semina and Tarkhova 1972). Kozlova and Mukhina (1967) reported that in the fall of 1958 the diatom concentrations within the Study Area averaged 6.3×10^4 cells/m^3 from the surface to a depth of 25 m and 2.2×10^4 cells/m^3 between 50 to 100 m depth. Silicoflagellate abundance was found to range from 2.0×10^3 to 2.5×10^4 cells/m^3 in the water column to a depth of 100 m. Similar estimates of diatom abundance (less than 10^6 cells/m^3) were reported for the Study Area in the summers of 1954 to 1958 by Marumo (1967).

Estimates of phytoplankton abundance in terms of chlorophyll a in the Study Area were found in Anderson (1964, 1965, 1969, 1972), Beck (1966a, 1966b, 1966c) Hobson (1966), Laurs (1967), Small and Curl (1968, 1972) and Small and Menzies (1981). Anderson (1964, 1972) reported that chlorophyll a in surface waters was always low (0.1 - 0.5 mg/m^3) during 1961 to 1962 in the northern portion of the Study Area. Small and Curl (1968) also reported that the concentration of chlorophyll over the Gorda Ridge along a transect at 42° N during the summer of 1962 was less than 0.5 mg/m^3. The best coverage of chlorophyll concentrations in the euphotic zone of the Study Area is given by Small and Curl (1972). Their study, conducted from April 1962 to August 1965, reports chlorophyll concentrations along transects off Newport (44° 39' N), Coos Bay (43° 20.5' N), and Brookings (42° 001 N). Mean chlorophyll concentrations were highest in spring (0.85 mg/m^3) and lowest during summer (0.39 mg/m^3). The mean concentration for all areas and all seasons was 0.82 mg/m^3.

PLANKTON

Table 1. List of references to major planktonic taxa reported to occur within the Gorda Ridge Study Area. References are listed in alphabetical order for each taxonomic group.

PHYTOPLANKTON

Division: Bacillariophyceae

1. Anderson (1972)
2. Cupp (1943)
3. Hasle (1976)
4. Hobson (1966)
5. Kozlova and Mukhina (1967)
6. Marumo (1967)
7. Semina (1972)
8. Semina and Tarkhova (1972)

Division: Chrysophyceae

1. Hobson (1966)
2. Kozlova and Mukhina (1967)

ZOOPLANKTON

Phylum: Annelida

Class: Polychaeta

1. Pearcy (1972)
2. Peterson and Anderson (1966)
3. Peterson and Miller (1976)

Phylum: Arthropoda

Order: Amphipoda

1. Laurs (1967)
2. Lee (1972)
3. Meyers (1975)
4. Pearcy (1972)

Order: Copepoda

1. Bowman and Johnson (1973)
2. Brodskii (1967)
3. Cross (1964)
4. Cross and Small (1967)
5. Davis (1949)
6. Fleminger (1964)
7. Fleminger (1967)
8. Hebard (1966)
9. Laurs (1967)
10. Lee (1972)
11. Meyers (1975)
12. Pearcy (1972)
13. Peterson (1972)

14. Peterson and Anderson (1966)
15. Peterson and Miller (1976)
16. Small and Cross (1972)
17. Smith (1974)

Order: Euphausiacea
1. Brinton (1967)
2. Brinton (1973)
3. Hebard (1966)
4. Laurs (1967)
5. Pearcy (1972)
6. Peterson and Miller (1976)

Order: Mysidacea
1. Pearcy (1972)

Order: Ostracoda
1. Pearcy (1972)

Phylum: Chaetognatha
1. Alvarino (1965)
2. Bieri (1959)
3. Meyers (1975)
4. Pearcy (1972)
5. Peterson and Miller (1976)

Phylum: Chordata
Class: Larvacea
1. Lee (1972)
2. Meyers (1975)
3. Pearcy (1972)
4. Peterson and Miller (1976)

Class: Thaliacea
Order: Doliolida
1. Lee (1972)
2. Pearcy (1972)

Order: Pyrosomida
1. Pearcy (1972)

Order: Salpida
1. Hubbard (1967)
2. Laurs (1967)
3. Pearcy (1972)

Phylum: Coelenterata
1. Pearcy (1972)

Phylum: Ctenophora
1. Pearcy (1972)

PLANKTON

Phylum: Mollusca

Class: Gastropoda

1. McGowan (1967)
2. Meyers (1975)
3. Pearcy (1972)
4. Peterson and Miller (167)

Class: Heteropoda

1. McGowan (1967)
2. Pearcy (1972)

PLANKTON

An overview of the data given in studies mentioned above suggests that the distribution of chlorophyll in the Study Area is patchy. Patchy chlorophyll distributions are particularly apparent in the data presented by Beck (1966a, 1966b, 1966c) for 56 stations along transects in the northern portion of the Study Area. Patchiness in chlorophyll extends both horizontally and vertically. During the summer the lease area is characterized by a well-developed subsurface chlorophyll maximum beneath the seasonal pycnocline (Anderson 1969, 1972). This feature is generally found between 55 and 65 m below the surface and below the depth of 1% surface light intensity. Chlorophyll concentrations within this layer are typically between 1 to 3 mg/m^3, or 3 to 10 times the values found in surface waters (Anderson 1969, 1972). The subsurface chlorophyll maximum develops in early summer and persists until November or December when the seasonal pynocline breaks down. Chlorophyll values then become more uniform with depth in near-surface waters.

Estimates of primary productivity of phytoplankton in the Gorda Ridge Study Area are give by Anderson (1964, 1965, 1972), Beck (1966a, 1966b, 1966c), Koblents-Miske (1965), Larrance (1971), Small and Curl (1968), Small et al. (1972), and Small and Menzies (1981). These studies indicate that the seasonal cycle of primary production within the Study Area follows that found in other temperate latitudes of the ocean (Anderson 1964, Raymont 1980, Ryther 1969). Concentrations of plant nutrients are high during the winter, but primary production remains low because of the depth of the mixed layer and low incident solar radiation. In the spring the water column becomes stratified as surface waters warm and low salinity water from the Columbia River spreads south into the region. These factors initially enhance phytoplankton growth. Phytoplankton production is maximal during this time, and then decreases throughout the summer as nutrient supplies diminish in the stratified surface mixed layer. A slight increase in production occurs in the fall when stratification of the water column breaks down and a new supply of nutrients is injected into the photic zone. Estimates of total annual primary production for the lease area range from 60 gC/m^2 (Anderson 1964), 72 - 85 gC/m^2 (Larrance 1971), 90 - 240 gC/m^2 (Koblents-Miske 1965), to 125 gC/m^2 (Anderson 1972).

Summaries of Zooplankton Abundance in the Study Area by Taxonomic Groups

Phylum: Annelida
Class: Polychaeta

Two studies (Laurs 1967; Peterson and Anderson 1966) were located which contain information on the abundance of pelagic polychaetes within the Study Area. Laurs (1967) found the relative abundance of pelagic polychaetes along a transect off Brookings (42 N) between August 1962 and April 1964 highest in spring and lowest in fall when they comprised 5% and 1%, respectively, of the biomass of secondary consumers (trophic level III) in the planktonic community. Peterson and Anderson (1966) reported a range of mean abundance of polychaetes in the euphotic zone of 0.4/m^3 to 19/m^3 during 1961 and 1962 for several stations between 41° 15' N and 45° N latitude.

Phylum: Arthropoda
Order: Amphipoda

Data on the abundance of pelagic amphipods within the Study Area were reported by Fleminger et al. (1974), Isaacs et al. (1969), Laurs (1967), Pearcy (1972) and Peterson and Anderson (1966). Laurs (1967) found that amphipods comprised 5.8% of the total biomass of planktonic secondary consumers (trophic level III) along a transect off Brookings (42° N) that was occupied between August 1962 and April 1964. The relative abundance of amphipods was lowest in the late winter and spring, intermediate in the summer, and highest in the fall. The abundance of amphipods was in summer 1958 (June and July) reported by Fleminger et al. (1974) was less than 0.016 g dry wt./m^3 in the region between 40° and 42° N latitude. In contrast, Isaacs et al. (1969) found abundances less than 0.001 g dry wt./m^3 during the summer of 1959 in the same region. Pearcy (1972) reported that amphipod abundance was approximately 0.002 g dry wt./m^3 at a station 45 miles west of Newport (44° 39' N). Peterson and Anderson (1966) provide the only volume-based estimates of amphipod abundance available for the Study Area. They report the mean abundance of amphipods in the euphotic zone between 42° N and 45° N as ranging between 0.2 to 31.5 animals/m^3. However, much higher concentrations (856/m^3) were found at one station (43° 45' N, 126° 34' W) on July 13, 1962. This one sample underscores the non-uniform,. or patchy, distribution of amphipods in the region. This feature of amphipod abundance had been also noted by Laurs (1967).

