Title
Ecology of Living Planktonic Foraminifera in the North and Equatorial Pacific Ocean

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Ecology of Living Planktonic Foraminifera in the North and Equatorial Pacific Ocean

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by

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December, 1957

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ABSTRACT

Planktonic Foraminifera are useful in solving various problems of paleoecology in the marine environment, especially in interpretation of world climatic changes during the Pleistocene. Very little is known of the ecology of this group; most of our knowledge is based upon populations of empty tests in the sediments. The present study concerns the ecology of the living organisms.

Planktonic Foraminifera were examined from over 700 plankton tows taken at more than 400 stations in the North and equatorial Pacific Ocean. Twenty-seven species were identified and then frequencies were determined.

Most specimens occur in the upper 100 meters of water. The species appear to be randomly distributed throughout the upper levels with no indication of layering of the abundant species.

The planktonic Foraminifera in the North and equatorial Pacific can be grouped into four faunas: a cold-water fauna, a transition fauna, and two warm-water faunas. The regions represented by them appear to be differentiated by characteristic temperature and salinity values. The cold-water fauna is limited to the area occupied by the subarctic water mass while the warm-water fauna is found throughout the region occupied by the equatorial and central water masses.

The abundance of living planktonic Foraminifera varies in

the different regions. Highest populations per unit volume of water occur in the subarctic water and at limited localities in the equatorial region. Lowest concentrations are found in the central oceanic areas. Abundance of planktonic Foraminifera may be controlled by variations in distribution of inorganic phosphate.

The distributions of most of the living species agree essentially with the distributions of their empty tests in the bottom sediments. Certain thin-walled species that are common in the plankton, however, are rare in the bottom sediments. Their rarity is attributed to solution and/or breakage.

The large size and probable high reproductive rate of tropical specimens make the equatorial region an area of rapid production of calcium carbonate. The very high standing crops in the subarctic region are in marked contrast with the relatively low calcium carbonate content of the underlying sediments. The small size and probable slow rate of reproduction of specimens are suggested as being partly responsible for the low rate of supply of calcium carbonate to the sediments in the subarctic region.

INTRODUCTION

Planktonic Foraminifera are important constituents of the plankton and are major contributors to extensive calcareous deposits covering the ocean floor. They are known to inhabit surface waters of all the oceans from the tropics to the polar seas. After death their calcareous skeletons fall to the ocean floor where they become part of the sediment. Globigerina ooze is composed principally of the remains of planktonic Foraminifera, and covers approximately 35 per cent of the sea floor (Kuenen, 1950). Murray (1897) has estimated that nine-tenths of all calcium carbonate found in Recent sediments at depths greater than 200 meters is composed of the tests of planktonic Foraminifera.

It is necessary to understand the ecology of living planktonic Foraminifera to interpret their distributions in modern and ancient sediments. Such knowledge also is necessary for interpretations of sequences in deep-sea cores. The purposes of the present study are: (1) to determine the species of living planktonic Foraminifera which occur in the North and equatorial Pacific, (2) to describe the distribution and abundance of each species, and (3) to relate the distribution and abundance of the species to known environmental factors.

ACKNOWLEDGMENTS

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SUMMARY OF PREVIOUS WORK

The first specimens of planktonic Foraminifera were described by d'Orbigny (1826) from empty shells found on the beach at Rimini, Italy. The pelagic nature of these specimens was not recognized at that time and it was not until later that they were discovered to be planktonic organisms.

In 1853 Ehrenberg and Baily independently examined the first meager sediment samples from the deep ocean. Both men recognized the foraminiferal nature of the material but came to opposite conclusions as to the actual environment of the living organisms. Ehrenberg believed that their habitat was the ocean floor while Baily thought that they were planktonic when living and that it was only after death that their empty tests settled to the bottom. In a letter to the first director of the U. S. Hydrographic Office (Maury, 1859), Baily gives evidence of a modern approach when he states, "I hope you will induce as many as possible to collect soundings with Brook's Lead in all parts of the world, so that we can map out the animalculae as you have the whales."

M'Donald (<u>in</u> Huxley, 1858) and Owen (1868) were the first to report the capture of planktonic Foraminifera by the use of plankton nets but their work was largely ignored by the great scientists of the day. Even as late as the time of the CHALLENGER Expedition (1873-1876) all of the naturalists aboard believed the Globigerinidae to live on the bottom in deep water. Murray

(1897) has given a very lucid account and relates how on board the CHALLENGER he finally proved them to be pelagic by the use of plankton nets. On several occasions he was able to dip up single specimens and to examine their life activities microscopically. On the basis of the CHALLENGER material, Murray (1897) showed that instead of having a random distribution the various planktonic species were distributed according to the temperature of the water and that the number of species decreased from the tropics toward the poles. Brady (1884) described and illustrated all of the planktonic species of Foraminifera collected during the CHALLENGER Expedition in the North and South Atlantic, Indian, Antarctic, and North and South Pacific Oceans. This great work is predominantly taxonomic in nature but also contains information concerning distribution.

Rhumbler (1900) described the planktonic Foraminifera taken by the DEUTSCHEN PLANKTON-EXPEDITION. Besides descriptions of the planktonic species from the Atlantic, he discussed their cytology and life activities. Rhumbler (1911) remains the best source of biological and morphological information on planktonic Foraminifera.

Philippi (1910) reported planktonic Foraminifera in 105 sediment samples taken during the DEUTSCHE SUDPOLAR EXPEDITION from the South Atlantic, Indian, and Antarctic Oceans, extending from the equator to 66° 42'S latitude. This work is noteworthy in being the first record of the use of planktonic Foraminifera for climatic interpretation. The Foraminifera found in 37 plankton samples taken during the expedition were described by Wiesner (1931).

Schott (1935) correlated the distribution of living specimens from plankton tows in the Atlantic with the distribution of their tests in the sediments below. He showed that certain species had restricted distributions that could be explained on the basis of environmental factors and gathered the first information on the vertical distribution of the planktonic Foraminifera.

Le Calvez (1936) described reproduction in a planktonic foraminifer, Orbulina universa. He also studied a hemi-planktonic species, Tretomphalus bulloides, whose complete life cycle has since been described by Myers (1943).

Phleger (1945) pointed out the need for additional knowledge of the ecology of planktonic Foraminifera from plankton tows and included data from 14 plankton samples taken from different depths in the Atlantic. Phleger (1951) also reported on information derived from 93 quantitative plankton samples taken in the Gulf of Mexico from the surface to 2,000 meters. Phleger, Parker and Peirson (1953) in their work on North Atlantic Foraminifera from bottom sediments considered surface temperature to be of importance in the ecology of the planktonic Foraminifera.

Previous work in the Pacific Ocean

Previous plankton studies. Work on foraminiferal ecology in the North Pacific has lagged behind such work in the Atlantic.

Most of the papers include descriptions of bottom specimens dredged near oceanic islands but give little pertinent information in the study of environmental relationships.

The first systematic sampling of living planktonic Foraminifera in the Pacific was carried out by the CHALLENGER in 1874. Forty-five plankton samples, scattered throughout the North and South Pacific were analyzed and reported by Brady (1884). Additional information and shipboard observations concerning these samples are given by Murray (1895). Agassiz (1902) reported (but did not identify) the planktonic Foraminifera from net tows during the voyage of the ALBATROSS (1899-1900) to the tropical Pacific. Three plankton samples from near New Zealand were analyzed for planktonic Foraminifera by Heron-Allen and Earland (1922).

Recently, interest in the ecology of planktonic organisms has led to the systematic collection of thousands of plankton samples by many agencies throughout the world. The Pacific Oceanic Fisheries Investigation (POFI) based at Hawaii have taken many samples in the equatorial Pacific in the period from 1950 to the present. In the early work of this organization various groups (including Foraminifera) were analyzed separately. The reports of King and Demond (1953), of Hida and King (1955), and of King and Hida (1957) furnish extensive information on the variations in abundance of Foraminifera in the equatorial Pacific although no information is given concerning the distribution of species.

<u>Previous studies of sediment samples</u>. Some information concerning the distribution of planktonic Foraminifera in the Pacific has been obtained by study of their empty tests in the sediments. D'Orbigny (1839) recorded the first planktonic species from bottom samples off the west coast of South America, but it was the CHALLENGER voyage through the Pacific in 1874 that marked the beginning of knowledge of the bottom sediments of this region. Brady (1884) and Murray (1895) listed the planktonic Foraminifera from these samples.

The occurrences of planktonic Foraminifera were reported by Picaglia (1893) from three stations of the VETTOR PISANI in the North and South Pacific, by Goes (1896) from dredgings between the Galapagos and the coasts of Mexico and Central America, by Flint (1899) in dredgings from one station in the South Pacific and five in the North Pacific, by Flint (1905) from the dredgings of U. S. S. NERO for several traverses across the Pacific, by Bagg (1908) from 19 ALBATROSS stations near the Hawaiian Islands and by Chapman (1910) from deep water soundings taken about Funafuti Atoll in the South Pacific. In Cushman's (1910-1917, 1921) work on the Foraminifera of the bottom sediments of the North Pacific and from the Philippine and adjacent seas more than 1600 samples were examined. A few additional samples were reported by Cushman (1924, 1925) from near Samoa and other islands of the tropical Central Pacific near Hawaii. Cushman (1927) recorded planktonic Foraminifera from 105 stations off the west coast of America. During the next decade relatively few samples were taken. Some planktonic Foraminifera were listed by Hanna and Church (1928) from one station off San Francisco, by Cushman and Wickenden (1929) from one nearshore station at the Juan Fernandez Island, Chile, by Cushman and Kellett (1929) from shore collections along the west coast of South America from Chile to Ecuador and by Cushman and Moyer (1930) in samples from the Catalina Channel, California. The planktonic Foraminifera were described by Revelle (1944) in 24 sediment samples from Cruise VII of the CARNEGIE in the North and South Pacific, by Butcher (1951) from 71 stations off San Diego, California, by Hamilton (1953) from Cape Johnson Guyot in the mid-Pacific west of Hawaii, by Cushman, Todd and Post (1954) from numerous stations in the lagoons and on the outer slopes of the Marshall Islands, and by Asano (1957) from the continental shelf bordering Japan.

THE LIVING ORGANISM

Very little is known of the biology of planktonic Foraminifera. The first microscopic observations of living planktonic Foraminifera were reported by Stuart (1866). He described pseudopodial movement along the spines of Orbulina universa (erroneously described as a radiolarian, Coscinosphaera coliosa).

The calcareous test of a living planktonic foraminifer is covered by a layer of protoplasm that completely envelopes the test and flows along the tenuous spines that occur in most species. In this way the protoplasm is extended out from the test as a living web serving to entrap floating organisms as food. Rhumbler (1900) reported that copepods furnish the major food supply of Globigerina and that diatoms and radiolarians are most important for the diet of Globorotalia. Gas bubbles and oil globules are found throughout the frothy protoplasm in many species. In radiolarians, alterations in the oil content of the protoplasm are believed to be partly responsible for ascending and descending movements. This may also be true for the closely related Foraminifera. Rhumbler (1900) reported zooxanthellae from the protoplasm of the Globigerinidae (but not the Globorotalidae). The presence of these symbiotic algae in many species suggests that excessive oxygen production by these organisms may result in gas bubbles that will lower the specific gravity of the Foraminifera and cause a rise toward the surface. These symbiotic algae are so numerous that they impart a yellow-orange color to the protoplasm. A greenish color in the protoplasm is occasionally observed in Foraminifera from plankton samples. This may be due to the presence of symbiotic zoochlorellae. Brilliant red protoplasm has been described by Murray (1895) and Agassiz (1902).

The nature and extent of the coloration may provide clues as to the physiological state of the organism and its reaction to the environment. Jepps (1956, p. 76) described the loss of color in Polystomella (a benthic species) immediately before reproduction. The fading of the normal yellow color is due, in this species, to the loss of brownish xanthosomes and also to some alteration in the chromatophores themselves.

The zooxanthellae may contribute to the food supply of the Foraminifera. Brandt (1885) has reported that starch passes from living zooxanthellae into the protoplasm of colonial radiolarians but Yonge (1934) thinks this should be reinvestigated. If the contained zooxanthellae should contribute any nourishment, this may be important in enabling the Foraminifera to populate the open seas where phytoplankton is rare. Hardy (1936) suggests that forms containing symbiotic algae may not be as dependent upon phytoplankton or other forms of nourishment as had been thought and in themselves may be responsible for a fraction of the open ocean productivity.

The reproductive behavior of planktonic Foraminifera is not well known. Various authors (Hyman, 1950; Schmid , 1934; Le Calvez, 1936) believe microspheric (asexual) and megalospheric (sexual) stages to exist. Such an alternation of generations is known for benthonic Foraminifera but no definite proof of this has ever been shown for planktonic species. Hofker (1956) and Cosijn (1942) believe that only asexual reproduction occurs. In the absence of an adequate study of the life history in laboratory cultures the only way to determine the sequence of events in the life of these organisms is an indirect one. By measuring the proloculus and counting the number of nuclei in stained specimens an idea often can be obtained of the position of the individual in its life cycle. Le Calvez (1938) and others have shown that the size of the proloculus may be misleading, however, and that the only safe procedure is to count the number of nuclei in properly preserved specimens. Rhumbler (1900) reports finding only one nucleus in Globigerina, Orbulina, Hastigerina, and Globorotalia. Hertwig (in Doflein, 1929) and Le Calvez (1936) have studied reproduction in Orbulina universa. In both instances only one nucleus was observed. By analogy from what is known of reproduction in benthonic Foraminifera, the above reports suggest the sexual generation. Le Calvez (1936) has shown in Orbulina universa that the familiar spherical individual found in the plankton gives rise, in the course of its development, to flagellated gametes. The fate of these gametes, however, is not known although Le Calvez (op. cit., p. 129) believes that they may develop into "the little globigerinid individuals always caught upon the bottom (i.e., the small bottom species of Brady, 1884)."

Tretomphalus bulloides is a species having a long bottom-living stage and a planktonic stage of short duration (Myers, 1943). The benthonic stage consists of both an asexual and sexual phase. In the course of time the megalospheric individual destined to give rise to gametes develops a large spherical float chamber and rises to the water surface. Here it releases clouds of gametes which then copulate and sink to the bottom to give rise to the succeeding asexual generation. Such a dependence upon a benthonic stage, although conceivable for oceanic forms, is not probable since their typical habitat is on the high seas where the depths are very great. The long time period required for ascent and descent, as well as the great environmental changes through which an organism would have to pass, are further reasons why a bottom-living phase is unlikely.

METHODS OF STUDY

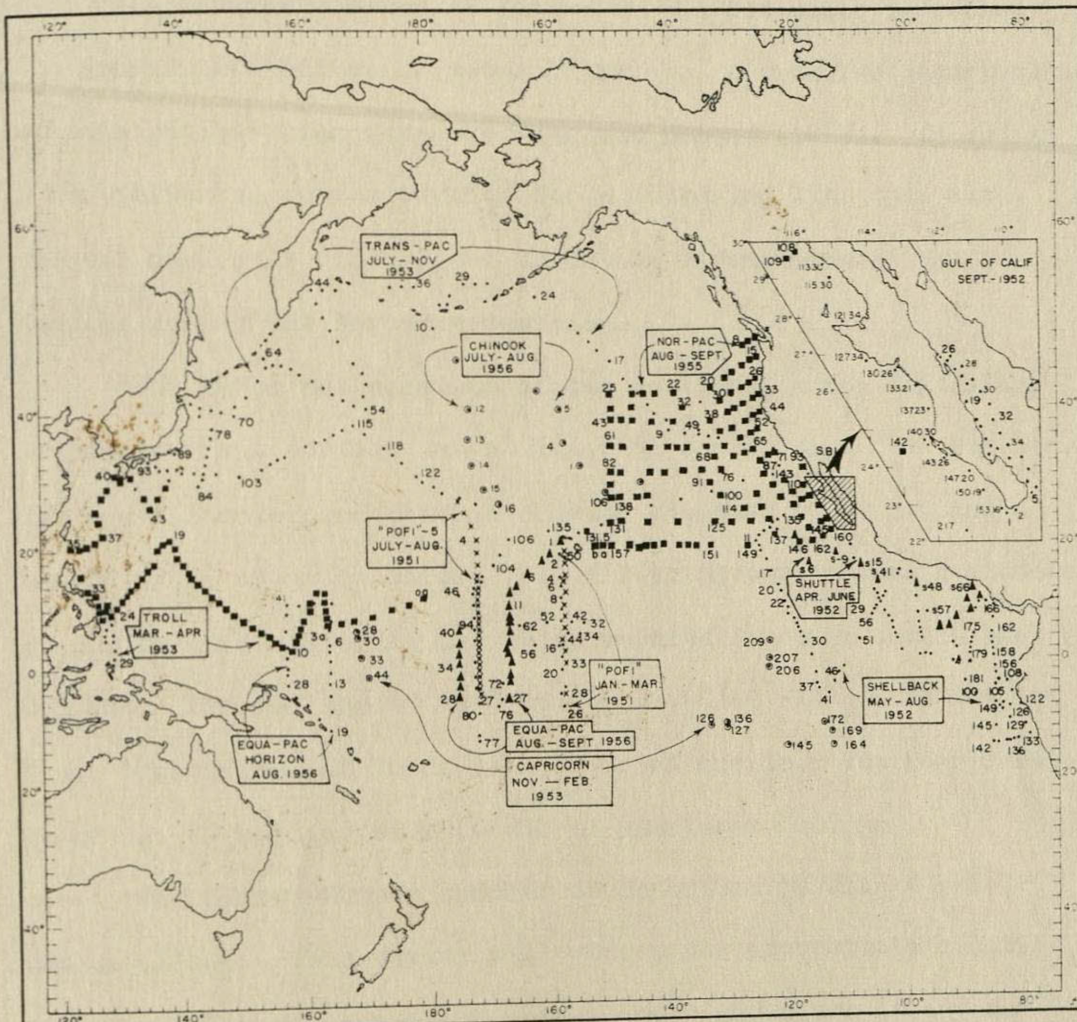
Field methods

The materials studied were obtained from more than 700 plankton samples taken during expeditions of the Scripps Institution of Oceanography, the U. S. Fish and Wildlife Service, the Pacific Oceanic Fisheries Investigation (POFI), and the U. S. Navy Electronics Laboratory. The cruises and the station locations are shown in figure 1. Positions and additional station data are given in table 1.