Phylum: Arthropoda
Order: Copepoda

Twelve studies were located which taken together provide a relatively complete picture ot the abundance of copepods in the Gorda Ridge Study Area. It should be noted, however, that all of these efforts were conducted prior to 1970. Bowman and Johnson (1973) determined the abundance of copepod species within the lease area from 40° to 42° N from 1949 to 1950. Fleminger (1964, 1967) conducted a similar study in the same region between 41° 15' N and 45° N during 1961 and 1962, and Peterson (1972) determined copepod abundance during the same period for the region between 43° N and 45° N. Cross (1964) determined copepod species abundances along transects off Newport (44° 39' N), Coos Bay (43° 20.5' N), and Brookings (42° 00'N) during 1962. Laurs (1967) measured copepod abundance along the Brookings transect from 1962 to 1964, and Hebard (1966) conducted a similar study during the same period along the Newport transect. Lee (1972) measured copepod abundance over the Gorda Ridge (42° 09' N - 42° 30' N) during August 1963. The abundance of individual species of copepods reported in these works were used to compile data on the seasonal range of copepod species abundances listed in Table 2. In addition to these studies, four studies conducted as part of the CalCOFI cruises in the region between 40° N and 42° N during 1951 to 1969 recorded the total abundance of Copepoda (Fleminger et al. 1974, Isaacs et al. 1969, Smith 1971, 1974). In general, the relative abundance of copepods within the Gorda Ridge region is low in the winter, intermediate in summer, and high in the spring and fall (Laurs 1967). Due to the pattern of current circulation within the lease area, individual species may only be present within the lease area during only a portion of the year, while other species appear to be endemic to this transitional region (Peterson 1972).

Phylum: Arthropoda
Order: Euphausiacea

Pearcy (1972) reported the average biomass of euphausiids at a station on the eastern edge of the lease area off Newport (44° 39' N) as 3.5 mg dry wt/m^3. Fleminger et al. (1974) estimated that the biomass of Euphausiacea between 40° N and 42° N during the summer of 1958 was 64 - 256 mg wet wt/m^3. [13 - 51 mg dry wt/m^3 using a 20% dry wt/wet wt conversion given by Parsons and Takahashi (1973)]. Isaacs et al. (1969) provided an estimate of 4-16 mg wet wt/m^3 (0.8 - 3.2 g dry wt/m^3) during October 1959 for the same region. Peterson and Anderson (1966) recorded a maximum abundance of 148 euphausiids/m^3 during 1961 to 1962 for the lease region between 42° N and 45° N. Laurs (1967) also measured euphausiid abundance along a transect off Brookings (42° 00' N) between 1962 to 1964, and reported that this group comprised 72% of the total biomass of planktonic primary consumers (trophic level II). The relative abundance of euphausiids appears to be low in the midsummer, intermediate in the spring and late summer, and high in the late winter (Laurs 1967). In addition, existing data suggest an inverse relationship both in time and space between the standing stocks of copepods and euphausiids.

Three studies were located which recorded the abundances of individual euphausiid species within the Study Area. Hebard (1966) recorded the abundance of euphausiid species along a transect off Newport from 1962 to 1964, and Brinton (1967, 1973) estimated euphausiid species abundances in the region of 40° N - 42° N during the period from 1949 to 1963. These data were used to compile the data on euphausiid species abundances reported in Table 3.

Table 2. Range of abundance of copepod species found in the Gorda Ridge Study Area. See text for sources of data.

	Range of abundance (number/m³)
Suborder: Calanoida	
Family: Acartiidae	
Acartia tonsa	0 - 4.8
Acartia Negligens	0 - 10.0
Acartia clausii	0 - 36.3
Acartia danae	0 - 66.0
Acartia longiremis	0 - 838.0
Family: Aetideidae	
Aetideopsis pacifica	Unknown
Aetideus armatus	0 - 8
Aetideus pacificus	Unknown
Chirundina streetsi	0 - 0.03
Euchirella curticauda	0 - 0.05
Euchirella galeata	0 - 0.05
Euchirella pulchra	0 - 0.18
Euchirella rostrata	0 - 0.30
Gaetanus miles	0 - 0.50
Gaetanus secundus	Unknown
Gaetanus simplex	0 - 0.03
Gaidius brevispinus	0 - 0.03
Gaidius pungens	0 - 0.10
Gaidius tenuispinus	0 - 8.00
Gaidius variabilis	0 - 0.03
Pseudochirella polyspina	0 - 0.001
Undeuchaeta intermedia	0 - 0.02
Undeuchaeta major	0 - 0.03
Undeuchaeta plumpsa	0 - 0.04
Family: Arietellidae	
Arietellidae plumifer	0 - 0.003
Arietellidae setosus	Unknown
Family: Augaptilidae	
Centraugaptilus porcellus	Unknown
Haloptilus pseudoxycephalus	Unknown
Family: Calanidae	
Bathycalanus bradyi	Unknown
Calanus cristatus	0 - 40
Calanus glacialis	0 - 0.05
Calanus lenvicornis	Unknown

PLANKTON

Calanus marshallae	Unknown
Calanus pacificus	0 - 1102
Calanus plumchrus	0 - 318
Calanus tenuicornis	0 - 2034
Family: Candaciidae	
Candacia bipinnata	0 -32
Candacia columbiae	0 -63
Family: Centropagidae	
Centropages bradyi	0 - 0.5
Centropages mcmurrichi	0 - 2.0
Family: Eucalanidae	
Eucalanus attenuatus	0 - 0.5
Eucalanus bungii	0 - 1655
Eucalanus elongatus hyalinus	0 - 51
Mecynocera clausii	0 - 0.5
Rhincalanus nastus	0 - 173
Family: Euchaetidae	
Euchaeta spinosa	Unknown
Paraeuchaeta abyssalis	Unknown
Paraeuchaeta birostrata	Unknown
Paraeuchaeta japonica	0 - 232
Family: Heterorhabdidae	
Heterorhabdus clausi	0 - 0.5
Heterorhabdus papilliger	0 - 5.0
Heterorhabdus tanneri	0 - 109
Heterostylites longicornis	0 - 5.0
Heterostylites major	0 - 2.0
Family: Lucicutiidae	
Lucicutia bicornuta	Unknown
Lucicutia flavicornis	0 - 295
Family: Metridiidae	
Gaussia princeps	0 - 0.003
Metridia curticauda	Unknown
Metridia lucens	0 - 462
Metridia pacifica	0 - 500
Pleuromamma abdominalis	0 - 17
Pleuromamma borealis	0 - 5
Pleuromamma guadrungulata	0 - 5
Pleuromamma scutullata	0 - 0.04
Pleuromamma xiphias	0 - 5
Family: Paracalanidae	
Calocalanus styliremis	0 - 500
Calocalanus tenuis	0 - 14
Paracalanus parvus	0 - 7458

PLANKTON

Family: Thaennidae	
Mixtocalanus robustus	Unknown
Phaenna spinifera	0 - 5.0
Family: Pontellidae	
Epilabidocera amphitrites	0 - 0.3
Epilabidocera longipedata	0 - 5.0
Family: Pseudocalanidae	
Clausocalanus arcuicornis	0 - 3135
Clausocalanus dubius	0 - 0.5
Clausocalanus furcatus	Unknown
Clausocalanus jobei	Unknown
Clausocalanus mastigophorus	Unknown
Clausocalanus parapergens	Unknown
Clausocalanus paululus	0 - 0.05
Clausocalanus pergens	0 - 6186
Ctenocalanus vanus	0 - 3135
Microcalanus pusillus	0 - 231
Pseudocalanus minutus	0 - 8977
Family: Scolecithricidae	
Amallothrix valida	Unknown
Amallothrix vorax	0 - 0.004
Lophothrix frontalis	0 - 0.05
Racovitzanus antarcticus	0 - 50
Racovitzanus pacificus	Unknown
Racovitzanus porrecta	0 - 0.027
Scaphocalanus brevicornis	0 - 11
Scaphocalanus echinatus	0 - 50
Scaphocalanus magnus	Unknown
Scaphocalanus medius	Unknown
Scaphocalanus minutus	0 - 0.015
Scaphocalanus subelongatus	0 - 0.015
Scolecithricella dentata	0 - 0.5
Scolecithricella minor	0 - 296
Scolecithricella ovata	0 - 8
Scolecithricella persecans	0 - 0.5
Scottocalanus sedatus	Unknown
Family: Tortanidae	
Tortanus discaudatus	0 - 8
Suborder: Cyclopoida	
Family: Corycaeidae	
Corycaeus amazonicus	Unknown
Corycaeus anglicus	0 - 12
Family: Oithonidae	
Oithona plumifera	Unknown
Oithona similis	0 - 3500

PLANKTON

Oithona spinirostris	0 - 3500
Family: Oncaeidae	
Lubbockia squillimana	0 - 2
Onacaea borealis	0 - 3
Onacaea conifera	0 - 46
Onacaea dentipes	Unknown
Onacaea media hymena	0 - 170
Onacaea meditteranea	Unknown
Onacaea subtilis	0 - 9
Onacaea tenella	0 - 3131
Suborder: Harpacticopida	
Family: Aegisthidae	
Aegisthus mucronatus	Unknown
Family: Clytemnestridae	
Clytemnestra rostrata	Unknown
Family: Ectinosomidae	
Microsetella norvegica	0 - 274
Microsetella rosea	0 - 39

Table 3. Abundance of planktonic euphausiids reported in the Gorda Ridge Study Area. Data compiled from Hebard (1966), and Brinton (1967, 1973).

	Range of Abundance (number/m³
Family: Bentheuphausiidae	
Bentheuphausia amblyops	Unknown
Family: Euphausiidae	
Euphausia pacifica	0 - 50
Euphausia gibboides	0 - 0.05
Euphausia recurva	0 - 0.05
Nematoscelis difficilis	0 - 0.5
Nematobrachion flexipes	0 - 0.001
Nyctiphanes simplex	0 - 0.05
Stylocheiron abbreviatum	0 - 0.05
Stylocheiron longicorne	0 - 0.5
Stylocheiron maximum	0 - 0.05
Tessarabrachion oculatus	0 - 0.5
Thysanoessa gregaria	0 - 5
Thysanoessa inspinata	0 - 0.235
Thysanoessa longipes	0 - 5
Thysanoessa parva	Unknown
Thysanoessa raschii	Unknown
Thysanoessa spinifera	0 - 0.5
Thysanopoda acutifrons	Unknown
Thysanopoda agregia	Unknown
Thysanopoda conuta	Unknown

Phylum: Chaetognatha

Six studies were located which contained data on the abundance of Chaetognaths in the Study Area. The average biomass of chaetognaths at a station 45 miles west of Newport along the 44° 39' N hydroline was 0.8 mg dry wt/m³ (Pearcy 1972). Fleminger *et al.* (1974) estimated that the abundance of Chaetognatha between 40° N and 42° N was less than 1 mg wet wt/m³ [or less than 0.1 mg dry wt/m³ using a 10% dry wt/wet wt conversion (Parsons and Takahashi 1973)] during the summer of 1958. Isaacs *et al.* (1969) estimated chaetognath biomass at less than 64 mg wet wt/m³ (6.4 mg dry wt/m³) during October 1959 within the same area. Chaetognath biomass in the Study Area would therefore appear to range from 0.1 to 6 mg dry wt/m³. Maximum abundance of chaetognaths in the region between 42° N and 45° N during 1961 and 1962 was reported by Peterson and Anderson (1966) to be 157 animals/m³. Only two studies were located which recorded the abundance of individual Chaetognath species in the Study Area (Bieri 1959; Alvarino 1965), both of which were conducted prior to 1959. These estimates of Chaetognath species abundance are compiled in Table 4.

Table 4. Range of abundance of chaetognath (arrow worm) species in the Gorda Ridge Study Area. Data compiled from reports by Bieri (1959) and Alvarino (1965).

	Range of Abundance (number/m³)
Eukrohnia bathypelagica	Unknown
Eukrohnia fowleri	Unknown
Eukrohnia hamata	0 - 0.05
Krohnitta subtilis	0 - 0.05
Pterosagitta draco	0 - 0.05
Sagitta bierii	0 - 5-
Sagitta decipiens	Unknown
Sagitta elegans	0 - 1
Sagitta enflata	0 - 0.05
Sagitta euneritica	0 - 5
Sagitta hexaptera	0 - 0.05
Sagitta macrocephala	Unknown
Sagitta macima	0 - 0.05
Sagitta minima	0 - 5
Sagitta scrippsae	0 - 5
Sagitta zetesios	Unknown

Phylum: Chordata
Class: Larvacea

Three reports were located which discussed the abundance of Larvacea within the Study Area. Peterson and Anderson (1966) gave a maximum abundance of 435 larvaceans/m^3 for the region between 42° N and 45° N during 1961 and 1962. Fleminger *et al.* (1974) estimated that the biomass of Larvacea in the region between 40° N and 42° N was 0 - 4 mg wet wt/m^3 during June and July 1958, and Isaacs *et al.* (1969) estimated an abundance of 0 to 0.016 mg wet wt/m^3 for the same region during October 1959.

Phylum: Chordata
Class: Thaliacea

Six references were located which discussed the abundance of Thaliacea within the Study Area. Fleminger *et al.* (1974) estimated that the abundance of total Thaliacea in the region between 40° N and 42° N was 0 - 1024 mg wet wt/m^3 during June and July 1958, and Isaacs *et al.* (1969) estimated an abundance of 0 - 64 mg wet wt/m^3 for the same region during October 1959.

The remaining four reports references dealt exclusively with the order Salpidae. Pearcy (1972) reported that the average abundance of salps was 1.8 mg dry wt/m³ at a station 45 miles west of Newport (44° 39' N). Peterson and Anderson (1966) occupied a series of stations between 42° N and 45° N during 1961 and 1962 and recorded a maximum abundance of 208 salps/m³. Hubbard (1967) examined the abundance of Salpidae along transects off Newport, Coos Bay and Brookings during 1961 to 1964 and concluded that Salpafusiformis was the most abundant salp (in terms of animals caught per tow) in this region throughout the year. Laurs (1967) found that salps comprised about 13% of the total biomass of planktonic secondary consumers (trophic level III) found along his transect off Brookings, OR (42° 00' N) during 1962-1964. The relative abundance of the salps was generally low in summer, winter, and fall, and highest in spring.

Phylum: Coelenterata
Order: Siphonophora

Three references to the abundance of Coelenterata in the Study Area were located and in each dealt exclusively with the Siphonophora. Fleminger et al. (1974) estimated that the abundance of Siphonophora between 40° N and 42° N, during June and July 1958 was 0 - 16 mg wet wt/m³. Isaacs et al. (1969) estimated the abundance of Siphonophores for the same region during October 1959 was 0 - 64 mg wet wt/m³. Peterson and Anderson (1966) reported maximum abundance of 18 animals/m³ in the region between 42° N and 45° N during 1961 to 1962.

Phylum: Ctenophora

Two works were found which provide data on the abundance of ctenophores within the Study Area. Fleminger et al. (1974) estimated that the abundance of Ctenophora was 0 - 16 mg wet wt/m³ during June and July 1958 between 40° N and 42° N. Isaacs et al. (1969) estimated an abundance of 0 - 0.25 mg wet wt/m³ for the same region during October 1959.

Phylum: Mollusca

Only one report (McGowen 1967) providing estimates the abundance of planktonic Mollusca within the Study Area. This study was conducted during November 1949 as part of the CalCOFI cruises and samples were collected in the region between 40° N and 45° N. The abundance of pelagic Mollusca obtained in this study are listed in Table 5.

Table 5. Range of abundance of planktonic molluscs found in the Study Area between 40° N and 45° N latitude by McGowan (1967).

	Range of Abundance (number/m^3)
Class: Gastropoda	
Order: Gymnosomata	
Clione limacina	Unknown
Order: Thecosomata	
Family: Cavoliniidae	
Cavolina unicinata	Unknown
Cavolina spectabilis	0 - 0.05
Family: Limacinidae	
Clio balantium	0 - 0.05
Clio pyramidata	0 - 0.05
Limacina helicina	0 - 5
Limacina inflata	0 - 0.05
Class: Heteropoda	
Order: Megastropoda	
Family: Carinariidae	
Caranaria japonica	0 - 0.05
Family: Pterotracheidae	
Atlanta peroni	0 - 5
Pterotrachea scututa	Unknown

VERTICAL DISTRIBUTION OF THE PLANKTON

Three studies were located that examined the vertical distribution of zooplankton in the Study Area. Pearcy (1972) reported the average vertical distribution of the standing stock of macroplankton in three depth strata ranging from the surface to 1000 m in the northern portion of the Study Area. His data were collected between 1962 and 1964. Both daytime and nighttime standing stocks of macroplankton were highest between 0 and 150 m. The wet weight biomass within this depth strata was higher at night (51.9 mg wet wt/mg^3) than during the day (10.1 mg wet wt/m^3), thus indicating that diel vertical migration was occurring. The remaining two studies dealt solely with the vertical distribution of copepods. Peterson and Anderson (1966) recorded the abundance of copepods collected at four depths between the surface and 100 m at a series of stations between 42° N and 45° N. No effort was made to distinguish differences between day and night distributions. Peterson (1972), also examined seasonal and diel vertical migrations of the common copepods found in the northern portion of the lease area. In contrast to Pearcy (1972), he concluded that diel vertical migration usually could not be demonstrated for many common copepod species. Although diel vertical migration was apparent for some of the less common species, the actual number of copepods that appeared to undergo diel vertical migration when expressed as a percentage of the total number of copepods was very low.

FEEDING ECOLOGY OF MAJOR ZOOPLANKTONIC GROUPS FOUND IN THE GORDA RIDGE STUDY AREA

No studies are available to date that deal specifically with zooplankton collected within the Gorda Ridge Study Area. There are, however, studies of the feeding ecology of zooplankton species from other locations that also occur in the Study Area. In particular, Raymont's (1983) monograph provides a good review this topic and is the source of much of the information that follows.

Phylum: Annelida
Class: Polychaeta

Although little is known of their food preferences the pelagic polychaetes are considered to be opportunistic carnivores. Tomopteris sp., a common pelagic polychaete found within the lease area, is classified as a secondary carnivore by Raymont (1983), and has been observed to feed on diatoms, copepods, chaetognaths, and larval herrings (Bigelow 1924, Lebour 1922, 1923, Nicol 1960).