Detailed observations of temperature and salinity were made at different depths at most of the stations. Oxygen and inorganic phosphate concentrations were obtained at many localities. Charts of the available surface temperatures, salinities, phosphate concentration and total plankton volumes from these stations are included in a later section. More complete data covering the expeditions of the Scripps Institution of Oceanography are on file at that institution. Some physical data have been published (Equapac Exped., S.I.O. Ref. 57-25; Norpac, S.I.O. Ref. 56-4; Wooster and Cromwell, in press). Hydrographic data collected during POFI cruises 5 and 8 have been reported by Cromwell (1954).

Three different types of plankton nets were used for sampling: the standard meter net, the 17 cm. truncated net, and the Clarke-Bumpus sampler. The meter net has been routinely used by Scripps expeditions and by the POFI program in the Pacific. This net has a mouth diameter of 1 meter and a length of

Figure 1. Locations of stations.



TRANS-PAC
JULY-NOV
1953
CHINOOK
JULY-AUG
1956
NOR-PAC
AUG-SEPT
1955
GULF OF CALIF
SEPT-1952
"POFI"-5
JULY-AUG
1951
TROLL
MAR.-APR.
1953
SHUTTLE
APR. JUNE
1952
"POFI"
JAN-MAR
1951
EQUA-PAC
AUG.-SEPT 1956
EQUA-PAC
HORIZON
AUG. 1956
CAPRICORN
NOV.-FEB.
1953
SHELLBACK
MAY-AUG
1952

approximately 5 meters. The front and middle sections are made of no. 30xxx silk grit gauze with apertures of 0.65 mm when new but which shrink to about 0.55 mm after use. The rear section and cod end are of no. 56xxx silk grit gauze with apertures of 0.31 mm. A current meter is fitted in the net mouth to record the approximate amount of water filtered. A detailed description of this net has been given by King and Demond (1953). By adding a non-filtering canvas section for a suckering line this same net was used as a closing net to obtain uncontaminated deep samples during the Norpac expedition.

The 17 cm net consists of two sections, a non-filtering, truncated front portion and a filtering cone-shaped rear section. The non-filtering section has a mouth diameter of 17 cm. and a length of 15 cm. The 46 cm. long filtering portion has a diameter at the forward end of 24 cm. which becomes narrower toward the cod end. The cod end is an 8-ounce glass jar with a diameter of 5 cm. The truncated front section is of muslin. The rear section is of no. 20 bolting silk (width of apertures 0.07 mm).

The Clarke-Bumpus sampler is described by Clarke and Bumpus (1940). This device will record the approximate quantity of water filtered and can be made to open and close at any desired depth. In the present work it was fitted with nets of either no. 8 or no. 20 bolting silk with apertures of 0.14 mm. and 0.07 mm. respectively.

The oblique tows, with either the meter net or Clarke-Bumpus sampler were made by lowering the net slowly at uniform speed and when the required depth was reached it was raised at a uniform rate of approximately 5 meters per minute. Throughout the period of the haul the time and wire angle were noted at intervals. The depth and duration of tow at each depth were calculated by assuming that the towing wire describes a straight line. Approximately equal amounts of time were spent at all depths from the surface to the greatest depth sampled.

Horizontal tows for study of vertical distribution were made with the same equipment but the net was opened by messenger only at predetermined depths. The vertical hauls with the 17 cm. net were made while the boat was stopped. The net, with a weighted cod end, was attached to a light line and lowered slowly by hand to the maximum depth and then retrieved at approximately one-half meter per second. After the tows the plankton clinging to the upper part of the net was washed into the cod end and transferred to a sample jar. Neutralized formalin was added to make a 5 to 10 per cent solution.

It is essential that neutralized formalin be used to preserve the samples. In the present study many samples could not be used because of the dissolution of the foraminiferal tests. It is known that formaldehyde is oxidized to formic acid with the subsequent solution of any calcium carbonate that may be present. The addition of inorganic carbonates (Na_2CO_3, $MgCO_3$, $NaHCO_3$) to the sample will help in counteracting this acidity but the CO_2 set free in neutralizing the acid remains in solution and eventually the pH will tend to fall. Buffers such as Na_2CO_3 and $MgCO_3$

should be used with caution since when present in excess they cause excessively high pH values (pH >10). This high pH, besides damaging the protoplasm, promotes the polymerization of the formaldehyde to waxy compounds (paraldehydes) which settle out on the tests of the Foraminifera making identification difficult. Atkins (1922) recommends the addition of $NaBO_2$ (Borax) as an answer to these difficulties. Such neutralized formalin has been routinely used by the Scripps Institution and the U. S. Fish and Wildlife Service for many years. Unfortunately solution has still occurred. Samples containing large quantities of zooplankton (especially Crustacea) show a much greater tendency to become acid than do those samples with small amounts of such material. A saturated solution of the organic buffer, Hexamethylenetetranine (Hexamine), has been used successfully as a buffer for some time, but its effectiveness over a long period is not known.

Laboratory methods

The Rose Bengal staining technique described by Walton (1952) was used in the early stages of the work to distinguish living from dead specimens. Staining procedures were used in the analysis of samples for vertical distribution studies but the routine staining of surface samples from the upper water layers was discontinued when it was observed that most of the Foraminifera contained protoplasm. The use of stains in analyzing plankton samples is time-consuming, makes the identification more difficult, and often decreases the usefulness of the sample for other purposes.

Furthermore, the living specimens can often be distinguished from the empty tests by the color of their unstained protoplasm alone.

It is possible that some empty tests have been included in the counts of each species. The error caused by these few extra tests in samples from the upper layers is believed to be insignificant, particularly in view of the much larger errors involved in other phases of plankton sampling.

The entire sample was poured into a gridded plastic counting tray. Care was taken to insure the removal of all material to the tray since the Foraminifera and pteropods are heavier than the other plankton and have a tendency to remain behind in the storage jar. The plankton was distributed as evenly as possible in the tray and specimens of each species of Foraminifera were counted. Individuals of less than 140 μ were not identified or included in the total population counts because of the probability of error in the identification of such small forms. These specimens were counted, however, and are included in the tables as "Globigerinids $<$ 140 μ." An exception to this occurs in the counts of Globigerina minuta where specimens smaller than 140 μ are included.

Several specimens of each species were picked from each sample by pipette and retained in a small vial for reference. Most of the samplescontaining less than an estimated 200-300 specimens were completely examined. In some samples certain species were so abundant that it was concluded that time would be wasted in counting all of the specimens. A fraction of such samples was examined for the abundant species and these were then omitted from the analysis of the remaining fraction. It was found that much of the other plankton contributing to the difficulty of analysis could be removed by floating off the lighter components from the denser pteropods, Foraminifera, etc. This was accomplished by spreading out the material in the tray and decanting the lighter organisms into a beaker. Caution should be exercised in using this method to avoid losing the Foraminifera. An efficient separation could be made in tropical samples where the tests were large and heavy but in the samples containing smaller specimens (usually spinous) the method could not be used since many tests were removed along with the other plankton.

The total population of all species in the sample was determined. Tables 2 to 7 list the occurrence of each species in per cent of the total population. The distribution of each species is charted in figures 8 to 34.

Effect of different sampling methods on the composition of the Foraminifera populations

The only way obvious to the writer to sample the entire Foraminifera population is to analyze all of the specimens in a given volume of water. This was done by Hentschel (1934) for *Globigerina*. In the surface water from many localities in the Atlantic he found that the number varied from 0 to 50 specimens in a liter sample. The individuals, however, from such small samples were mostly juveniles which were difficult to identify. To obtain a sample containing sufficient specimens for accurate species identification would require the examination of much larger quantities of water than Hentschel used. The difficulties involved in handling and analyzing large samples are so great that fine meshed nets have almost always been used for routine sampling. Presumably the loss of some of the very smallest individuals still occurs but since identification of these is almost impossible this loss appears to be of little taxonomic importance.

It is believed that the 17 cm. net and the Clarke-Bumpus samplers with fine-mesh nets sample the smaller specimens adequately, since the aperture of the netting used is fine enough to prevent all but the smallest stages to pass through, but the smaller volume of water filtered (1-4 M^3), as compared with approximately 1,000 M^3 for the meter net, results in the inadequate sampling of rare species and larger forms. A further disadvantage of fine-mesh nets is that they retain large quantities of phytoplankton.

The meter net filters large quantities of water (approximately 1,000 M^3 for a 30-minute tow) and obtains large numbers of easily identifiable specimens with very few phytoplankton. Since the effective aperture of the front section of the net is relatively large (0.55 mm.), however, many smaller individuals of Foraminifera may pass through and will not be represented proportionately in the sample. Many specimens of smaller size are nevertheless still found in the sample, probably because they are retained by the finer section of the net and also because of the spinous nature of the specimens and some decrease of mesh size due to clogging.

The use of samples obtained with three different nets and three different mesh sizes in the present study introduces problems in interpretation of results. Comparisons between the total number of specimens of Foraminifera retained by nets of the different mesh sizes (0.55 mm. and 0.14 mm.) taken during the Transpac expedition shows that for the same depths and volume of water filtered the tow with the finer mesh caught from 9 to 370 times as many specimens as that made with the coarser net. Similar results are indicated by data presented by King and Hida (1957). In their work a comparison was made of the effect of two different mesh sizes on the plankton volume, the number of zooplankters per unit of water strained, and the percentage composition of the catch. A pair of consecutive hauls, the first with a net of 0.31 mm. apertures and the second with a net having apertures of 0.55 mm., was made at three stations in the equatorial region. King and Hida found that the average plankton volume obtained by the finer mesh nets for the same volume of water filtered was from 1-1/4 to 1-3/4 times that of the coarser mesh nets. The fine-mesh nets retained three to five times as many organisms as the coarse-mesh nets, the greatest difference being in the larger numbers of Foraminifera and copepods retained in the fine-mesh nets.

Variations due to patchiness

In some areas the drawing of closely spaced isopleths has not been possible because of extreme fluctuations in concentrations of Foraminifera. Certain other regions, however, show generally consistent values over wide areas. The patchiness of plankton has been noted by many workers and contributes an unknown source of error in quantitative sampling. The filtering of a large volume of water over long horizontal distances may minimize variations due to uneven distributions.

Not so well known is the fact that the vertical distribution of Foraminifera and the depth of the water filtered by the net also will influence the quantitative results. For example, an oblique tow to 200 meters samples the upper 50 meters only 25 per cent of the time. If the bulk of the population lies in the surface layers of 0 to 50 meter depth, such a tow will indicate a smaller number of specimens per unit volume than actually occurs at the level of maximum concentration.

Certain irregularities have been introduced in this study by considering all stations equally, regardless of season or time of day. More detailed studies of seasonal and diurnal variations will be necessary to understand fully the variations caused by these factors.

The reliability of single plankton tows has been demonstrated by various workers. Winsor and Clarke (1940) in a statistical study of variation in the catch of plankton nets showed a coefficient of variation of 31 per cent for oblique hauls, 53 per cent for vertical hauls, and 124 per cent for horizontal hauls. Silliman (1946), in an analysis of variability in the number of sardine eggs in a set of paired hauls, found that the number of eggs in one haul could not be considered significantly different (at the level $P = 0.05$) from the number in the other unless it was about half or double.

DESCRIPTION OF THE ENVIRONMENT

General features

The area of investigation includes the North Pacific and a part of the South Pacific extending to approximately 16° S latitude. The oceanography of this large area is complex. The distributions of sea surface temperature (fig. 2) are primarily related to the greater heating of the water in the tropics than in higher latitudes. Maximum and minimum monthly mean sea surface temperatures are shown in figure 3. The salinity values (fig. 4) are dependent upon the relation between the processes of evaporation and precipitation with the result that the maximum salinities are found not in the equatorial regions but in the sub-tropical belt. Nevertheless there is a general correlation between surface temperatures and salinities so that high temperatures are usually associated with high salinities and low temperatures with low salinities. The greatest horizontal change in these variables occurs in the North Pacific at the Arctic convergence (or polar front) near the 40° parallel. The steepest gradients are found in the western North Pacific off Japan, whereas the eastern North Pacific is characterized by less abrupt changes.

The prevailing winds and the density structure of the various water masses have resulted in the series of clockwise circulations for the North Pacific as shown in figure 5.

The North and South Equatorial Currents flow westward between the equator and latitudes 20° to 25° N. and sandwiched

Figure 2. Distribution of sea surface temperatures (^{o}C). North Pacific values observed simultaneously with the plankton samples; August values for the South Pacific from Sverdrup, Johnson and Fleming, 1942, Chart III.

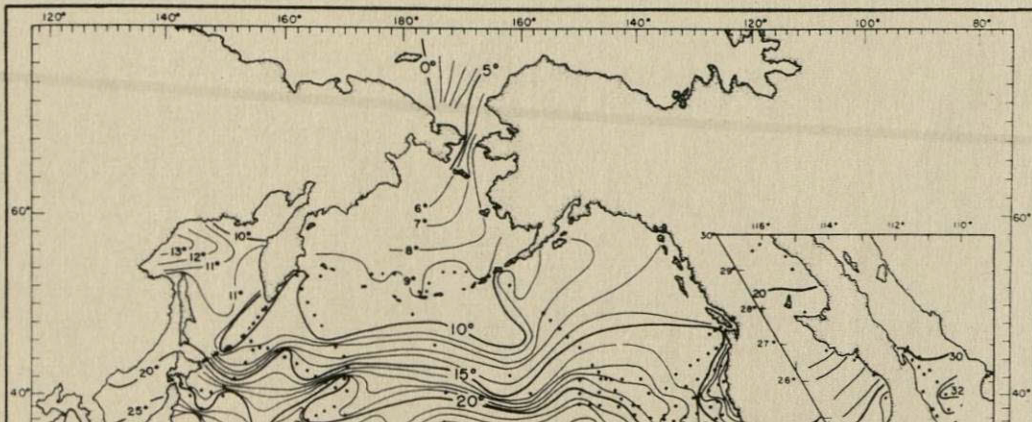

120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°
0°
5°
6°
7°
8°
9°
10°
11°
12°
13°
15°
20°
25°
26°
27°
28°
29°
116°
114°
112°
110°
30
32
22°
23°
24°
25
26°
27°
28°

Figure 3. Maximum and minimum monthly mean sea surface temperatures (°C). Solid line: February; dashed line: August. (From G. Schott, 1935)