Phylum: Arthropoda
Order: Amphipoda
Suborder: Hyperiidea

Amphipods are usually regarded to be carnivorous (Bigelow 1924, Kane 1963, Lebour 1922, Raymont 1983). However, one of the peculiar and characteristic features of hyperiid amphipods that affects their feeding ecology is the predeliction for the group to live commensally, or perhaps parasitically, on other zooplankton. Such associations have been observed between hyperiids and cnidarians (including medusae and siphonophores), and pelagic tunicates (such as Pyrosoma, salps, and doliolids) (Raymont 1983).

Family: Hyperiidae

The Hyperiidae are often associated with medusae and ctenophores (Raymont 1983). They are apparently carnivorous, although Conover (1960) observed that the genus Hyperia, reported to be present within the Study Area, can feed on both living and dead plankton.

PLANKTON

Family: Lanceolidae

Little is known about the feeding ecology of this deep-water family. Bowman and Gruner (1973) believe that they feed on the tissues of deep-water siphonophores and medusae. No information is available on the feeding ecology of the one member of this family reported to be present within the Study Area.

Family: Lycaeida

No information is available on the feeding ecology of this family in the Study Area. Raymont (1983) states that members of this family are often found associated with salps and may feed on the salps' tissues.

Family: Oxycephalidae

No information is available on the feeding ecology of the Oxycephalidae within the Study Area. Members of this family are associated with ctenophores and are reported to actively feed upon the tissues of these organisms (Harbison *et al.* (1978).

Family: Paraphronimidae

Members of this family are associated with siphophores (Raymont 1983), however little is known of their feeding ecology. No information is available on the feeding ecology of this group in the Study Area.

Family: Phromidae

The only member of this family found within the lease area is *Phronima sedentaria.* The larvae of this species enters salps and lives parasitically until metamorphosis into planktonic adults. (Raymont 1983). From the examination of the adults' mouthparts Shih (1969) believes that this amphipod is omnivorous.

Family: Vibilidae

Three species of the genus *Vibilia* are found within the lease area. Madin and Harbison (1977) reported that *Vibilia* feeds on the food material collected by salps.

Order: Copepoda
Suborder: Calanoida

PLANKTON

Family: Acartiidae

Studies on the feeding ecology of the Acartiidae found within the lease area conclude that members of this family are omnivorous. Anraku and Omori (1963) showed that the mouthparts of *Acartia* were characteristic of copepods consuming both phytoplankton and animal prey. Omnivorous feeding of this genus has also been demonstrated in laboratory experiments.

Family: Aeteidae

Members of this family are thought to be carnivores or omnivores (Raymont 1983). The genera *Aetideus*, *Chirundina*, *Euchirella*, *Gaetanus*, *Gaidius*, and *Undeuchaeta*, all of which are found within the Study Area, have mouthparts characteristic of omnivores or carnivores. Many have been found to contain both phytoplankton and animal remains in their gut (Esterly 1916, Mullin 1966, Raymont 1983, Timonin 1971).

Family: Arietellidae

Members of this family are believed to be primarily carnivores or omnivores (Raymont 1983). No information is available on the food preferences of the two species found within the Study Area.

Family: Augaptilidae

Members of this family are thought to be carnivores or omnivores. According to Petipa *et al.* (1973), the genus *Haloptilus* appears to be solely carnivorous, while Raymont (1983) lists this genus as omnivorous.

Family: Calanidae

Members of this family are considered to be primarily herbivorous (Beklemishev 1954, Marshall and Orr 1955, Wickstead 1962). This designation is based on examination of mouthpart structure (Arashkevich and Timonin 1970, Mullin 1966) and on the remains of phytoplankton found in the gut (Arashkevich and Timonin 1970). The deeper living genus *Bathycalanus* is thought to be omnivorous (Raymont 1983).

Family: Candaciidae

Members of this family appear to be entirely carnivorous (Petipa *et al.* 1973).

Family: Centropagidae

Members of this family are thought to be omnivores. This designation comes from an examination of their mouthpart structure (Anraku and Omori 1963), and feeding experiments (Lebour 1922).

Family: Eucalanidae

Mouthpart and gut content analyses suggest the Eucalanidae are primarily herbivorous (Arashkevich and Timonin 1970, Raymont 1983).

Family: Euchaetidae

The Euchaetidae are thought to be solely carnivorous (Petipa et al. 1973, Raymont 1983).

Family: Heterorhabdidae

Members of this family are believed to be primarily carnivorous (Raymont 1983).

Family: Lucicutiidae

There is little known about ther feeding ecology of this family. Their distribution with depth suggests that they are carnivores or omnivores (Raymont 1983).

Family: Metridiidae

Mouthpart structure, gut content analysis, and feeding experiments indicate that members of this family are omnivores (Araskevich and Tomonin 1970, Haq 1967, Mullin 1966, Raymont 1983).

Family: Paracalanidae

Members of this family are thought to be primarily herbivorous, although in times of scarcity they may feed on small zooplankton (Raymont 1983, Timonin 1971).

Family: Phaennidae

Little is known about the feeding ecology of this family. Nothing is known about the feeding preferences of the two species reported to occur within the Study Area.

Family: Pontellidae

The Pontellidae are thought to be exclusively carnivorous (Raymont 1983).

Family: Pseudocalanidae

Mouthpart and gut content analysis suggest the Pseudocalanidae are primarily herbivorous (Arashkevich and Timonin 1970, Corkett and McLaren 1978).

Family: Scolecithricidae

Little is known about the feeding ecology of this family of copepods. At least one species found within the Study Area, Scottocalanus persecans, appears to be a carnivore based on the abundant remains of copepods found in the gut (Easterly 1916).

Family: Tortanidae

Tortanus discaudatus is the only species within this family reported to be present within the Study Area. This copepod is believed to be exclusively carnivorous (Landry 1978).

Suborder: Cyclopoida

No information is available on the feeding ecology of Cyclopoid copepods found in the Study Area. Raymont (1983) states that the genera Oithona, Oncaea, and Corycaeus, which are found within the Study Area, are primarily carnivorous.

Order: Euphausiacea

The Euphausiacea found within the Study Area have diverse feeding behaviors. They have been reported to feed on phytoplankton, small crustaceans such as copepods, protozoans such as Globigerina, radiolarians, tintinnids, or detritus (Hickling 1925, Marshall 1954, Ponomareva 1954, 1963, Tchinodonova 1959). Of the species reported to occur within the Study Area. Euphausia pacifica, Tessabranchion oculatus, Thysanoessa longipes, and T. raschii are all believed to be primarily herbivores. However, these species can also apparently switch to carnivorous feeding when sufficient zooplankton prey is available (Lasker 1966, Raymont 1983). The genera Nematobrachion and Stylocheiron are thought to be carnivorous (Raymont 1983), while the genera Bentheuphausia and Nematoscelis have been found to contain a largepoi i mr D sNto

Sajo 1968 aymt1983.

PLANKTON

Phylum: Chaetognatha

The Chaetognatha are generally considered primary or secondary carnivores. Copepods are regarded as a major component of their diet (Raymont 1983). Copepods exceeding 1 mm in length are most often consumed and there is evidence that the size of prey selected increases with the size of the predator (Raymont 1983). They will, however, consume many other members of the zooplankton including amphipods, ostracods, small euphausiids, other chaetognaths, and larval herring (Bigelow 1924, Hardy 1956, Lebour 1922, Marshall 1954, Parry 1947, Tchinodonova 1959). Experiments by Reeve (1966) indicate that chaetognaths are able to detect the movements of their prey. Vibrations are apparently detected by stimulation of non-motile cilia-like structures on the chaetognath's body.

Phylum: Chordata
Class: Larvacea

Oikopleura is the only organism within this class reported to be present within the lease site. The filter-feeding ecology of this organism is based on its ability to secrete a mucopolysaccharide test or "house". The water passing into the house is directed to two filter food traps situated right and left of the organism's chamber. Very minute particles, including nanoplankton and bacteria, are collected on the filters (Sorokin 1971), and are directed via a funnel to the mouth of the organism (Raymont 1983).

Order: Salpidae

The Salpidae also feed by trapping particles in a secretion of mucus and are considered to be primarily herbivores (Foxton 1961, Fraser 1962, Hubbard 1966, Laurs 1967, Marshall 1954, Raymont 1983, Yount 1958). Madin (1974) examined the feeding of six species of salps including one, Thalia democratica, which is present in the Study Area. Although the minimum size of particles retained by the salps was around 1 μm, there appeared to be no active selection of various food particles of specific sizes. Harbison and Gilmer (1976) examined the feeding of Pegea confederata, also found within the Study Area, and concluded that this species could retain particles as small as 0.7 μm.

Phylum: Coelenterata
Class: Hydroza
Order: Chondrophora

Velella vellella is the only species of this order reported to be present within the Study Area. Raymont (1983) lists members of this genus as being carnivorous: about 10% of their diet consists of copepods, the remainder consists of fish eggs and small larval crustaceans.

PLANKTON

Order: Siphonophora

There is no information on the feeding preferences of Siphonophores reported to be present within the Study Area. Raymont (1983) classifies members of this order as carnivores that feed on a wide range of zooplankton, including copepod nauplii, decapod crustaceans, and small fish.

Class: Schyphozoa

Schyphozoa are reported to be carnivores that feed on a variety of zooplankton including copepods, amphipods, other crustaceans, eggs, pteropods, small ctenophores, and larval fish (Raymont 1983). However, no information is available about the feeding ecology of the members of the three families of deep-sea Schyphozoa reported to occur within the Study Area.

Phylum: Ctenophora
Order: Beroida

Beroe cucumis is the only species of this order reported to be present in the Study Area. This species is classified as a secondary carnivore that feeds almost exclusively on lobate ctenophores (Raymont 1983).

Order: Cydippida

Pleurobrachia pileus is the only species of this order reported to be present in the Study Area. Raymont (1983) classifies this species as a non-selective tertiary carnivore that feeds mainly on copepods, fish eggs, fish larvae, and chaetognaths.

Phylum: Mollusca
Class: Gastropoda
Order: Gymnosomata

Clione limacina is the only species of this order reported to be present within the Study Area. Raymont (1983) states that the veligers of this species are herbivorous and that the adults feed largely as carnivores on shelled pteropods.

PLANKTON

Order: Thecosomata

The thecosomes are predominantly herbivorous plankton feeders that graze on dinoflagellates and diatoms of suitable size and shape. The feeding is a combination of ciliary transport with mucus secretion (Raymont 1983). No information is available regarding the feeding ecology of this group in the Study Area.

Class: Heteropoda

The heteropods are carnivores. Some species eat chaetognaths, copepods and other zooplankton including fish larvae, ctenophores, siphonophores, and other pelagic gastropods, but they appear to actively select salps (Raymont 1983). No information is available on the feeding ecology of this group in the Study Area.

DATA GAPS

The picture of the planktonic community of the Gorda Ridge Study Area that emerges from this survey, while not completely blank, generally lacks cohesiveness and detail. In simple numerical terms, 93 reports were identified that dealt either directly or indirectly with the plankton of the study region. The identity and numbers of the major groups of epipelagic net phytoplankton (diatoms, in particular) and net zooplankton (Tables 5 and 6) have been established within bounds that are not unreasonable a somewhat arbitrarily-defined region of the northeast Pacific Ocean. A total of 263 taxa of planktonic organisms were identified as belonging or likely to belong, to the planktonic assemblage found over the Gorda Ridge (Appendices 1 and 2).

There are, however, major gaps in the data needed to assemble a comprehensive overview of the structure and function of the planktonic community of the Study Area. A beginning, but not necessarily exhaustive list of such work would include the following:

1. Nanno- and Bacterioplankton

Virtually all studies of plankton in the Gorda Ridge Study Area dealt with members of the community that could be collected in nets. We found no information on the nanno- and bacterioplankton. The taxonomic diversity of these groups as well as their contributions to primary production and nutrient cycling need to be assessed.

2. Composition of the Phytoplankton

With the exception of diatoms found in the Study Area, the species composition of the phytoplankton is not known.

3. Temporal and spatial variations in plankton numbers and biomass

Several studies were located which reported numbers and biomass of various components of the plankton. Much of this work, however, was carried out prior to 1969. More recent data is needed. Furthermore, knowledge of seasonal variations in the composition of the planktonic community is far from complete. There is no information on the seasonal or diel vertical distribution of plankton other than the copepods and a few euphausiids. Little is known about the plankton of mesoplegic and bathypelagic depths. On another temporal scale, we were unable to find any long-term data sets to assess variability in the plankton over a relatively long period of time, one, for example, that would allow us to examine the influence of an El Nino event on primary productivity or zooplankton species composition.

4. Primary Production: rates and limits

Given current concerns about reassessments of rates of primary production in world ocean, the data available for the Study Area needs to be verified. Factors that limit primary production, and the fate of primary production, that is, its transfer through various components of the pelagic food web, need to be determined.

5. Trophic Interactions

Almost nothing is known, on a first-hand basis, about the feeding ecology of the zooplankton in the Study Area. Estimates of feeding rates, even on a seasonal basis, are unavailable for even the most common zooplankters of the region. At best, literature values can be found for the ingestion rates of some species that occur within region. Construction of food webs and energy flow models for the region, based on the information now available would be, by necessity, highly generalized and conjectural.

6. Secondary Production and the Vertical Transport of Organic Matter

Perhaps the most serious deficiency in the data available for the Study Area is the complete lack of studies assessing rates of secondary production in the plankton. Such data, together with estimates of the downward flux of organic matter through the water column, are needed before a credible model of the planktonic community can be assembled.

Table 6. Summary of data on the abundance and productivity of phytoplankton in the Gorda Ridge Study Area.

		Reference	
Numbers (#/m^3)			
Diatoms	$2.2 - 6.4 \times 10^4$	Kozlova and Mukhina	1967
	10^6	Marumo	1967
Silicoflagellates	$2.0 - 2.5 \times 10^6$	Kozlova and Mukhina	1967
Biomass as chlorophyll a	(mg/m^3)		
Surface waters	0.1 - 0.5	Anderson	1964, 1972
	0.5	Small and Curl	1968
	0.39 - 0.85	Small and Curl	1972
Subsurface max.	1 - 3	Anderson	1969, 1972
Annual Productivity (gC/m^2)			
Euphotic zone	60	Anderson	1964
	72 - 85	Larrance	1971
	90 - 240	Koblents-Miske	1965
	125	Anderson	1972

Table 7. Summary of estimates of the numbers and biomass of major groups of zooplanktonic organisms found in the Gorda Ridge Study Area. References for each group can be found in the text under the corresponding taxonomic heading. Biomass is in grams dry weight unless noted.

	Number of reports	Numbers #/m^3	Biomass mg/m^3
Polychaetes	2	0.4 - 19	
Amphipods	5	0.2 - 32 (856 max.)	1 - 16
Copepods	12	see Table 2	
Euphausiids	5	0 - 50, also see Table 3	0.8 - 51
Chaetognaths	6	0 -157, also see Table 4	0.1 - 6.4
Larvaceans	3	435 (max.)	0 - 4 (wet wt.)
Thaliaceans (total)	2		0 - 1024 (wet wt.)
Salps	4	208 (max.)	1.8
Ctenophores	2		0 - 16 (wet wt.)
Molluscs	1	0 - 5, also see Table 5	

ACKNOWLEDGEMENT

The references identified in this section were obtained, in part, by a computer-assisted search of the Aquatic Sciences and Fisheries Abstracts, Biological Abstracts, and National Technical Information Service data bases. Further information was obtained through personal contacts within Oregon State University and Humboldt State University. Researchers at these institutions verified the impression gathered by the review of the published literature that few workers have collected plankton samples within the region of Gorda Ridge Study Area. Existing data from this region was generated during sampling transects along the Brookings hydroline transect at 42° North (e.g., Lee 1971, Laurs 1967), or the Newport hydroline at 44° 39' North (e.g., Cross 1964). Considerably more is known about the plankton of the California Current south of the Gorda Ridge lease site and nearshore studies of the plankton within the upwelling regions off northern Oregon and Washington. These data were used in conjuction with the data collected within the Study Area proper to provide a better description of plankton and planktonic processes in the region of the Gorda Ridge Study Area.

We would particularly like to thank Marilyn Guin, of the Hatfield Marine Science Center Library, for help in generating the initial reference lists and for her assistance in obtaining hard-to-find reports through inter-library loans. We also thank Dr. Larry Small, of the College of Oceanography at Oregon State University for help in locating studies carried out in the Study Region. Thanks also go to Sue Pullen for pushing and pulling manuscripts through various stages of word processing.

This work was supported by Interagency Agreement #63-630-8501 between the Oregon Department of Geology and Mineral Industries and Oregon State University.

REFERENCES

Alvarino, A. 1965. Distributional atlas of Chaetognatha in the California Current region. CalCOFI Atlas No. 6. 291 pp.

Anderson, G.C. 1964. The seasonal and geographic distribution of primary productivity off the Washington and Oregon coasts. Limnol. Oceanogr. 9: 284-302.

Anderson, G.C. 1965. Fractionation of phytoplankton communities off the Washington and Oregon coasts. Limnol. Oceanogr. 10: 477-480.

Anderson, G.C. 1969. Subsurface chlorophyll maximum in the northeast Pacific Ocean. Limnol. Oceanogr. 14: 386-391.

Anderson, G.C. 1972. Aspects of marine phytoplankton studies near the Columbia River, with special reference to a subsurface chlorophyll maximum. pp. 219-240. In: Columbia River Estuary and Adjacent Ocean Waters. Bioenvironmental Studies. A.T. Pruter and D.L. Alverson (Eds.), Univ. of Wash. Press. 1972.

Anraku, M. and M. Omori. 1963. Preliminary survey of the relationship between the feeding habit and the structure of the mouthparts of marine copepods. Limnol. Oceanogr. 8: 116-126.

Arashkevich, E.G. and A.G. Timonin. 1970. The feeding of copepods in the tropical part of the Pacific Ocean. Dokl. Akad. Nauk, SSSR 191: 935-938.

Barnes, C.A. and R.G. Paquette. 1957. Circulation near the Washington Coast. Proceedings of the Eighth Pacific Science Congress. Oceanography 3: 583-608.