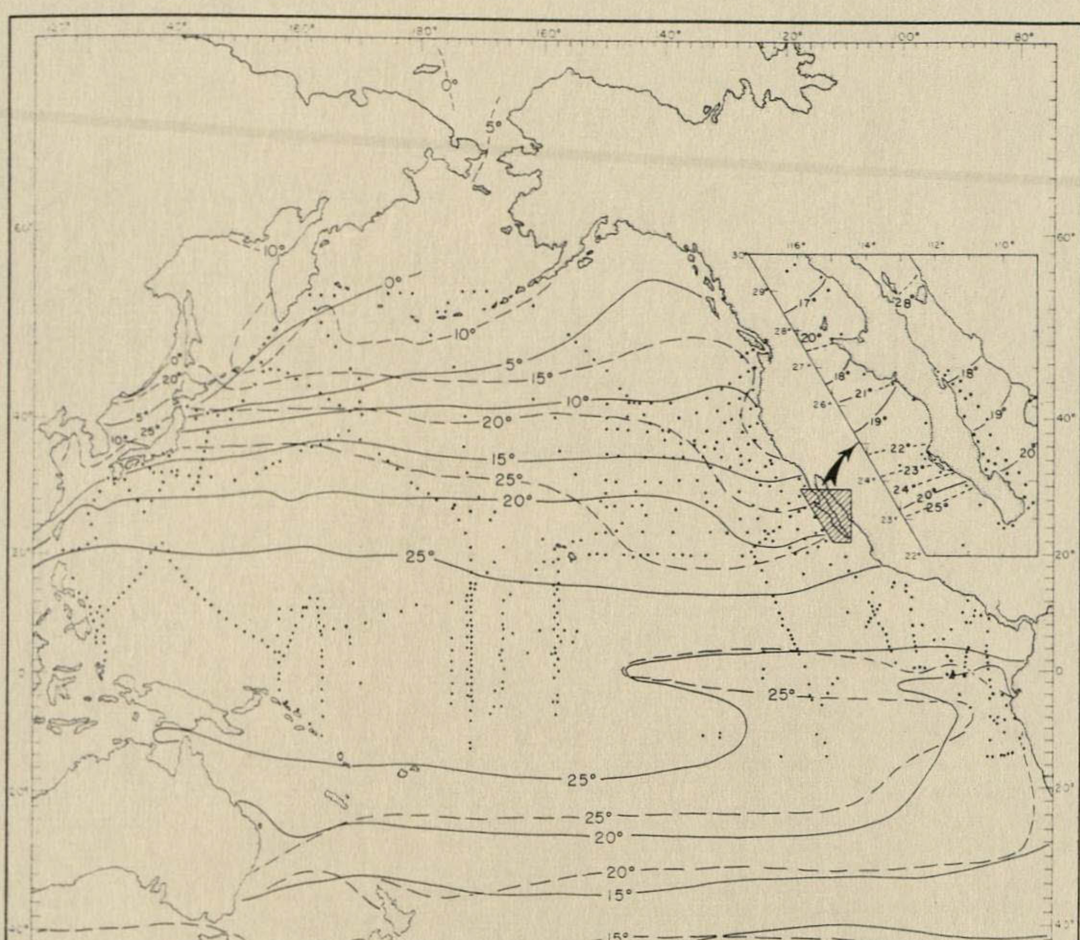
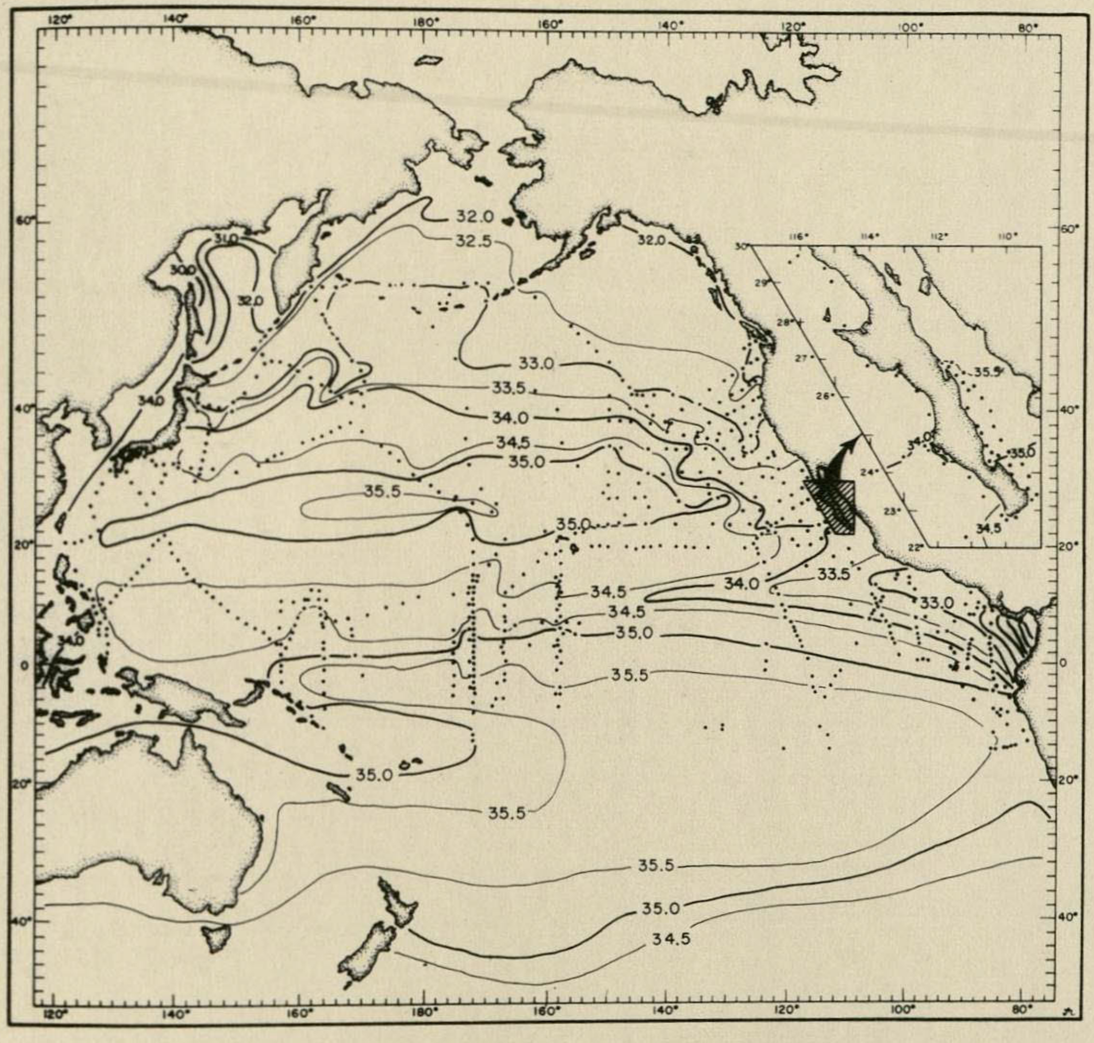

0°
5°
10°
0°
10°
5°
15°
10°
20°
15°
25°
20°
25°
25°
25°
25°
20°
20°
15°
15°
10°

Figure 4. Distribution of sea surface salinities ($^{o}/oo$). North Pacific values taken simultaneously with the plankton samples; summer values for the South Pacific from Sverdrup, Johnson and Fleming, 1942, Chart VI.



120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°
32.0
32.5
31.0
30.0
32.0
34.0
33.0
33.5
34.0
34.5
35.0
35.5
35.0
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34.5
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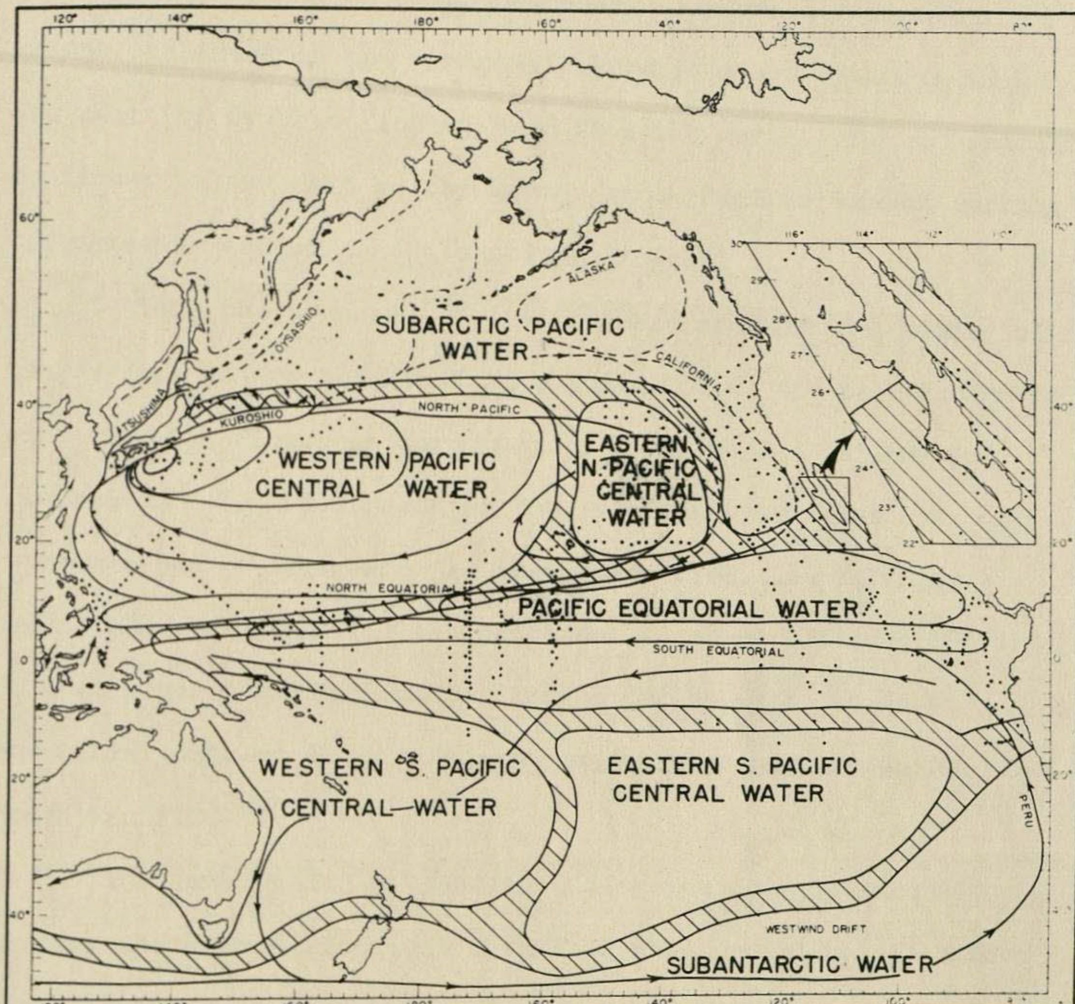
34.5
116°
114°
112°
110°
30°
29°
28°
27°
26°
24°
23°
22°
35.5
34.0
35.0
34.5

Figure 5. Approximate boundaries of the upper water masses of the Pacific Ocean together with course of the major ocean currents. (Adapted from Sverdrup, Johnson and Fleming, 1942, figs. 205 and 209A)


SUBARCTIC PACIFIC WATER
OYASHIO
ALASKA
CALIFORNIA
TSUSHIMA
KUROSHIO
NORTH PACIFIC
WESTERN PACIFIC CENTRAL WATER
EASTERN N. PACIFIC CENTRAL WATER
NORTH EQUATORIAL
PACIFIC EQUATORIAL WATER
SOUTH EQUATORIAL
WESTERN S. PACIFIC CENTRAL WATER
EASTERN S. PACIFIC CENTRAL WATER
PERU
WESTWIND DRIFT
SUBANTARCTIC WATER

between (in latitudes 5° to 10° N) is the countercurrent flowing to the east. Near the Philippine Islands the North Equatorial Current divides, part turning north to become the warm Kuroshio. Along the Japan coast at about 35° N latitude the Kuroshio turns seaward and divides into two branches. The smaller northern branch continues to the northeast where it mixes with the cold, low salinity Oyashio flowing down from the north. The main stream continues to the east as the warmer North Pacific Current sending off numerous eddies to the south as it goes.

Along the boundary of the Kuroshio and Oyashio, mixing of the surface waters results in the formation of the cold subarctic current which flows eastward between the Aleutian Islands and latitude 42° N. Upon reaching the American west coast most of the water turns southward, as the broad, cool, low salinity California Current which can be traced to about latitude 25° N. In this region the California Current merges with the North Equatorial Current to complete the major current gyre in the North Pacific.

The combination of density differences due to unequal heating and evaporation at the surface and the action of surface currents have resulted in the formation of large semi-permanent masses of water having certain characteristic properties. These large bodies of water are called water masses and are defined oceanographically on the basis of their temperature and salinity distributions. The characteristic temperature and salinity values reflect to some extent the climate of the source region. As currents move this water from its place of origin, mixing occurs with other waters but the various sources can still be recognized. Water masses undoubtedly have other physical and chemical characteristics that are as yet too subtle for analysis but which may be important for various constituents of the plankton. Figure 5 shows the geographic extent of the upper water masses of this region.

Subarctic North Pacific region

"Subarctic Water" is found north of latitude 45° N where it is characterized at the surface by low temperatures and salinities. North of the Aleutian Islands, the surface temperature varies from near 0° C in the coldest month (February) to about 8° C in the warmest month (August). The temperature-salinity relations of this water mass are shown in figure 6. Surface currents transport large amounts of this water toward the east and south along the west coast of North America. As this water travels from the source region the temperature and salinity increase so that the water gradually loses its subarctic character. The greatest annual temperature range (21° C) occurs at approximately 40° N latitude near Japan. From this maximum value the temperature range decreases toward the northeast and east, to approximately 5° off the coast of North America (latitude 40° N).

The surface phosphate concentration is generally high throughout this region (see fig. 7). Wooster (1953, p. 50) reports

Figure 6. Temperature-salinity relations of the surface water masses of the North Pacific Ocean.

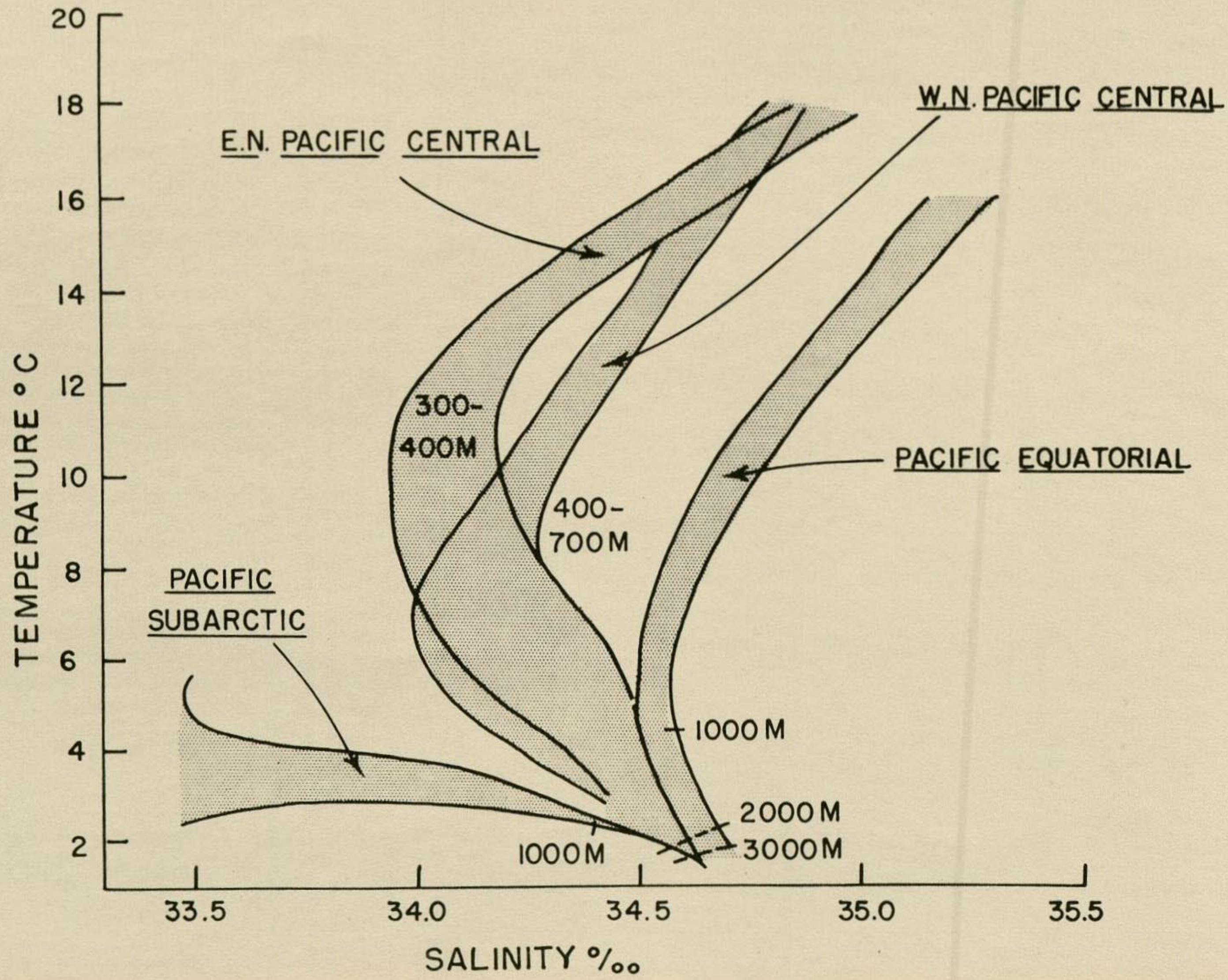
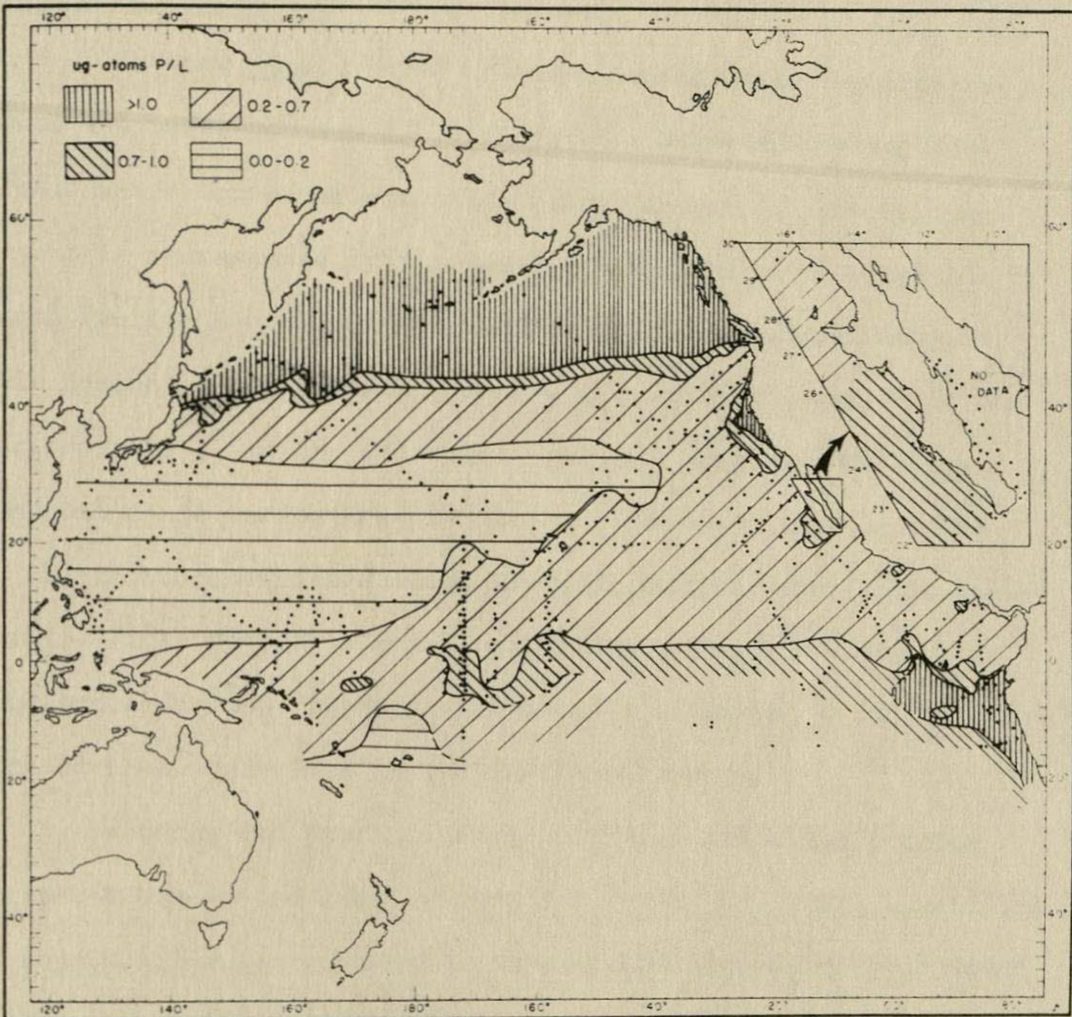

E.N. PACIFIC CENTRAL
W.N. PACIFIC CENTRAL
PACIFIC EQUATORIAL
PACIFIC SUBARCTIC
300-400M
400-700M
1000M
1000M
2000M
3000M
TEMPERATURE °C
20
18
16
14
12
10
8
6
4
2
33.5
34.0
34.5
35.0
35.5
SALINITY ‰

Figure 7. Distribution of inorganic phosphate in the surface layers. Data from various cruises of the Scripps Institution of Oceanography, the Swedish ALBATROSS Expedition, and participating agencies in NORPAC Expedition.


ug-atoms P/L
>1.0
0.2-0.7
0.7-1.0
0.0-0.2
NO DATA

a sharp increase in phosphate concentration just south of the boundary between the Aleutian and North Pacific Currents, and high values throughout the area to the north.

Transition region (California Current)

Sverdrup et al. (1942) limit this region to the area between latitudes 48° and 23° N where the southward-flowing Subarctic water converges with the Equatorial water. The western extent is represented by the boundary of the Subarctic and the North Pacific Central waters. The annual temperature range in this region is not extreme, varying from approximately 7° in the northwest to 3° in the southwest portion. Near the coast the seasonal range varies from 3° along the coast of Washington to 6° at various localities along southern California and Baja California. This region is dominated by the southward, slow-moving California Current, but seasonal changes in the upper layers cause more complex conditions in certain localities.

Sverdrup and Fleming (1941) report a subsurface counter current close to the coast (below 200 M) carrying large quantities of Equatorial water northward. In the fall and winter this water is present at the surface as the Davidson Current, which flows north on the coastal side of the California current at least as far as latitude 48° N. The predominance of northwesterly winds, together with sharp breaks in the coastline, result in the offshore transport of surface water resulting in upwelling of cold subsurface water at various points along the coast. There is some tendency for upwelling throughout the year but the strongest upwelling occurs during spring and early summer. Upwelling returns nutrients into the euphotic zone so that increased phytoplankton and zooplankton production can occur. Wooster (1953) reports relatively high surface phosphate concentrations in this region.

North Pacific Central region

In general, the water masses characteristic of this area are intermediate in properties between the Subarctic and Equatorial water. The eastern portion extending from the longitude of Hawaii to the transitional water of the California Current differs slightly in its temperature-salinity character from the larger western expanse and has been designated as a separate water mass. This Eastern North Pacific Central water is distinguished from the Western North Pacific water by lower salinity values at depths of 300-400 meters. In the center of the Western North Pacific gyral the yearly temperatures vary from a minimum of 23° C to a maximum of 27.5° C. In the Kuroshio, off Japan, the seasonal range is approximately 12°. The annual range decreases from off Japan to the south and east becoming less than 2° near the boundary of the equatorial region and approximately 6° near the boundary of the transition region of the California Current.

Graham and Moberg (1944) reported that the surface phosphate values throughout this region are extremely low, with the low concentrations extending to considerable depths. They associated the low values with the steep density gradients and with the poorly developed current systems, both of which prevent upwelling of phosphate-rich water.

Equatorial Pacific region

This area includes the equatorial warm water belt of the Pacific. The latitudinal extent of this region is greatest in the eastern Pacific; it extends on a wedge toward the west, finally disappearing at the equator north of New Guinea.

In this area a mixed layer extends downward to a zone of rapid transition below which lies the true Equatorial water mass having a very uniform character. The temperature-salinity relationships of this latter distinct water mass are shown in figure 6. The thickness of the mixed layer varies from a depth of 50 meters in the east to deeper than 150 meters in the western Pacific. In the region of the equator this layer is nearer the surface because of upwelling. The annual range of temperature is small over most of this region, the greatest changes occurring south of the Galapagos Islands (5° annual range) and at the zones of upwelling along the equator. Throughout most of the region the seasonal range of temperature varies only 1 or 2° C.

Divergence of the surface water along the equator, particularly in the eastern portion, results in the upwelling of cooler water to the surface, as discussed by Cromwell (1953).

THE SPECIES OF PLANKTONIC FORAMINIFERA

General Statement

Planktonic Foraminifera immersed in sea water present a different appearance than when seen dry. This fact, together with the presence of long thin spines in numerous species and the presence of protoplasm and organic detritus, usually not seen in specimens from the sediment, increases the difficulty of identification. This is particularly true in small juvenile specimens. For these reasons, the identification of specimens with a diameter smaller than 140 µ was not attempted except for the extremely small species, *Globigerinoides* cf. *G. minuta*.

A certain amount of variation exists within each species and different authors have placed varied emphasis on each of the specific characters. In some of the early work there was a lack of attention to details of structure and this has resulted in the lumping together of several distinct forms.

A detailed synonomy and taxonomic discussion of each species has not been attempted here. The synonomies given include the original reference and occasional additional references of special interest. The specimens used by Phleger, Parker and Peirson (1953) in their study of North Atlantic Foraminifera have been examined and their nomenclature has been followed in most cases. Species not listed by them as occurring in the Atlantic are briefly described. Previous records of the distribution of each species in the Pacific Ocean and a brief summary of the information gained through this study are included. The species are listed in alphabetical order.

Candeina nitida d'Orbigny

(Plate 2, figure 19)

Candeina nitida d'Orbigny, 1839, in De la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 108, pl. 2, figs. 27,28.

Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900) and Schott (1935). Brady (1884) records it from three localities in the North Pacific.

Previous reports from Recent sediments in the Pacific

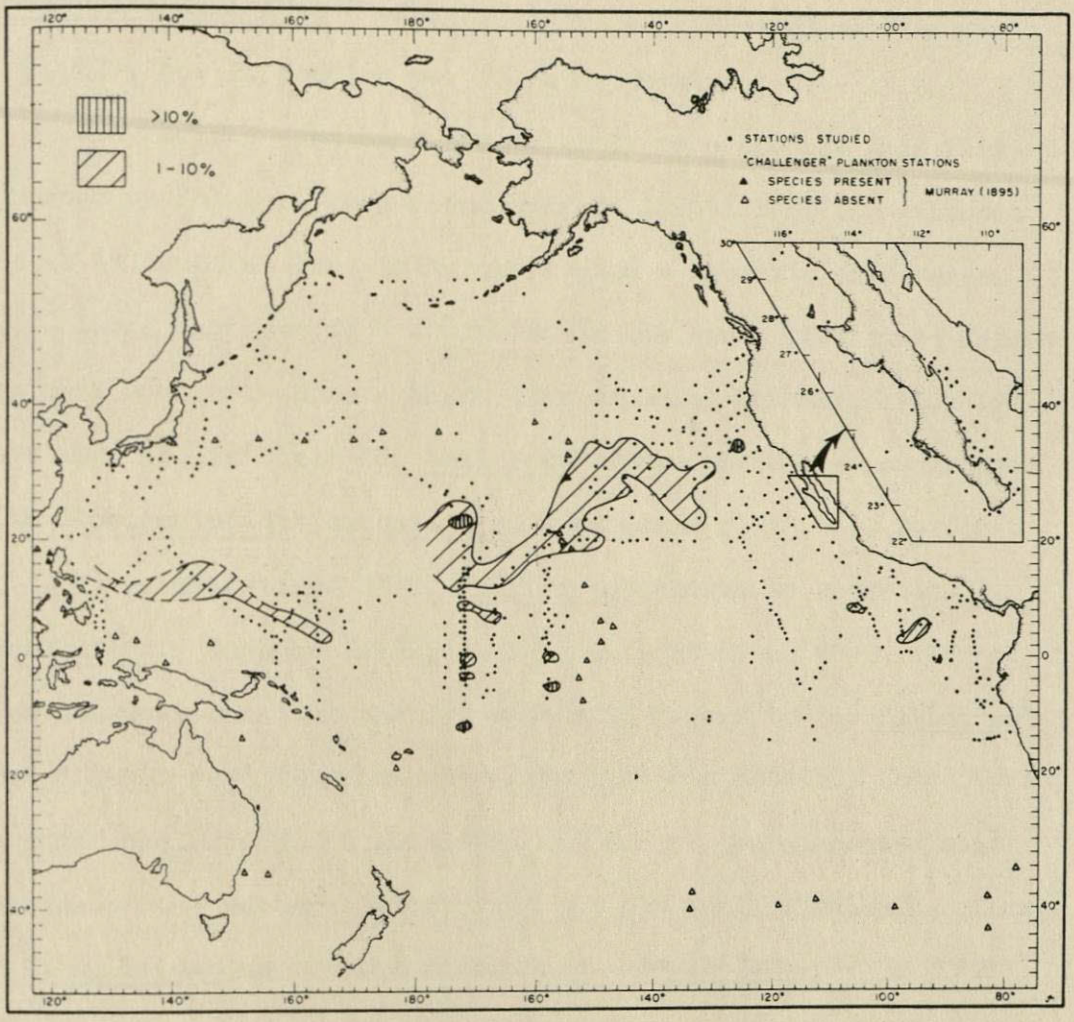
Brady (1884), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921), Hamilton (1953), Cushman, Todd and Post (1954) report this species from the tropical and warm-temperate regions of the Pacific as follows:

Very rare off the Philippines; common at Funafuti and in the Marshall Islands; with frequencies of 2 per cent of the total foraminiferal population west of Hawaii; abundant near Hawaii. In the North Pacific Cushman states that it occurs in many samples but never in any great numbers.

Distribution in the present study

This species (fig. 8) is found in the tropical and warm-temperate regions of the Pacific. Its maximum concentration appears to be near the Hawaiian Islands; patches with lower concentrations occur within the equatorial water from Panama to the

Figure 8. Distribution of *Candeina nitida* d'Orbigny in per cent of total planktonic Foraminifera.



>10%
1-10%
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

Philippines.

Globigerina bulloides d'Orbigny

(Plate 1, figures 1, 2, 3, 4)

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 277, no. 1; Modèles no. 76; and young, no. 17.

The Pacific specimens are slightly more compact than those reported by Phleger, Parker and Peirson (1953) from the Atlantic but it is doubtful that this constitutes a specific difference.

There has been much confusion in the early literature regarding this species. Some authors (for example, Cushman, 1914, 1927) have included in their "G. bulloides" forms which are now grouped with Globigerinoides sacculifera. Cushman's (1914, pl. 2, figs. 7, 8, 9) illustrations of "G. bulloides" appear to represent G. sacculifera. Cushman (1927, p. 171) in a study of Foraminifera from the west coast of America states in regard to "G. bulloides" that "there are a very few specimens that can possibly be referred to this species. It is evidently not one of the characteristic species of the eastern Pacific and the few small specimens referred to G. bulloides may be the young of G. sacculifera, H. B. Brady." Recent workers have shown G. bulloides to be very common in the area studied by Cushman. For example, Butcher (1951) records an average frequency of 14 per cent off San Diego, California. Natland (1933) reports this species as abundant from Catalina Island.

Previous reports from the plankton

This species has been reported from plankton tows by Tizard and Murray (1882), Brady (1884), Rhumbler (1900), Murray (1897), Heron-Allen and Earland (1922), Wiesner (1931), Schott (1935), and Phleger (1945, 1951). In the Pacific Ocean Brady (1884) recorded it at 32 stations. In the equatorial Atlantic Schott (1935) found this species only from depths below 100 meters. He explained this phenomenon as an example of tropical submergence of an epiplanktonic high latitude species into the deep, cold waters of the equatorial region.