Beck, J.R. 1966a. Physical, chemical, and biological data from the northeastern Pacific Ocean: Columbia River effluent area, July-December 1963. Vol. I. Univ. of Washington Dept. of Oceanography Tech. Rept. No. 159.

Beck, J.R. 1966b. Physical, chemical, and biological data from the northeastern Pacific Ocean: Columbia River effluent area, July-December 1963. Vol. II. Univ. of Washington Dept. of Oceanography Tech. Rept. No. 159.

Beck, J. R. 1966c. Physical, chemical, and biological data from the northeastern Pacific Ocean: Columbia River effluent area, July-December 1963. Vol. III. Univ. of Washington Dept. of Oceanography Tech. Rept. No. 159.

Bieri, R. 1959. The distribution of the planktonic Chaetognatha in the Pacific and their relationship to the water masses. Limnol. Oceanogr. 4: 1-27.

PLANKTON

Bigelow, H.B. 1924. Plankton of the offshore waters of the Gulf of Maine. Bulletin of the U.S. Bureau of Fisheries 40: 1-509.

Biklemishev, K.V. 1954. Feeding of some common plankton copepods in far eastern seas. Zoologicheskii Zhurnal, Moscow 33: 1210-1229.

Bowman, T.E. and H.E. Gruner. 1973. The families and genera of Hyperiidea (Crustacea: Amphipoda). Smithsonian Contrib. Zool. 146: 64 pp.

Bowman, T.E. and M.W. Johnson. 1973. Distributional atlas of calanoid copepods in the California Current region, 1949 and 1950. CalCOFI Atlas No. 19. 239 pp.

Brinton, E. 1967. Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part I. CalCOFI Atlas No. 5. 275 pp.

Brinton, E. 1973. Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part II. CalCOFI Atlas No. 18. 336 pp.

Brodskii, K.A. 1967. Calanoida of the far eastern seas and polar basin of the USSR. Zool. Inst. Acad. Sci. USSR. No. 35.

Burt, W.V. and B. Wyatt. 1964. Drift bottle observations of the Davidson Current off Oregon. pp. 156-165. In: Studies on Oceanography. Univ. of Tokyo Press, Tokyo.

Conover, R.J. 1960. The feeding behavior and respiration of some planktonic Crustacea. Biol. Bull. 119: 399-415.

Corkett, C.J. and I. A. McLaren. 1978. The biology of Pseudocalanus. Adv. Mar. Biol. 15: 1-231.

Cross, F.A. 1964. Seasonal and geographical distribution of pelagic copepods in Oregon coastal waters. Oregon State University Masters Thesis, 62 pp.

Cross, F.A. and L.F. Small. 1967. Copepod indicators of surface water movements off the Oregon coast. Limnol. Oceanogr. 12: 60-72.

Cupp, E.E. 1943. Marine planktonic diatoms of the west coast of North America. Univ. California Press, Berkely, 1943.

Davis, C.C. 1949. The pelagic Copepoda of the northeastern Pacific Ocean. Univ. of Washington Press, 1949.

Esterly, C.D. 1916. The feeding habits of pelagic copepods. Univ. Calif. Publs. Zool. 16: 171-184.

Favorite, R., A.J. Dodimead, and K. Nasu. 1976. Oceanography of the subarctic Pacific region, 1960-71. International North Pacific Fisheries Commission, Bulletin Number 33, 187 pp.

Fleminger, A. 1964. Distributional atlas of calanoid copepods in the California Current region, Part I. CalCOFI Atlas No. 2. 313 pp.

Fleminger, A. 1967. Distributional atlas of calanoid copepods in the California Current region, Part II. CalCOFI Atlas No. 7. 213 pp.

Fleminger, A., J.D. Isaacs, and J.G. Wyllie. 1974. Zooplankton biomass measurements from CalCOFI cruises of July 1955 to 1959 and remarks on comparison with results from October, January and April cruises of 1955 to 1959. CasCOFI Atlas No. 21. 118 pp.

Foxton, P. 1961. Salpa fusiformis Cuvier and related species. Discovery Reports 32: 1-32.

Fraser, J.H. 1962. The role of ctenophores and salps in zooplankton production and standing crop. Conseil Permanent International pour l'Exploration de la Mer 153: 121-123.

Haq, S.M. 1967. Nutritional physiology of Metridia lucens and M. longa from the Gulf of Maine. Limnol. Oceanogr. 12: 40-51.

Harbison, G.R. and R.W. Gilmer. 1976. The feeding rates of the pelagic tunicate Pegea confederata and two other salps. Limnol. Oceanogr. 21: 517-528.

Harbison, G.R., D.C. Briggs, and L.P. Madin. 1977. The associations of Amphipoda Hyperiidea with gelatinous zooplankton. II. Associations with Cnidaria, Ctenophora and Radiolaria. Deep Sea Res. 24: 465-489.

Hardy, A. 1956. The Open Sea. London, Collins Clear-Type Press. 335 pp.

Hasle, G.R. 1976. The biogeography of some marine planktonic diatoms. Deep Sea Res. 23: 319-338.

Hebard, J.F. 1966. Distribution of Euphausiacea and Copepoda off Oregon in relation to oceanographic conditions. Oregon State University Ph.D. Thesis, 85 pp.

Hickling, C.F. 1925. Notes on euphausiids. J. Mar. Biol. Ass. United Kingdom 13: 735-745.

Hobson, L.A. 1966. Some influences of the Columbia River effluent on marine phytoplankton during January 1961. Limnol. Oceanogr. 11: 223-234.

Hubbard, L.T. 1967. Distribution and occurrence of the Salpidae off the Oregon coast. Oregon State University Masters Thesis, 31 pp.

Isaacs, J.D., A. Fleminger, and J.K. Miller. 1969. Distributional atlas of zooplankton biomass in the California Current region: Spring and Fall 1955 - 1959. CalCOFI Atlas No. 10. 252 pp.

PLANKTON

Kane, J.E. 1963. Observations on the moulting and feeding of a hyperid amphipod. Crustaceana 6: 129-132.

Kilburn, P.D. 1961. Summer phytoplankton at Coos Bay, Oregon. Ecology 42: 165-166.

Koblents-Mishke, O.I. 1965. Primary production in the Pacific. Oceanology 5: 104-116.

Kozlova, O.G. and V.V. Mukhina. 1967. Diatoms and silicoflagellates in suspension and floor sediments of the Pacific Ocean. Int. Geology Rev. 9: 1322-1342.

Landry, M.R. 1978. Predatory feeding behavior of a marine copepod, Labidocera trispinosa. Limnol. Oceanogr. 23: 1103-1113.

Larrance, J.D. 1971. Primary production in the mid-subarctic Pacific region, 1966-68. Fishery Bulletin 69: 595-613.

Lasker, R. 1966. Feeding, growth, respiration, and carbon utilization of a euphausiid crustacean. J. Fish. Res. Bd. Canada 23: 1291-1317.

Laurs, R.M. 1967. Coastal upwelling and the ecology of lower trophic levels. Oregon State University Ph.D. Thesis, 121 pp.

Lebour, M.V. 1922. Food of plankton organisms. J. Mar. Biol. Ass. United Kingdom 12: 458-467.

Lebour, M.V. 1923. Food of plankton organisms. J. Mar. Biol. Ass. United Kingdom 12: 644-677.

Lee, W.Y. 1972. The copepods in a collection from the southern coast of Oregon, 1963. Oregon State University Masters Thesis, 62 pp.

Madin, L.P. 1974. Field observations on the feeding behavior of salps (Tunicata: Thaliacea). Mar. Biol. 25: 143-147.

Madin, L.P. and G.R. Harbison. 1977. The associations of Amphipoda Hyperiidea with gelatinous zooplankton. I. Associations with Salpidae. Deep Sea Res. 24: 449-463.

Marshall, N.B. 1954. Aspects of Deep Sea Biology. London, Hutchins and Company, Ltd. 380 pp.

Marshall, S.M. and A.P. Orr. 1955. The Biology of a marine copepod Calanus finmarchicus (Gunnerus). Edinburgh, Oliver and Boyd, Ltd. 188 pp.

Marumo, R. 1967. General features of diatom communities in the North Pacific Ocean in summer. Information Bull. on Planktology in Japan Commemoration Number of Dr. Y. Matsue, 1967.

McGowan, J.A. 1967. Distributional atlas of pelagic molluscs in the California Current region. CalCOFI Atlas No 6. 218 pp.

Meyers, A.H. 1975. Vertical distribution of zooplankton in the Oregon coastal zone during an upwelling event. Oregon State University Masters Thesis, 62 pp.

Mullin, M.M. 1966. Selective feeding by calanoid copepods from the Indian Ocean. pp. 545-554. In: Some Contemporary Studies in Marine Science. H. Barnes (Ed.), Hafner Publ. Co., New York, 1966.

Nemoto, T.K. and Y. Saijo 1968. Chlorophyll pigments in the stomach of euphausiids. J. Oceanogr. Soc. Japan 24: 253-260.

Nicol, J.A.C. 1960. The Biology of Marine Animals. New York, Interscience. 707 pp.

Parry, D.A. 1947. Structure and function of the gut in *Spadella cephaloptera* and *Sagitta setosa.* J. Mar. Biol. Ass. United Kingdom 26: 16-36.