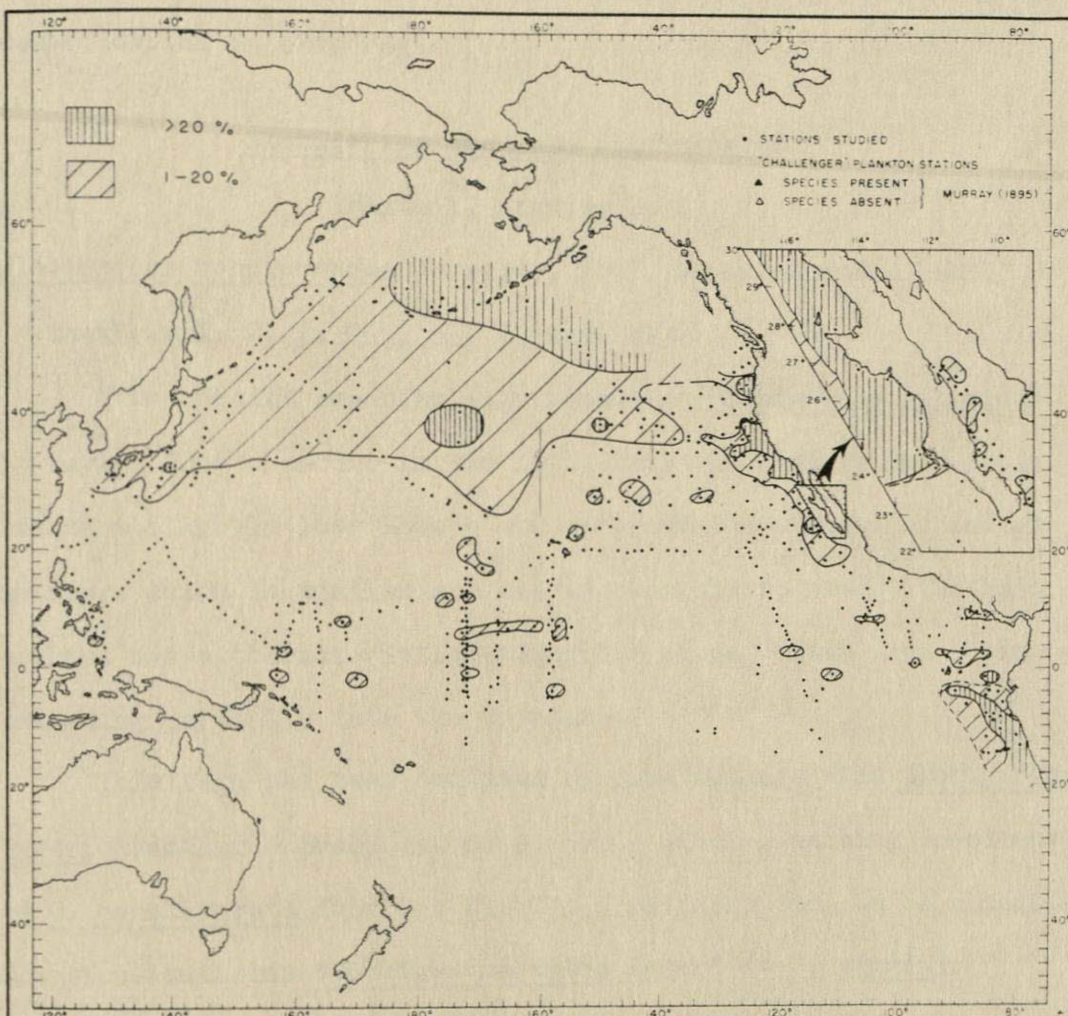
Previous reports from Recent sediments in the Pacific

D'Orbigny (1839), Brady (1884), Goes (1896), Bagg (1908), Flint (1905), Cushman (1914, 1924, 1925, 1927), Hanna and Church (1928), Chapman (1910), Cushman and Kellett (1929), Butcher (1951), Carsola (1952), Natland (1933), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) report this species from widely scattered localities from the tropics to north of the Arctic Circle as follows: common off Japan and the Philippines; in the Marshall Islands and about Funafuti; with a frequency of 3 per cent west of Hawaii; abundant off California with frequencies of 2 to 30 per cent reported at San Diego; common in the sediments of the Beaufort and Chukchi Seas.

Distribution in the present study

This species (fig. 9) has been found at highest frequencies in samples from northern latitudes and also is found occasionally in low frequencies from equatorial waters. It appears to show the closest affinity to the "cold water fauna." In temperate latitudes

Figure 9. Distribution of *Globigerina* *bulloides* d'Orbigny in per cent of total planktonic Foraminifera.



>20 %
1-20 %
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

it occurs throughout the water column from the surface to the greatest depth sampled. The vertical distribution of this form in the equatorial Pacific is not known. Its rare occurrence in oblique hauls from the upper layers suggests that it may live at deeper depths in this region.

Globigerina conglomerata Schwager

(Plate 1, figures 6, 7)

Globigerina conglomerata Schwager, 1866, Novara-Exped., Geol. Theil, vol. 2, p. 255, pl. 7, fig. 113.

This species superficially resembles *Globigerina bulloides* in having four chambers in the last whorl but differs from it in having a slightly less lobate and more massive structure, and an aperture which is smaller and not as smoothly rounded. The last chamber has a characteristic triangular shape, often with a lip extending partially into the aperture.

This form has been confused by some authors with *Globigerina eggeri* Rhumbler. Brady (1884, p. 596), after examining specimens of *G. conglomerata* from Kar Nicobar, considers them to be almost identical with his "*Globigerina dubia* Egger" (= *G. eggeri*). Cushman's 1927 and 1921 records of "*G. conglomerata*" from the west coast of North America and the Philippines are doubtful in view of his confusion of this species with *G. eggeri*.

Previous reports from the plankton

This is the first recorded occurrence of this species from plankton tows in any ocean.

Previous reports from Recent sediments in the Pacific

Cushman, Todd and Post (1954) and Hamilton (1953, as G. cf. venezuelana) record this species from sediments of the equatorial and closely adjacent warm-water regions of the Pacific. Lankford (personal communication) notes that this species is relatively common in samples from the equatorial region, indicating that it may be more widely distributed than previous work would indicate.

Distribution in the present study

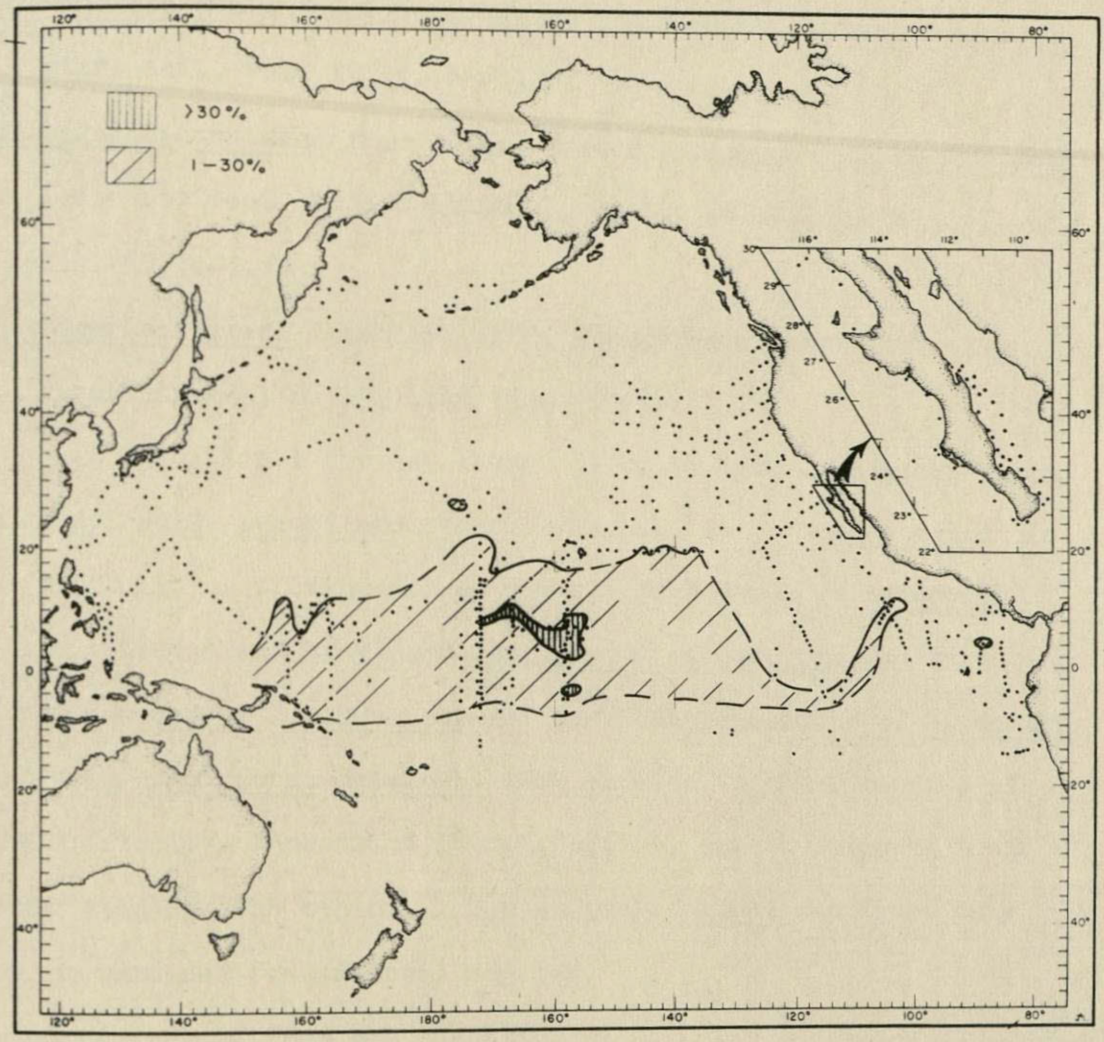
G. conglomerata (fig.10) appears to be closely associated with the equatorial Pacific region. It is strange that it was not found in tows off Japan nor was it reported by Asano (1957) from bottom sediments in that area.

Globigerina digitata Brady

Globigerina digitata Brady, 1879 (Part), Quart. Jour. Micr. Sci. vol. 19, p. 72; 1884, part Rept. Voy. CHALLENGER, Zool., vol. 9, p. 599, pl. 80, figs. 6-10 (not pl. 82, figs. 6, 7)

Brady has included two distinct species in his Globigerina digitata. Parker (in press) has designated the trochoid form as G. digitata and has referred the planispiral form to the genus Globigerinella. Further discussion will be found under Globigerinella sp. Globigerina digitata appears to be rare in the area studied.

Figure 10. Distribution of *Globigerina conglomerata* Schwager in per cent of total planktonic Foraminifera.



>30%
1-30%

Globigerina eggeri Rhumbler

(Plate 1, figures 5, 8, 9, 10)

Globigerina bulloides form No. 3, Owen, 1868, Journ. Linn. Soc., vol. 9, p. 157, pl. V, fig. 9.

Globigerina dubia Brady (not Egger, 1857), 1879, Quart. Journ. micr. sci., vol. 19, n. ser., p. 71.

Globigerina cretacea Brady, 1884 (not d'Orbigny) (= *G. subcretacea* Lominchi) Rept. Voy. CHALLENGER, Zool., vol. 9, p. 596, pl. 82, fig. 10, a-c.

Globigerina eggeri Rhumbler, 1900, Nordische Plankton, pt. 14, Foraminiferen, p. 19, text figs. 20 a-c.

A gradational series appears to exist between typical large, high-spired *G. eggeri* and other forms such as *G. subcretacea*. It is difficult to distinguish in some cases between *G. dutertrei* (Vide, Wiseman and Ovey) and *Globigerina pachyderma*. In this study *G. eggeri*, "*G. subcretacea*" and young specimens of *G. eggeri* and/or *G. pachyderma-dutertrei* were grouped together because of the difficulty of positive identification, particularly of their young stages. The typical large adult *G. eggeri* was found only in the warm and transitional regions.

Previous reports from the plankton

This species has been reported from plankton tows by Owen (1868), Brady (1884), Murray (1897), Rhumbler (1900), Schott (1935), and Phleger (1951). Brady (1884) records this form from 14 stations in the Pacific.

Previous reports from Recent sediments in the Pacific

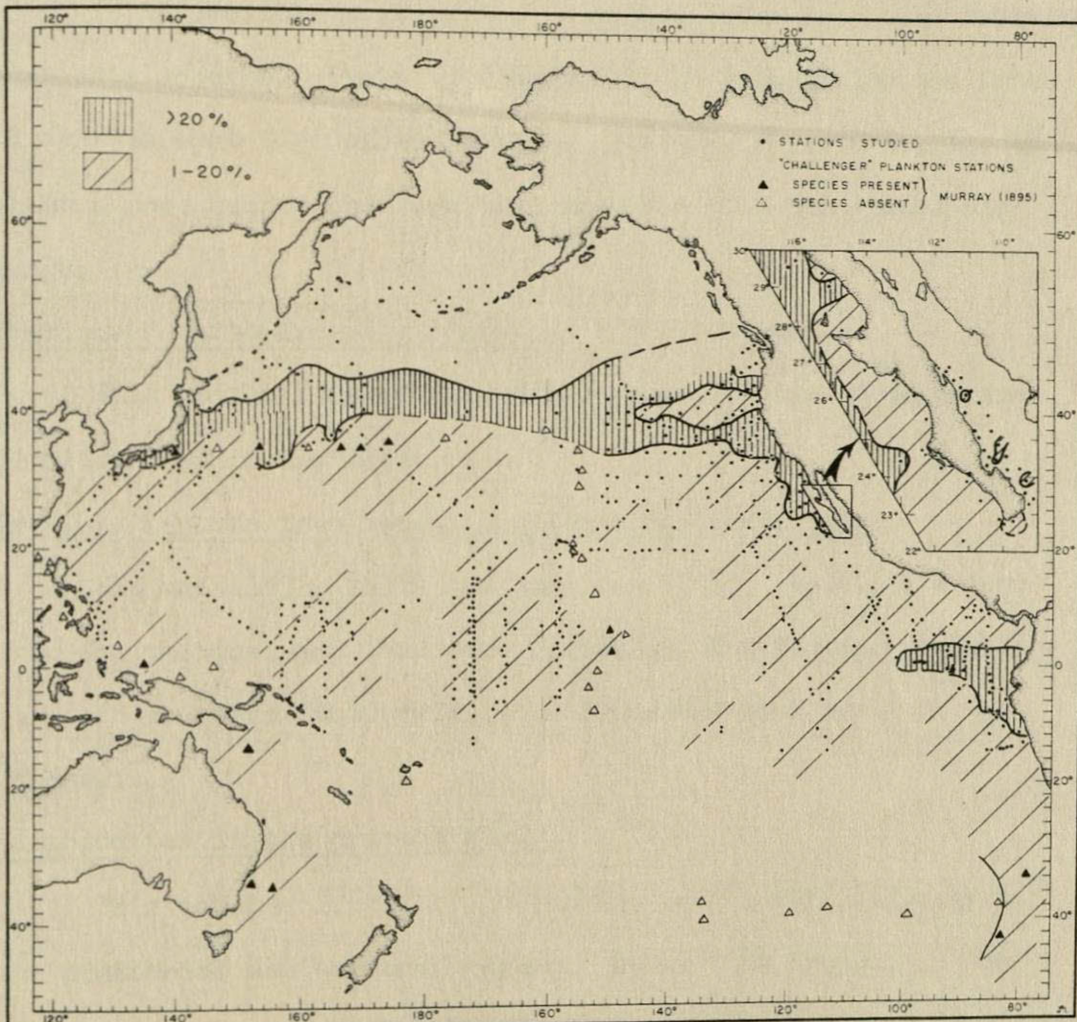
Murray (1895), Chapman (1910), Goes (1896), Bagg (1908), Cushman (1914, 1921, 1925, 1927), Hamilton (1953), Cushman, Todd and Post (1954), Asano (1957), Cushman and Moyer (1930), Cushman and Kellett (1929), Cushman and Wickenden (1929), Natland (1933), and Butcher (1951) record this form from localities throughout the equatorial, central and transitional regions of the Pacific as follows: off Japan, probably off the Philippines and in the Marshall Islands; off Funafuti; west of Hawaii at 1 per cent; near Hawaii; from Chile to Ecuador and off Juan Fernandez Island; abundant off southern California, with an average frequency of 63 per cent off San Diego.

Distribution in the present study

Specimens of the Globigerina eggeri group (fig. 11) were found throughout the warm water, transitional and subarctic regions of the Pacific. The frequency of occurrence varied, however, reaching a maximum in the transition areas of the California Current, Peru Current and areas of mixing between cold and warm water such as the junction of the Kuroshio and Oyashio Currents northeast of Japan.

Typical large G. eggeri (pl. 1, figures 5, 10) were not found in the subarctic region although what were considered to be immature specimens were found in most of the cold water samples.

Figure 11. Distribution of *Globigerina eggeri* Rhumbler in per cent of total planktonic Foraminifera.



>20 %
1-20 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)
120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°

Globigerina hexagona Natland

(Plate 1, figures 11, 12, 13, 14, 15)

Globigerina hexagona Natland, 1938, Bull. Scripps Inst. Oceanogr., Tech. Ser., vol. 4, no. 5, p. 149, pl. 7, figs. 1 a-c.

It is possible that several distinct forms have been included with this species. Plate 1, figures 11, 12 illustrates the form closest to that figured by Natland. Plate 1, figures 13, 14, 15 shows a more compressed form that occurs within the geographic range.

Previous reports from the plankton

This is the first recorded occurrence of this species from plankton tows in any ocean.

Previous reports from Recent sediments in the Pacific

Natland (1933, 1938) and Hamilton (1953) report this form from the tropical and temperate regions of the Pacific as follows: rare off southern California; at a frequency of 2 per cent west of Hawaii.

Distribution in the present study

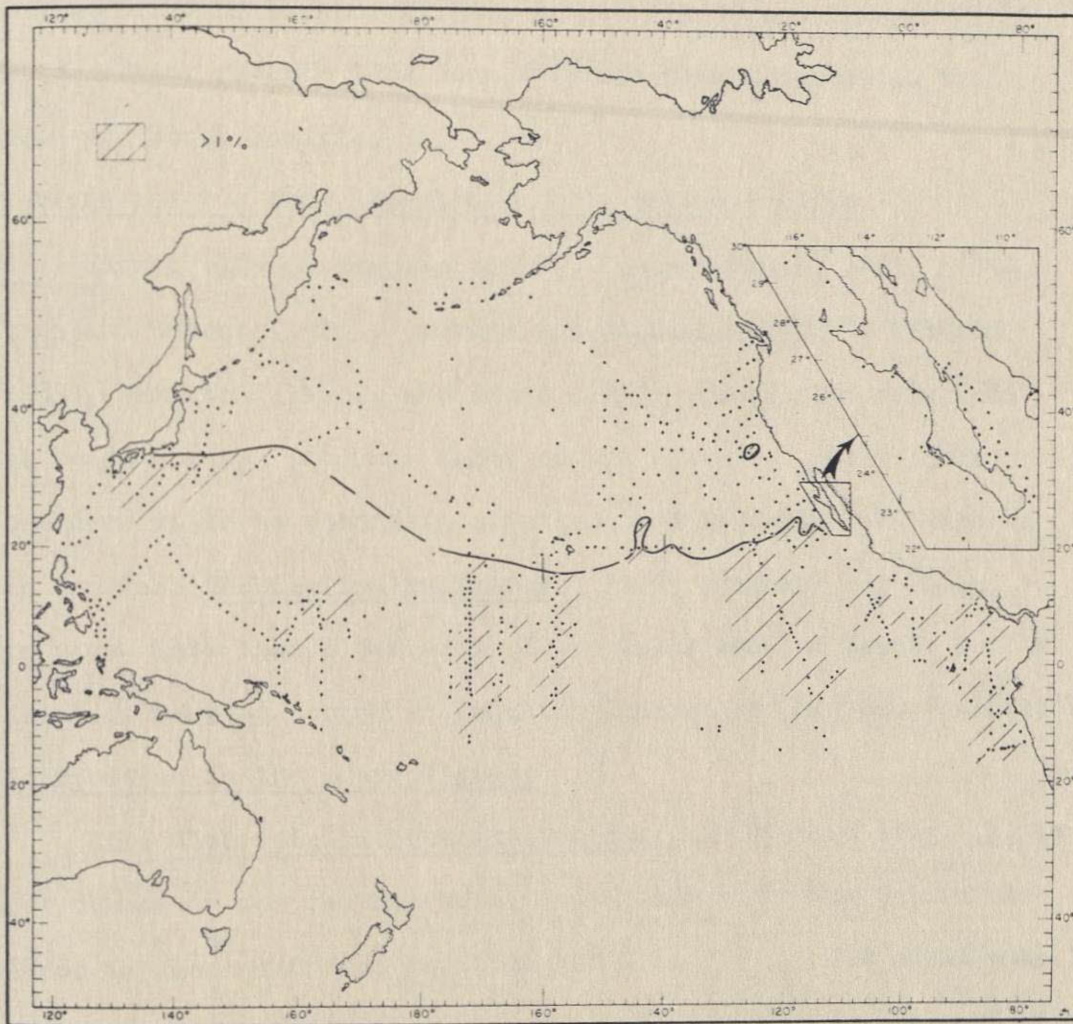
This species (fig. 12) is present in highest frequency in the equatorial west-central region. It is also present in the transitional waters of the Peru and California Currents.

Globigerina inflata d'Orbigny

(Plate 1, figures 16, 17, 18)

Globigerina inflata d'Orbigny, 1939, in Barker-Webb, and Berthelot, Hist. Nat. Îles Canaries, vol. 2, Foraminifères, p. 134, pl. 2,

Figure 12. Distribution of <u>Globigerina hexagona</u> Natland in per cent of total planktonic Foraminifera.


>1%

figs. 7-9.

Previous reports from the plankton

This species has been reported from plankton tows by Owen (1868), Tizard and Murray (1882), Brady (1884), Murray (1897), Rhumbler (1900), Wiesner (1931), Schott (1935) and Phleger (1945, 1951). Brady records this form from six plankton tows in the North and South Pacific.

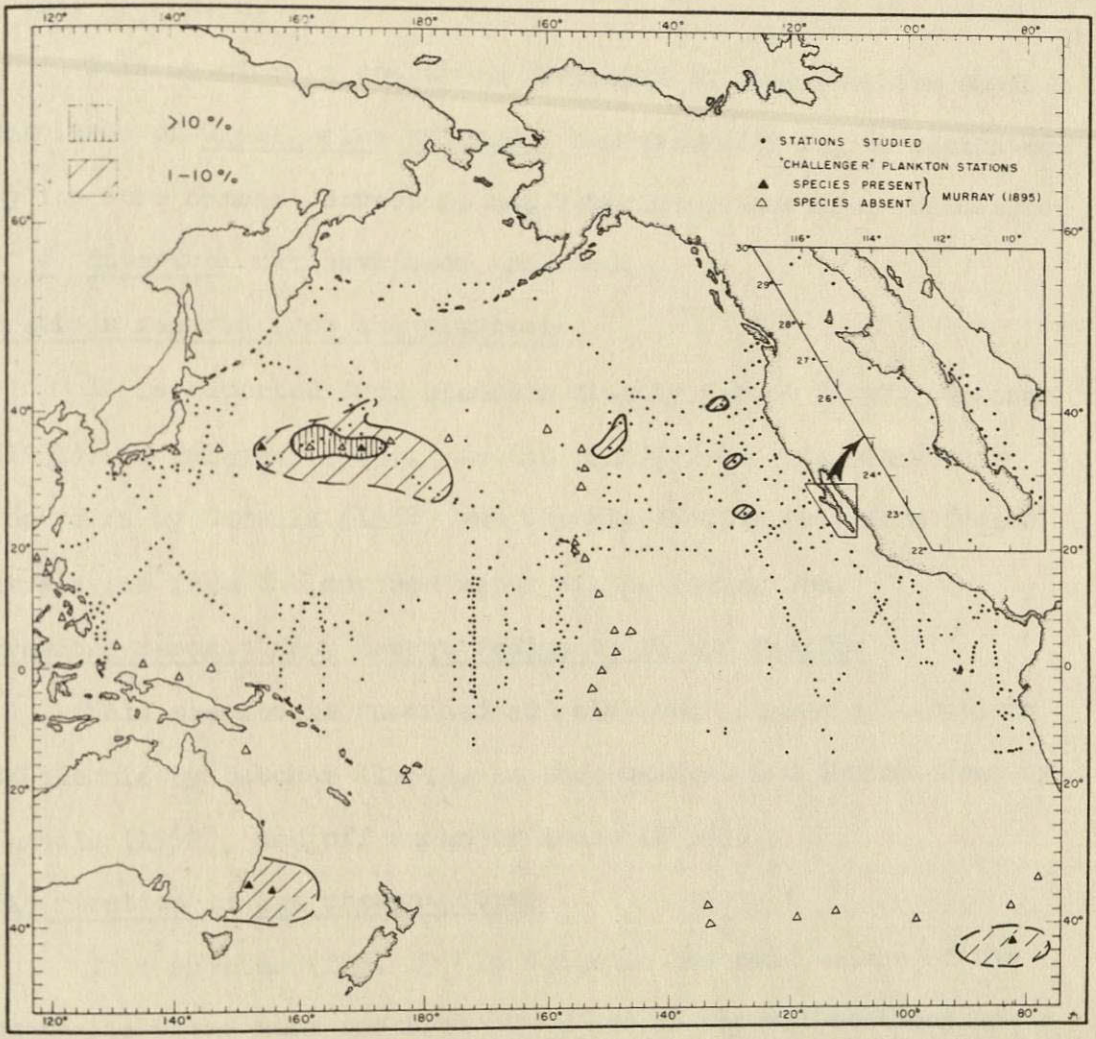
Previous reports from Recent sediments in the Pacific

Murray (1895), Chapman (1910), Cushman (1914, 1921, 1925), Hanna and Church (1928), Cushman and Wickenden (1929), Natland (1933), Hamilton (1953), and Asano (1957) record this form from the temperate and tropical belts of the Pacific. Brady (1884) considers it to be second in abundance and in extent of range to the tropical *Globigerina bulloides*. It is abundant off Japan, comprises less than 1 per cent of the fauna west of Hawaii and is listed as rare to common in Catalina Channel and off San Francisco.

Distribution in the present study

Like *Globorotalia truncatulinoides* this species (fig. 13) is most common in the central water fauna extending from California almost to Japan and from latitude 40° N to 25° N. Its occasional occurrence in the transition region is believed to be a result of central water influence.

Figure 13. Distribution of *Globigerina inflata* d'Orbigny in per cent of total planktonic Foraminifera.



>10 %
1-10 %
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

Globigerina pachyderma Ehrenberg

(Plate 1, figures 20, 21, 22, 23)

Aristerosphira pachyderma Ehrenberg, 1861, Monats. k. preuss. Ak., Wiss. Berlin, p. 303; 1872 (1873) Abhandl. Ak. k. Wiss. Berlin, pl. 1, fig. 4.

This species is sometimes difficult to separate from small specimens of Globigerina bulloides but generally may be separated by its more compact structure and restricted aperture. Specimens of G. dutertrei may have been included.

Previous reports from the plankton

It is reported from plankton tows by Murray (1897), Wiesner (1931) and Phleger (1945). In the Pacific the only planktonic record is by Carsola (1952) who reports finding this form frozen in sea ice from the surface water of the Bering Sea.

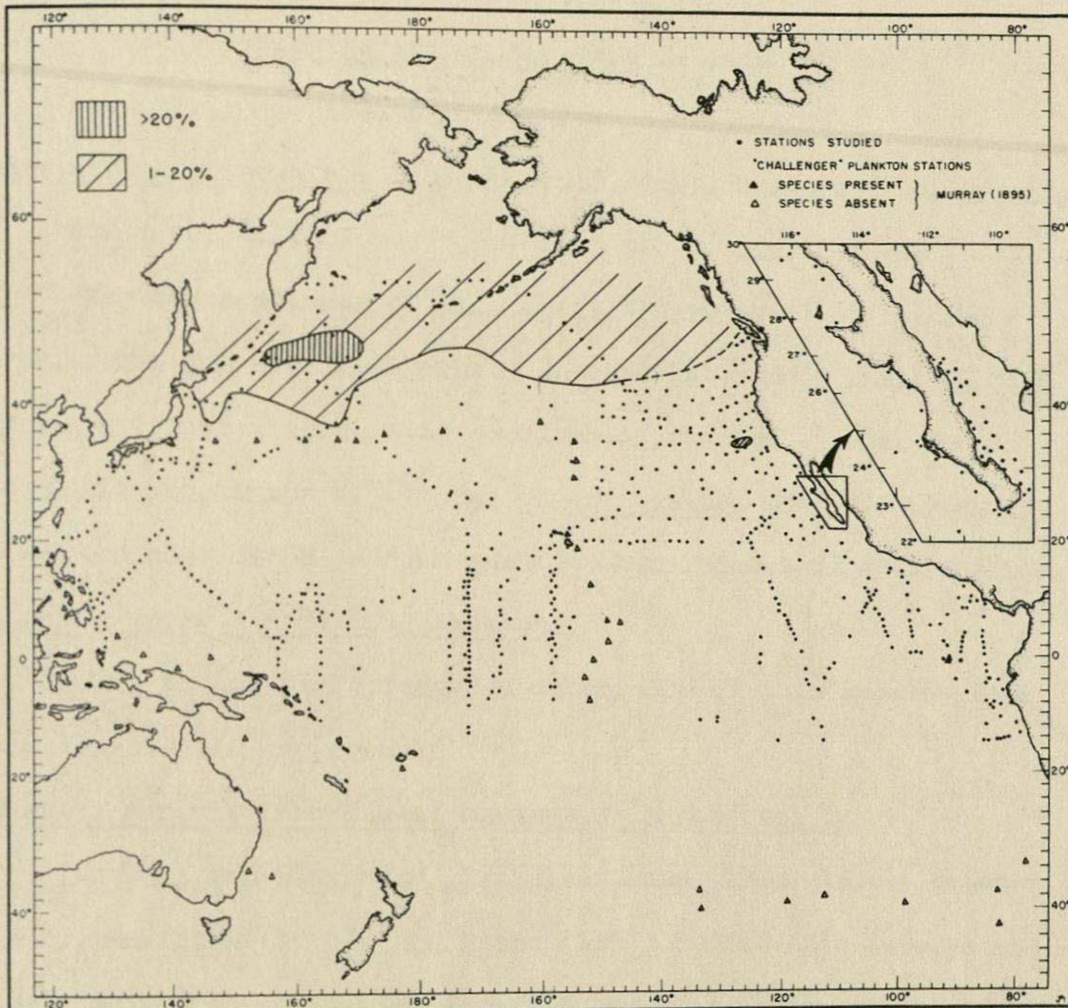
Previous reports from Recent sediments in the Pacific

This species is recorded as relatively common off southern California by Butcher (1951), in the Beaufort and Chukchi Seas by Carsola (1952), and off Japan by Asano (1957).

Distribution in the present study

This species (fig. 14) is found in the cold waters of the subarctic water mass north of 40° N and at several stations in the California Current and off northern Japan. The vertical distribution is not known but specimens were not found in plankton samples shallower than 50 meters. It is possible that this species is found at the surface only in very high latitudes and submerges

Figure 14. Distribution of _Globigerina pachyderma_ (Ehrenberg) in per cent of total planktonic Foraminifera.


>20%
1-20%
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

into deeper, colder water in temperate regions. This is a less extreme view than Wiesner's (1931) conjecture that it is only planktonic within the zone of pack ice but leads a benthonic existence in the temperate region beyond the ice boundary.

Globigerina quinqueloba Natland

(Plate 1, figures 24, 25)

Globigerina quinqueloba Natland, 1938, Bull. Scripps Inst. Oceanogr. Tech. Ser., vol. 4, no. 5, p. 149, pl. 6, figs. 7 a-c.

Typical specimens of this species have the last chamber overlapping the umbilical area. In cold water many small spinous specimens occur without this overlapping chamber. These forms occur with specimens of typical G. quinqueloba and in this study have been considered to represent immature stages of this species.

Previous reports from the plankton

This is the first recorded occurrence of this species from plankton tows in any ocean.

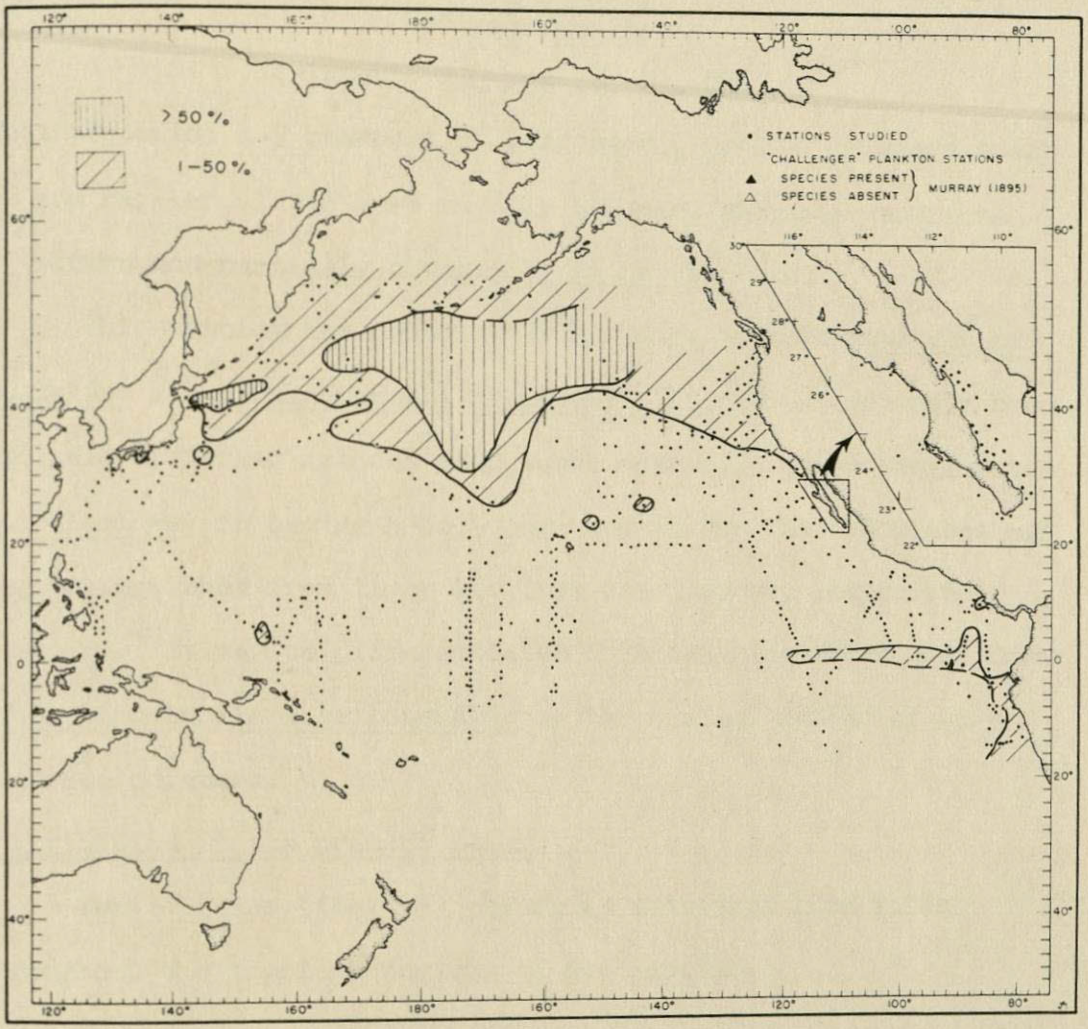
Previous reports from Recent sediments in the Pacific

Cushman and Wickenden (1929), Natland (1933, 1938), Butcher (1951), Hamilton (1953), and Asano (1957) report this species at widely scattered localities from off the Juan Fernandez Islands, southern California, west of Hawaii and Japan. Natland records it as abundant in the Catalina Channel while Butcher records an average frequency of 4 per cent off San Diego.