Parsons, T.R. and M. Takahashi. 1973. Biological oceanographic processes. First Edition. Pergamon Press, Oxford. 186 pp.

Pearcy, W.G. 1972. Distribution and ecology of oceanic animals off Oregon. pp. 351-377. In: Columbia River Estuary and Adjacent Ocean Waters. Bioenvironmental Studies. A.T. Pruter and D.L. Alverson (Eds.) Univ. Wash. Press, 1972.

Peterson, W.K. and G.C. Anderson. 1966. Net zooplankton data from the northeastern Pacific Ocean: Columbia River effluent area, 1961, 1962. Univ. of Washington Dept. of Oceanography Tech. Rept. No. 160.

Peterson, W.K. 1972. Distribution of pelagic Copepoda off the coasts of Washington and Oregon during 1961 and 1962. pp. 313-343. In: Columbia River Estuary and Adjacent Ocean Waters. Bioenvironmental Studies. A.T. Pruter and D.L. Alverson (Eds.), Univ. of Wash. Press, 1972.

Peterson, W.K. and C.B. Miller. 1976. Zooplankton along the continental shelf off Newport, Oregon, 1969-1972: distribution, abundance, seasonal cycle, and year-to-year variations. Oregon State University Sea Grant College Program Publication No. ORESU-t-76-002.

Petipa, T.S., E.V. Pavlova, and Y.I. Sorokin. 1973. Radiocarbon studies of the feeding of mass plankton forms in the tropical zone of the Pacific. pp. 135-155. In: Life Activity of Pelagic Communities in the Ocean Tropics. M.E. Vinogradov (Ed.). Israel Program for Scientific Translations.

PLANKTON

Ponomareva, L.A. 1954. Euphausiids of the Sea of Japan feeding on Copepoda. Reports of the Academy of Science U.S.S.R. Zoology 98: 153-154.

Ponomareva, L.A. 1963. Euphausiids of the North Pacific. Their distribution and ecology. Akademiya Nauk SSST. Institute for Scientific Translations No. 1368. 154 pp.

Raymont, J.E.G. 1980. Plankton and Productivity in the Oceans. Vol. I. Phytoplankton. Pergamon Press, London, 489 pp.

Raymont, J.E.G. 1983. Plankton and Productivity in the Oceans. Vol. II. Zooplankton. Pergamon Press, London, 824 pp.

Reeve, M.R. 1966. Observations on the biology of a chaetognath. pp. 613-630. In: Some Contemporary Studies in Marine Science. H. Barnes (Ed.). Hafner Publ. Co., New York, 1966.

Ryther, J.H. 1969. Potential productivity of the sea. Science 130: 602-608.

Semina, H.J. 1972. The size of phytoplankton cells in the Pacific Ocean. Int. Revue Ges Hydrobiol. 57: 177-205.

Semina, H.J. and I.A. Tarkhova. 1972. Ecology of phytoplankton in the North Pacific Ocean. pp. 117-124. In: Biological Oceanography of the Northern North Pacific Ocean. A.Y. Takenouti (Ed.), Idemitsu Shoten 1972.

Shih, C.T. 1969. The systematics and biology of the family Phronimidae (Crustacea: Amphipoda). Dana Report 74: 1-100.

Small, L.F. and F.A. Cross. 1972. Effects of the Columbia River plume on two copepod species. pp. 344-350. In: Columbia River Estuary and Adjacent Ocean Waters. Bioenvironmental Studies, A.T. Pruter and D.L. Alverson (Eds.), Univ. of Washington Press, 1972.

Small, L.F. and H. Curl. 1968. The relative contribution of particulate chlorophyll and river tripton to the extinction of light off the coast of Oregon. Limnol. Oceanogr. 13: 84-91.

Small, L.F. and H. Curl. 1972. Effects of Columbia River discharge on chlorophyll a and light attenuation in the sea. pp. 203-218. In: Columbia River Estuary and Adjacent Ocean Waters. Bioenvironmental Studies. A.T. Pruter and D.L. Alverson (Eds.), Univ. of Wash. Press 1972.

Small, L.F., H. Curl, and W.A. Glooschenko. 1972. Estimates of primary production off Oregon using an improved chlorophyll-light technique. J. Fish. Res. Bd. Canada 29: 1261-1267.

Small, L.F. and D.W. Menzies. 1981. Patterns of primary productivity and biomass in a coastal upwelling region. Deep Sea Res. 28: 123-149.

Smith, P.E. 1971. Distributional atlas of zooplankton volume in the California Current region, 1951 through 1966. CalCOFI Atlas No. 13. 144 pp.

Smith, P.E. 1974. Distribution of zooplankton volumes in the California Current region, 1969. CasCOFI Atlas No. 20. 125 pp.

Sorokin, J.I. 1971. On the role of bacteria in the productivity of tropical oceanic waters. Int. Rev. Ges. Hydrobiol. 56: 1-48.

Tchindonova, J.G. 1959. Feeding of some groups of macroplankton in the north-western Pacific. Trudy, Institute of Okeanology 30: 166-189.

Timonin, A.G. 1971. The structure of plankton communities of the Indian Ocean. Mar. Biol. 9: 281-289.

Wickstead, J.H. 1962. Food and feeding in pelagic copepods. Proc. Zool. Soc. London 139: 545-555.

Wyatt, B., W.V. Burt, and J.G. Patullo. 1972. Surface currents off Oregon as determined from drift bottle returns. J. Physical Oceanogr. 2: 286-293.

Yount, J.L. 1958. Distribution and ecologic aspects of central Pacific Salpidae (Tunicata). Pacific Science 12: 111-130.

APPENDIX 1

Plankton found within the Gorda Ridge Study Area.

Reference Code Numbers

1. Pearcy (1972)
2. Peterson and Miller (1976)
3. Hebard (1966)
4. Hubbard (1967)
5. Laurs (1967)
6. Lee (1972)
7. Cross (1964)
8. Cross and Small (1967)
9. Meyers (1975)
10. Smith (1974)
11. Fleminger (1964)
12. Alvarino (1965)
13. Brinton (1967)
14. McGowan (1967)
15. Fleminger 91967)
16. Brinton (1973)
17. Bowman and Johnson (1973)
18. Anderson (1972)
19. Hobson (1966)
20. Semina and Tarkhova (1972)
21. Semina (1972)
22. Kilburn (1961)
23. Kozlova and Mukhina (1967)
24. Hasle (1976)

Zooplankton Species List

	Reference
Phylum: Annelida	
Class: Polychaeta	
Family Alciopidae	
Rhynchonereella angelina	1
Family Lumbrineridae	
Ninoe gemmea	1
Family Poeobiidae	
Poeobius meseres	1
Family Tomopteridae	
Tomopteris cavallii	1,2
T. nisseni	1,2
T. pacifica	1,2

PLANKTON

Phylum: Arthropoda
Order: Amphipoda

Family Cystisomidae	
Cystisoma fabricii	1
Family Dairellidae	
Dairella californica	1
Family Hyperiidae	
Hyperia hystrix	1,5
Hyperoche medusarum	1,5
Parathemisto pacifica	1,5,6,9
Phronimopsis spinifera	1
Family Lanceolidae	
Lanceola loveni	1
Family Lycaeidae	
Lycaea pulex	1
Tryphana malmi	1,5
Family Oxycephalidae	
Oxycephalus clausi	1,5
Streetsia challengeri	1,5
Family Paraphronimidae	
Paraphronima crassipes	1,5
P. gracilis	1,5
Family Phromidae	
Phronima sedentaria	1,5,6
Family Phrosinidae	
Primno abyssalis	1,5,6
P. macropa	1,5
Family Scinidae	
Scina crassicornis burmudensis	1
Family Vibiliidae	
Vibilia armata	1,5
V. progingua	1,5
V. wolterecki	1

Order: Copepoda
Suborder: Calanoida

Family Acartiidae	
Acartia clausii	1,2,6,7,9,10
A. danae	1,2,3,5,7,8,11

A. longiremis	1,2,3,5,6,7,9,10
A. tonsa	2,5,6,10,11
Family Aeteidae	
Aetideopsis pacifica	1
Aetideus armatus	1,3,5,6,7,15
A. pacificaus	1,2,3,9
Chirundina streetsi	1,5,6,7
Euchirella curticauda	1,3,5,6,15,17
E. galeata	1,3,5,15,17
E. pulchra	1,3,5,6,7,15,17
E. rostrata	1,3,5,7,15,17
Gaetanus miles	15
G. secundus	1
G. simplex	1,2,3,5,7
Gaidius brevispinus	1,2,3,5,6
G. pungens	1,3,5,6,7,11,17
G. tenuispinus	1,3,6
G. variabilis	1,3,5
Pseudochirella polyspina	1,3,5
Undeuchaeta intermedia	1,3
U. major	1,5,6
U. plumosa	1,3,5,6
Family Arietellidae	
Arietellus plumifer	1,3
A. setosus	5
Family Augaptilidae	
Centraugaptilus porcellus	1
Haloptilus pseudooxycephalus	1
Family Calanidae	
Bathycalanus bradyi	1
Calanus cristatus	1,2,3,6,7,9,11,17
C. glacialis	5,11
C. lenvicornis	5
C. marshallae	2,9
C. pacificus	1,3,5,6,17
C.plumchruss	1,2,3,5,7,9,17
C. tenuicornis	1,2,3,7,9,11,17
Family Candaciidae	
Candacia bipinnata	1,2,3,5,6,7,11,17
C. columbiae	1,2,3,5,6,7,17
Family Centropagidae	
Centropages bradyi	17
C. mcmurrichi	1,2,7,8,10
Family Eucalanidae	
Eucalanus attenuatus	1,17

E. bungii	1,2,3,5,6,7,9,11,17
E. elongatus hyalinus	1,3,5,6,7,11,17
Mecynocera clausii	2,17
Rhincalanus nastus	1,2,3,5,6,7,11,17
Family Euchaetidae	
Euchaeta spinosa	1
Pareuchaeta abyssalis	5
P. birostrata	1
P. japonica	1,3,5,6,7,9
Family Heterorhabdidae	
Heterorhabdus clausi	15
H. papilliger	1,3,11,17
H. tanneri	1,3,6,15
Heterostylites longicornis	1,3,5,6,7,15
H. major	1,3,5,6
Family Lucicutiidae	
Lucicutia bicornuta	1
L. flavicornis	1,2,3,5,6,7,11,17
Family Metridiidae	
Gaussia princeps	1,3,5
Metridia curticauda	1
M. lucens	1,2,3,5,6,7,9,11
M. pacifica	1,2,3,5,9,17
Pleuromamma abdominalis	1,2,3,5,6,7,11,17
P. borealis	1,2,3,5,11
P. guadrungulata	1,3,5,6,7,11
P. scutullata	1,3,5,6,7
P. xiphias	1,3,5,6,7,11,17
Family Paracalanidae	
Calocalanus sp.	2
C. styliremis	2,15
C. tenuis	2
Paracalanus parvus	1,2,3,5,7,11
Family Phaennidae	
Mixtocalanus robustus	1
Phaenna spinnifera	1,3,6
Family Pontellidae	
Epilabidocera amphitrites	1,2,3,5,6,7
E. longipedata	1,9,17
Family Pseudocalanidae	
Clausocalanus arcuicornis	1,2,3,5,6,7,11
C. dubius	3
C. furcatus	2
C. jobei	2

C. mastigophorus	2
C. parapergens	2
C. paululus	2
C. pergens	2,11
Ctenocalanus vanus	2,11
Microcalanus pusillus	1,2,3,5,9
Pseudocalanus sp.	1,2,3,5,6,7,9,10
Family Scolecithricidae	
Amallothrix valida	1,5
A. vorax	1,3,5
Lophothrix frontalis	1,3,5,6,15
Racovitzanus antarcticas	1,2,3,9,11
R. pacificus	1
R. porrecta	1,3,7
Scaphocalanuss brevicornis	1,3,5,6,7
S. echinatus	11
S. magnus	1
S. medius	1
S. minutus	1,3
S. subelongatus	1,3
Scolecithricella dentata	11
S. minor	1,2,3,5,7,9,15
S. ovata	1,3,5,11
Scottocalanus persecans	1,3,5,6,7,17
S. sedatus	1
Family Tortanidae	
Tortanus discaudatus	1,2,3,5,7,9,10

Suborder: Cyclopoida

Family Corycaeidae	
Corycaeus amazonicus	2
C. anglicus	2
Family Oithonidae	
Oithona plumifera	1
O. similis	1,2,5,6,7,9,10
O. spinirostris	1,2,3,5,6,7,9,10
Family Oncaeidae	
Lubbockia squillimana	1,3
Onacaea borealis	2,9
O. conifera	1,2,6,7
O. dentipes	2
O. media hymena	2
O. meditteranea	2
O. subtilis	2
O. tenella	2

PLANKTON

Suborder: Harpacticoida

Family Aegisthidae	
Aegisthus mucronatus	1,7
Family Clytemnestridae	
Clytemnestra rostrata	1,7
Family Ectinosomidae	
Microsetella sp.	1,2,3,5,7,9

Order: Euphausiacea

Family Bentheuphausiidae	
Bentheuphausia amblyops	1
Family Euphausiidae	
Euphausia pacifica	1,2,3,5,13,16
E. gibboides	5,13,16
E. recurva	16
Nematoscelis difficilis	1,3,5,13,16
Nyctiphanes simplex	13
Stylocheiron abbreviatum	1,3,5,16
S. longicorne	1,3,5,13,16
S. maximum	1,3,5,13,16
Tessarabrachion oculatus	1,3,5,16
Thysanoessa gregaria	1,3,5,13,16
T. inspinata	1,3,5
T. longipes	1,3,5,13,16
T. parva	1
T. raschii	1
T. spinifera	1,2,3,5,13,16
Thysanopoda acutifrons	1
T. cornuta	1
R. egregia	1

Order: Mysidacea

Family Eucopiidae	
Eucopia sp.	1
Family Lophogastridae	
Gnathophausia gigas	1
G. ingens	1
Family Mysidae	
Boreomysis rostrata	1
Boreomysis sp.	1

PLANKTON

Order: Ostracoda

Gigantocypris agassizii	1

Phylum: Chaetognatha

Eukrohnia bathypelagica	1
E. fowleri	1
E. hamata	1,9,12
Krohnitta subtilis	12
Pterosagitta draco	12
Sagitta bierii	1,2,12
S. decipiens	1
S. elegans	1,2,9
S. enflata	12
S. euneritica	1,12
S. hexaptera	12
S. macrocephala	1
S. macima	1
S. minima	1,2,12
S. scrippsae	1,2,12
S. zetesios	1

Phylum: Chordata
Class: Larvacea

Family Oikopleuridae

Oikopleura sp.	1,2,6,9

Class: Thaliacea
Order: Doliolida

Doliolum sp.	1,6

Order: Pyrosomida

Pyrosoma atlanticum	1

Order: Salpidae

Helicosalpa virgula	1,4
Iasis zonaria	1,4,5
Pegea confoederata	1,4,5
Salpa fusiformis	1,4,5
Thalia democratica	1,4
Thetys vagina	1,4,5

PLANKTON

Phylum: Coelenterata
Class: Hydroza
Order: Chondrophora

Velella velella	1

Order: Siphonophora
Suborder: Calycophorae

Family Clausophyidae	
Chuniphyes moserae	1
C. multidentata	1
Family Diphyidae	
Chelophyes appendiculata	1
Lensia conoidea	1
Muggiaeta atlantica	1
Sulculeolaria guadrivalvis	1
Family Hippopodiidae	
Vogti spinosa	1
Family Prayidae	
Praya dubia	1
P. reticulata	1

Suborder: Physonectae

Family Agalmidae	
Nanomia cara	1
Family Physophoridae	
Physophora hydrostatica	1
Family Pyrostephidae	
Bargmannia sp.	1

Class: Schyphozoa
Order: Coronatae

Family Atollidae	
Atolla vanhoeffeni	1
A. wyvillei	1
Family Paraphyllinidae	
Paraphyllina ransoni	1

PLANKTON

Family Perphyllidae

Periphylla periphylla	1

Phylum: Ctenophora
Order: Beroida

Beroe cucumis	1

Order: Cydippida

Pleurobrachia pileus	1

Phylum: Mollusca
Class: Gastropoda
Order: Gymnosonata

Clione limacian	1

Order: Thecosomata

Family Cavoliniidae

Cavolina uncinata	1
Corolla spectabilis	1,14

Family Limacinidae

Clio balantium	1,14
C. pyramidata	14
Limacina helacina	1,2,9,14
L. inflata	14

Class: Heteropoda
Order: Mesogastropoda

Family Carinariidae

Caranaria japonica	1,14

Family Pterotracheidae

Atlanta peroni	14
Pterotrachea scututa	1

APPENDIX 2
Phytoplankton Species
See Appendix 1 for Reference Code Numbers

	Reference
Division Bacillariophyta	
Class: Diatomatae	
Order: Centrales	
Bacteriastrum delicatuilum	18
Chaetoceros atlanticus	20
C. compressus	18
C. concavicornis	19,20,21,23
C. convolutus	18,20
C. debilis	22
C. decipiens	22
C. messanensis	23
C. radicans	18
Coscinodiscus marginatus	19
C. oculus-iridis	20
C. radiatus	22,23
ZDactyliosolen mediterraneus	18
Leptocylindricus danicus	18
L. mediterraneus	24
Minidiscus trioculatus	24
Rhizosolenia fragilissima	18
R. alata	18
Thalassiosira aestivalis	22
T. bioculata	24
T. decipiens	22
T. eccentrica	24
T. floridana	24
T. gravida	21,24
T. lineata	24
T. nordenskoildii	21
T. pacifica	24
T. subtilis	24
Order: Pennales	
Asterionella japonica	18
A. kariana	18
Detiocula seminae	20,21,23,24
Fragilaria sp.	18
Nitzschia americana	24
N. bicapitata	24
N. delicatissima	19
N. pseudonana	24
N. seriata	21
Pseudoeunotia doliolus	24

PLANKTON

Synedra ulna	18
Thalassionema nitzschioides	18,19,23
Thalassiothrix longissima	20,23