Distribution in the present study

This species (fig. 15) is common in the cold waters of the

Figure 15. Distribution of Globigerina quinqueloba Natland in per cent of total planktonic Foraminifera



>50 %
1-50 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

subarctic region north of latitude 40° N. It is also found in the transition region represented by the water of the California and Peru Currents. There are some scattered occurrences along the equator.

Globigerina sp.

(Plate 1, figures 26, 27, 28)

Test trochoid; 4-5 chambers in last whorl, earlier chambers small and regular, later ones rapidly becoming elongate; aperture sunken and partially covered by later chambers.

This species has certain similarities to both *Globigerina bulloides* and *Globigerinella aequilateralis* and has probably been included by former authors with these species. It is similar to *G. bulloides* in having 4 to 5 chambers in the last whorl but may be distinguished from it by its less conspicuous, compressed aperture. It may be differentiated from non-planispiral specimens of *Globigerinella aequilateralis* by the smaller number of more elongate chambers.

Distribution in the present study

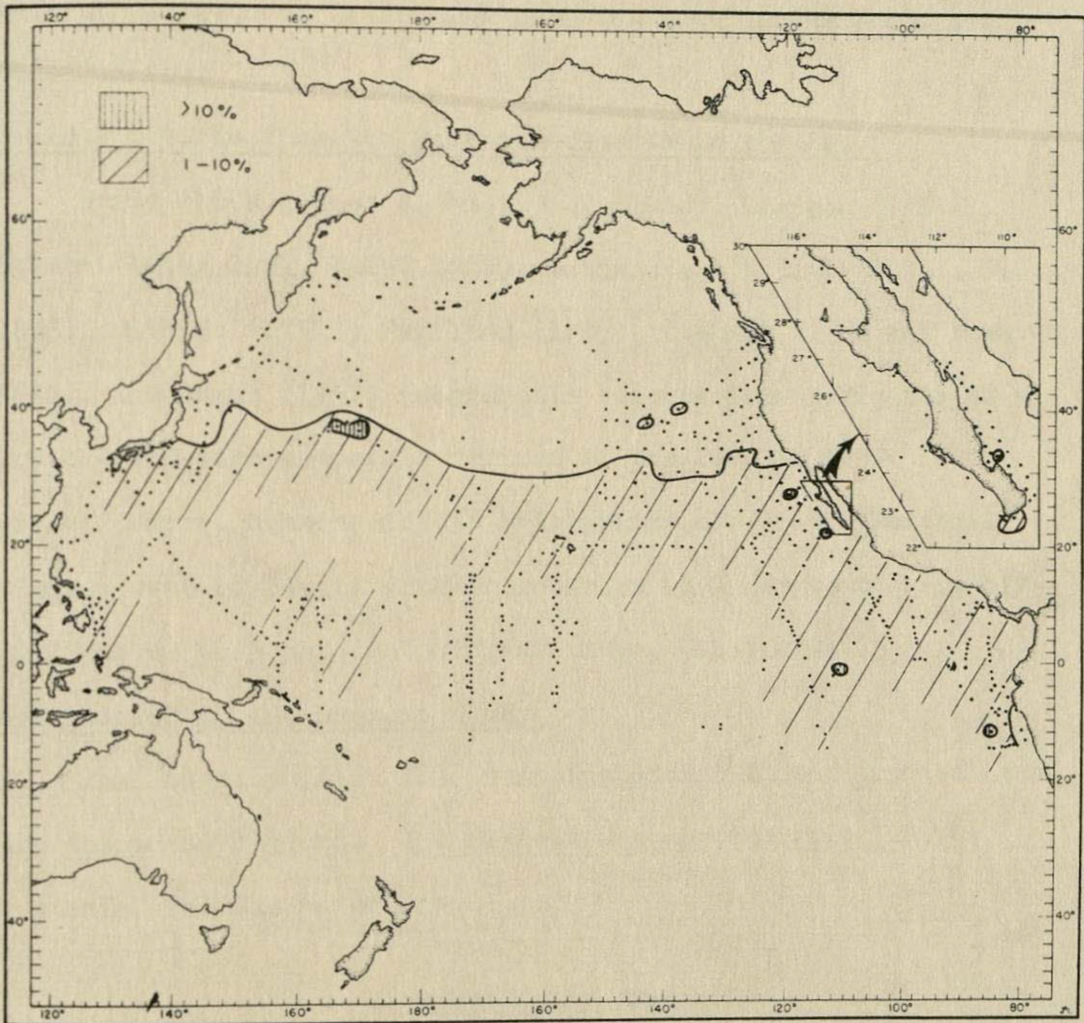
This species (fig. 16) occurs at scattered localities throughout the tropical regions of the Pacific.

Globigerinella aequilateralis Brady

(Plate 2, figures 1, 2)

Globigerina aequilateralis Brady, 1879, Quart. Journ. Micr. Sci., vol. 19, p. 71; 1884, Rept. Voy. CHALLENGER, Zool., vol. 9, p. 605, pl. 80, figs. 18-21.

Figure 16. Distribution of *Globigerina* sp. in per cent of total planktonic Foraminifera.



>10%
1-10%

Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900), Heron-Allen and Earland (1922), Wiesner (1931), Schott (1935), and Phleger (1945, 1951). Brady (1884) records it from 11 plankton tows in the North and South Pacific.

Previous reports from the Recent sediments in the Pacific

Brady (1884), Goes (1896), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1924, 1927), Cushman and Kellett (1929), Natland (1933), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) record this species from sediments of the tropical and warm temperate regions of the Pacific as follows: rare off Japan; common off the Philippines and in the Marshall Islands; west of Hawaii with frequencies of 5 per cent; rare off Catalina; up to 5 per cent off San Diego, California.

Distribution in the present study

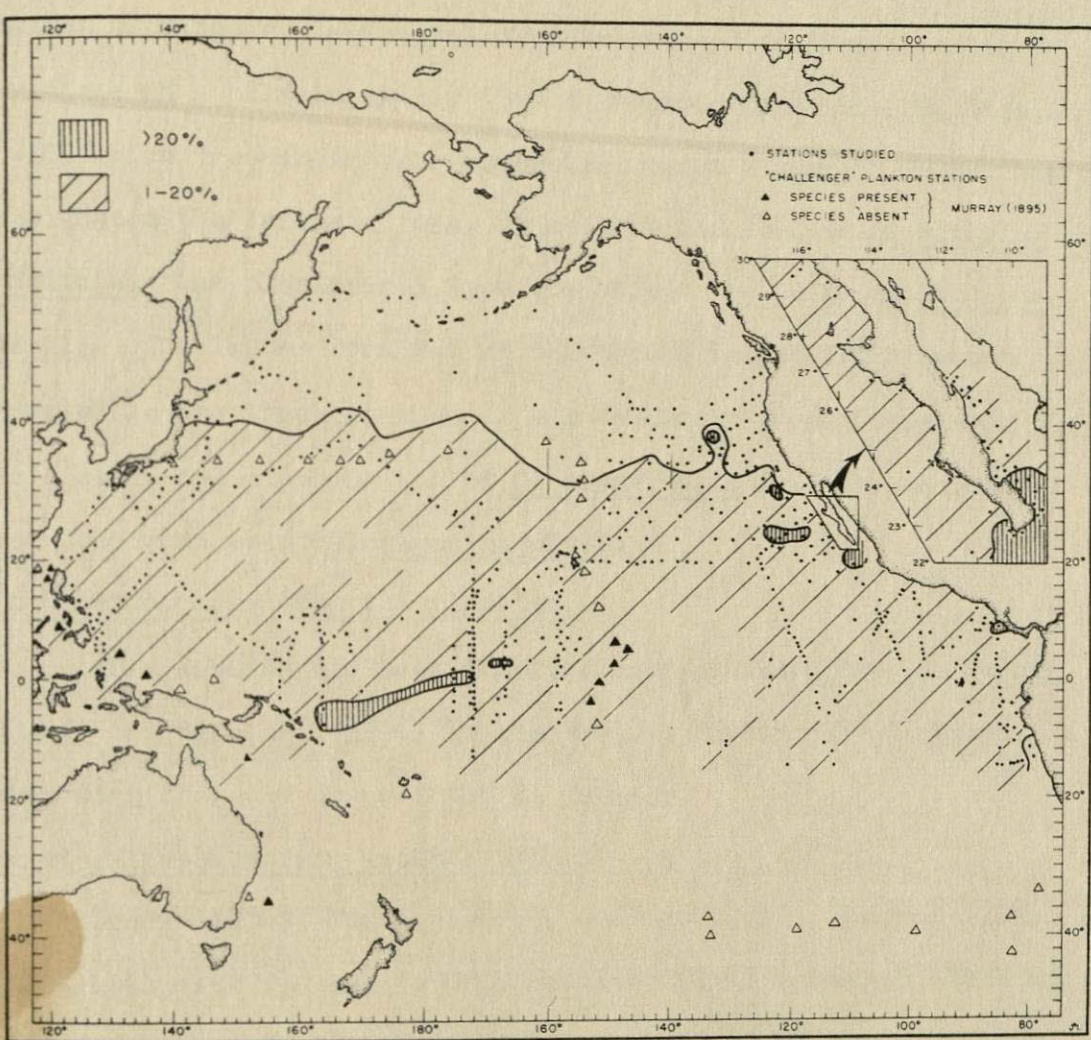
This species (fig. 17) is most abundant in the tropical and warm temperate regions. The highest frequencies occur in the equatorial Pacific water mass.

Globigerinella sp.

(Plate 2, figures 3, 4)

Globigerinella digitata Brady (part), 1879, Quart. Journ. Micr. Sci., vol. 19, p. 72; 1884 (part) Rept. Voy. CHALLENGER, Zool., vol. 9, p. 599, pl. 82, figs. 6, 7 (not pl. 80, figs. 6-10)

Figure 17. Distribution of *Globigerinella aequilateralis* (Brady) in per cent of total planktonic Foraminifera.



>20%
1-20%
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

<u>Hastigerinella</u> <u>digitata</u> (Rhumbler), Cushman, Todd and Post, 1954, U.S. Geol. Surv. Prof. Paper 260-H, pt. 2, pl. 91, figs. 9, 10.

Parker (in press) states that the form described by Brady includes two distinct species. Brady (1884, pl. 82, figs. 6, 7) has illustrated a planispiral type which he describes as being "radiate in a palmate manner" and a trochoid type (pl. 80, figs. 6-10) which "resembles an outstretched index finger." Parker has designated the trochoid form, which is worldwide, as <u>Globigerina</u> <u>digitata</u>. The planispiral type she refers to the genus <u>Globigerinella</u>. The latter form was most frequent in Pacific plankton tows while the trochoid species has been only rarely observed. In this study the distribution of <u>Globigerinella</u> sp. also includes rare occurrences of <u>Globigerina</u> <u>digitata</u>.

<u>Previous reports from the plankton</u>

This species has been recorded from plankton tows by Murray (1897) and Schott (1935). In the Pacific Murray (1895) reports this form from one tow off the Ki Islands.

<u>Previous reports from Recent sediments in the Pacific</u>

Brady (1884), Murray (1895), Chapman (1910), Cushman (1914, 1921, 1924, 1927), Bagg (1908), Hamilton (1953), Cushman, Todd and Post (1954) record this form from sediments of the equatorial and closely adjacent warm water regions of the Pacific as follows: common at one station off the Philippines but rare at others; from the Marshall Islands and Funafuti; at a frequency of less than 1 per cent west of Hawaii; rare off the west coast of Mexico. It is not recorded off the California coast nor from Japan.

Distribution in the present study

Highest concentrations of Globigerinella sp. (fig. 18) were found in the equatorial Pacific region. Significant frequencies also occur in waters of the Kuroshio Current in the west central Pacific.

Globigerinita glutinata (Egger)

(Plate 2, figures 7, 8)

Globigerina glutinata Egger, 1893, Abhandl. K. bay. Akad. Wiss München, Cl. II, vol. 18, p. 371, pl. 13, figs. 19-21. Rhumbler, 1911, Ergeb. Plankton-Exped. Humboldt Stift., vol. 3, p. 148, pl. 29, figs. 14-26; pl. 33, fig. 20; pl. 34, fig. 1.

This species is similar to that described by Phleger et al. (1953).

Previous reports from the plankton

This species has been recorded from plankton tows by Rhumbler (1911). The specimens captured in the present study are the first reported from the plankton tows in the Pacific.

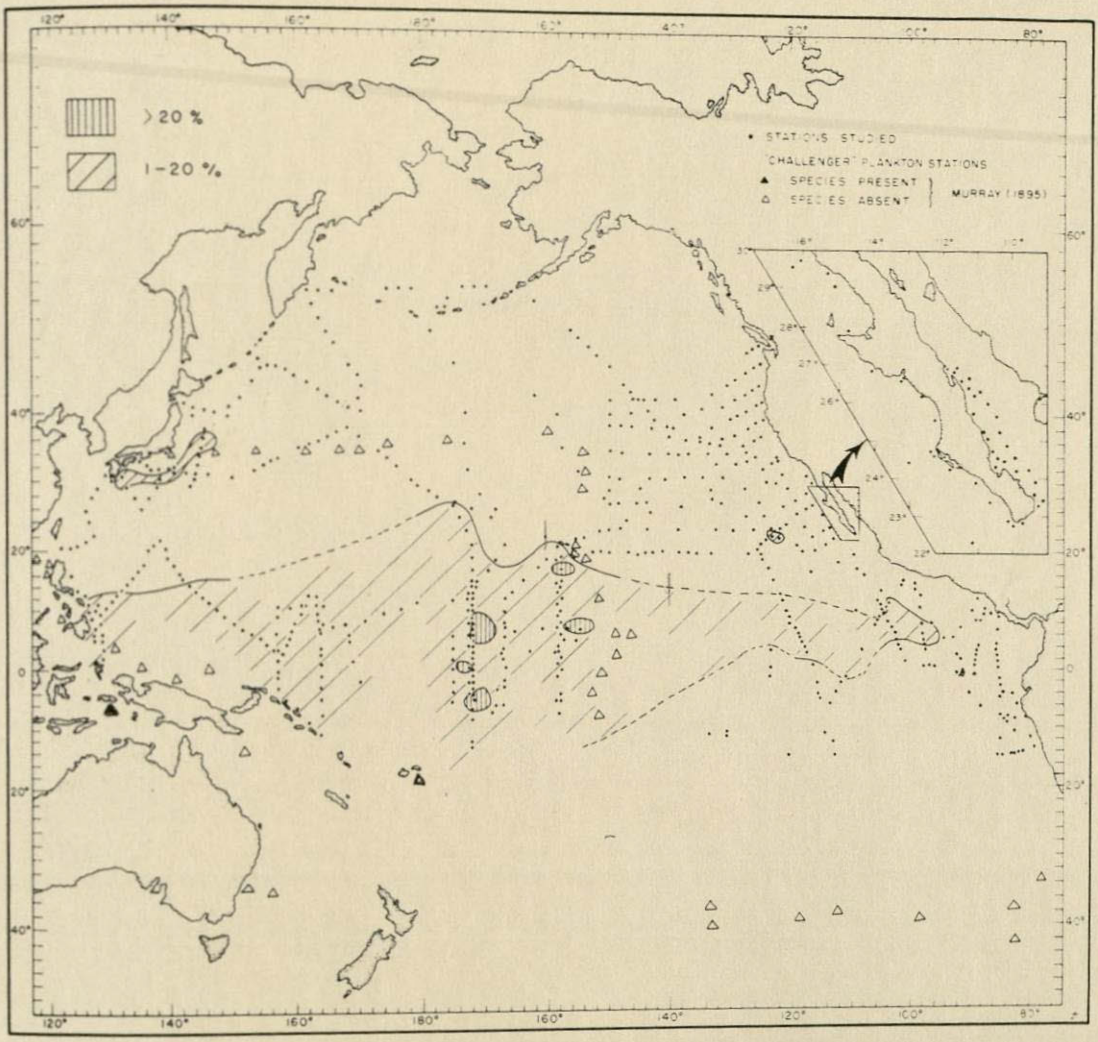
Previous reports from Recent sediments in the Pacific

Hamilton (1953) is the only one to report this species from the Pacific. He records it at frequencies of 5 per cent from Cape Johnson Guyot west of Hawaii.

Distribution in the present study (fig. 19)

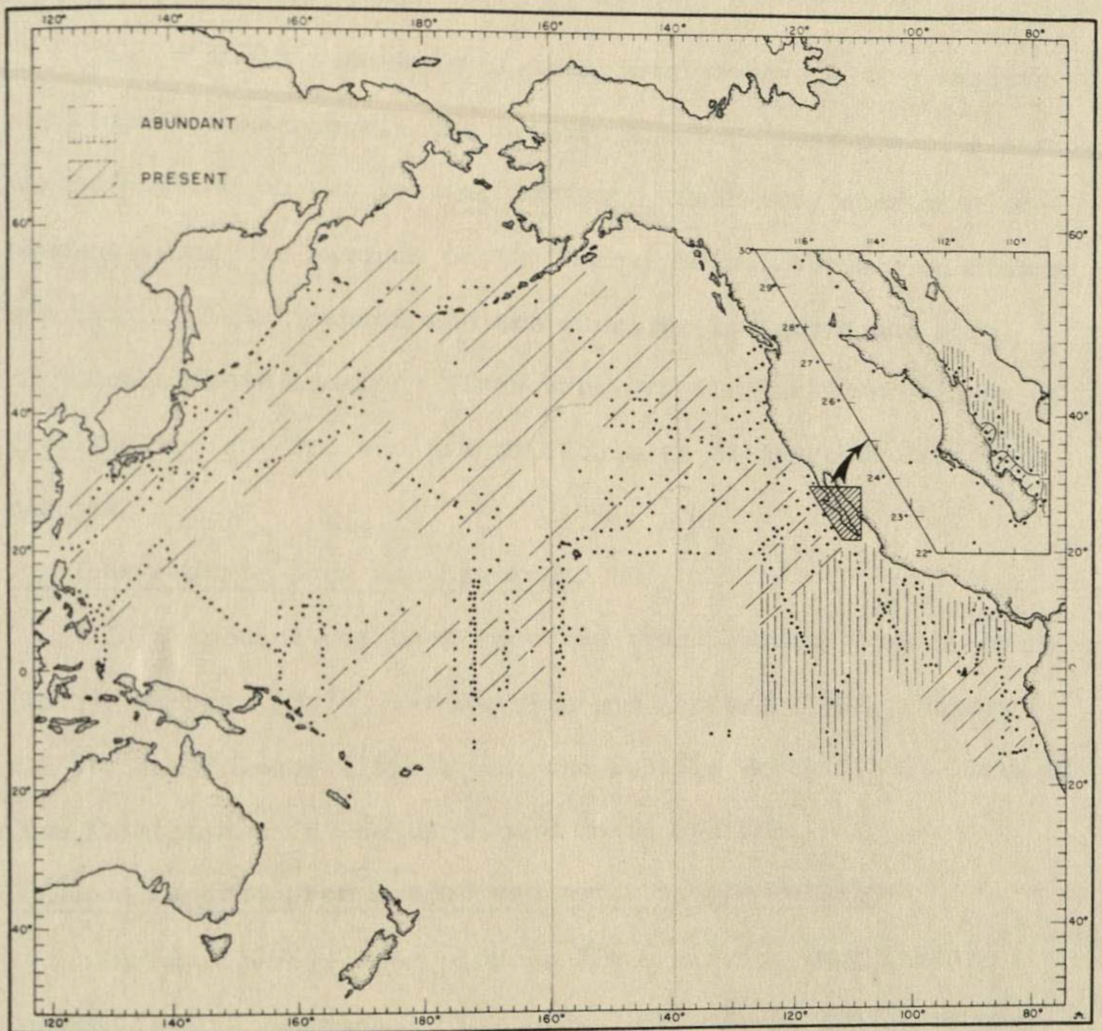
This species is most abundant in the tropical regions but it (or a closely related form) also ranges into the subarctic water. The colder water specimens are smaller than those from the tropics.

Figure 18. Distribution of *Globigerinella* sp. in per cent of total planktonic Foraminifera.



>20 %
1-20 %
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

Figure 19. Distribution of *Globigerinita glutinata* (Egger) in per cent of total planktonic Foraminifera.


ABUNDANT
PRESENT
120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°
116°
114°
112°
110°
30
29°
28°
27°
26°
24°
23°
22°

Globigerinoides conglobata (Brady)

(Plate 2, figures 5, 6)

Globigerina conglobata Brady, 1879, Quart. Journ. Micr. Sci., vol. 19, p. 72; 1884, Rept. Voy. CHALLENGER, Zool., vol. 9, p. 603, pl. 80, figs. 1-5; pl. 82, fig. 5.

Large adult specimens of this species have a very massive and compact appearance. The primary aperture consists of a narrow arched opening on the ventral surface. Accessory apertures are present along the sutures on the dorsal side. Younger specimens are usually less compact and the aperture is larger and more distinct. These immature forms are very similar to specimens of Globigerinoides sp. and are difficult to distinguish from that species.

Previous reports from the plankton

This species has been recorded from plankton tows by Brady (1884), Murray (1897), Heron-Allen and Earland (1922), Schott (1935), and Phleger (1951). In the Pacific Brady (1884) lists it from 11 stations in the North and South Pacific.

Previous reports from Recent sediments in the Pacific

Murray (1895), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1924, 1925, 1927), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) record this form as common to abundant from the sediments of the tropical and warm temperate regions of the Pacific. At Cape Johnson Guyot west of Hawaii it makes up 12 per cent of the recent fauna. In colder temperate regions the abundance decreases markedly; the frequency is less than 1 per cent off San Diego, California (Butcher, 1951).

Distribution in the present study

This species (fig. 20), which is limited to the warm water region, has its greatest abundance in the equatorial Pacific.

Globigerinoides cf. *G. minuta* Natland

(Plate 2, figures 9, 10, 11)

Globigerinoides minuta Natland 1938, Bull. Scripps Inst. Oceanogr. Tech. ser., vol. 4, no. 5, p. 150, pl. 7, fig. 2, 3.

This form is closely related to Natland's species but has a slightly more spinose surface. Accessory apertures are present. Immature stages are difficult to separate from juvenile specimens of *Globigerinita glutinata* that occur with them. Adult specimens may be differentiated from *Globigerinita glutinata* by their relatively higher spires when compared with equal sized individuals of the latter species.

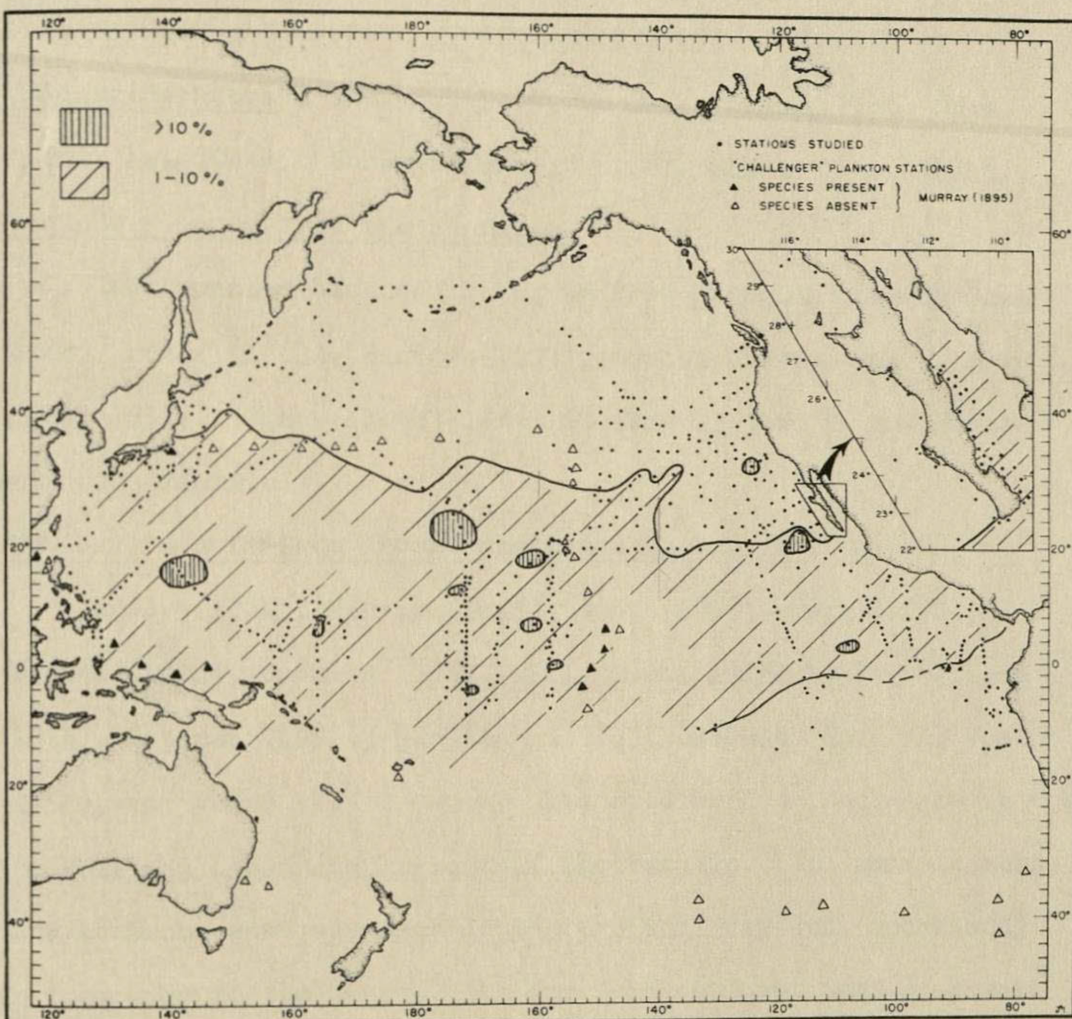
Previous reports from the plankton

This is the first record of this species from plankton tows in any ocean.

Previous reports from Recent sediments in the Pacific

Natland (1933) and Uchio (personal communication) report this form as common from southern California and Baja California.

Figure 20. Distribution of _Globigerinoides conglobata_ (Brady) in per cent of total planktonic Foraminifera.



>10 %
1-10 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

Distribution in the present study

This species (fig. 21) is most abundant in the subarctic regions but occasionally occurs in the temperate zone.

Globigerinoides rubra (d'Orbigny)

(Plate 2, figures 12, 13)

Globigerina rubra d'Orbigny, 1839, in De la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 82, pl. 4, figs. 12-14.

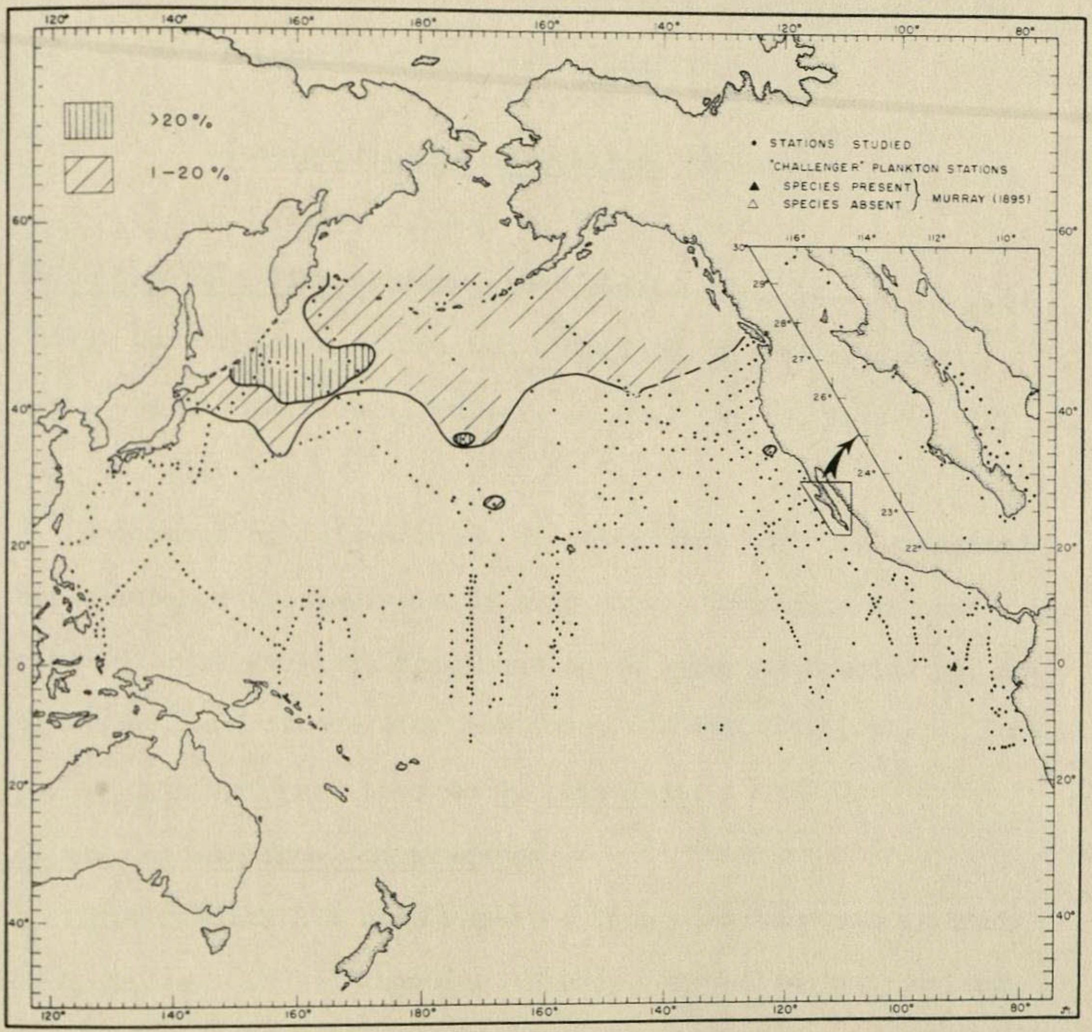
Previous reports from the plankton

This species has been recorded from plankton tows by Owen (1868), Brady (1884), Murray (1897), Schott (1935), and Phleger (1945, 1951). Brady (1884) lists it from 11 tows in the North and South Pacific.

Previous reports from Recent sediments in the Pacific

Brady (1884), Murray (1895), Goes (1896), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1924, 1925, 1927), Natland (1933), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) record this species from sediments in the tropical and temperate regions of the Pacific. The above records show it to be most abundant in the tropical regions, decreasing in frequency to the north. At Cape Johnson Guyot west of Hawaii it has a frequency of 33 per cent. Natland (1933) lists it as common in Catalina Channel. Butcher (1951) records frequencies off San Diego up to 11 per cent, with an average frequency of 4 per cent.

Figure 21. Distribution of *Globigerinoides* cf. *G. minuta* Natland in per cent of total planktonic Foraminifera.



>20%
1-20%
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

Distribution in the present study

This species (fig. 22) is found throughout the tropical and temperate regions of the Pacific. Highest frequencies occur in equatorial waters but considerable numbers are also found within the transition zone. The greatest concentrations (up to 2,586/ 1,000 M^3) are recorded in the Gulf of California.

Globigerinoides sacculifera (Brady)

(Plate 2, figures 14, 15, 18)

Globigerina sacculifera Brady, 1877, Geol. Mag., vol. 4, p. 535; 1879, Quart. Journ. Micr. Sci., vol. 19, p. 73; 1884 Rept. Voy. CHALLENGER, Zool., vol. 9, p. 604, pl. 80, figs. 11-17; pl. 82, fig. 4.

Specimens of this species do not always have the elongated final chamber characteristic of this form. Some authors have considered such sac-less specimens to be separate species (G. triloba Reuss), and others (for instance, Cushman, 1914, pl. 2, figs. 7, 8, 9) have referred them to G. bulloides.

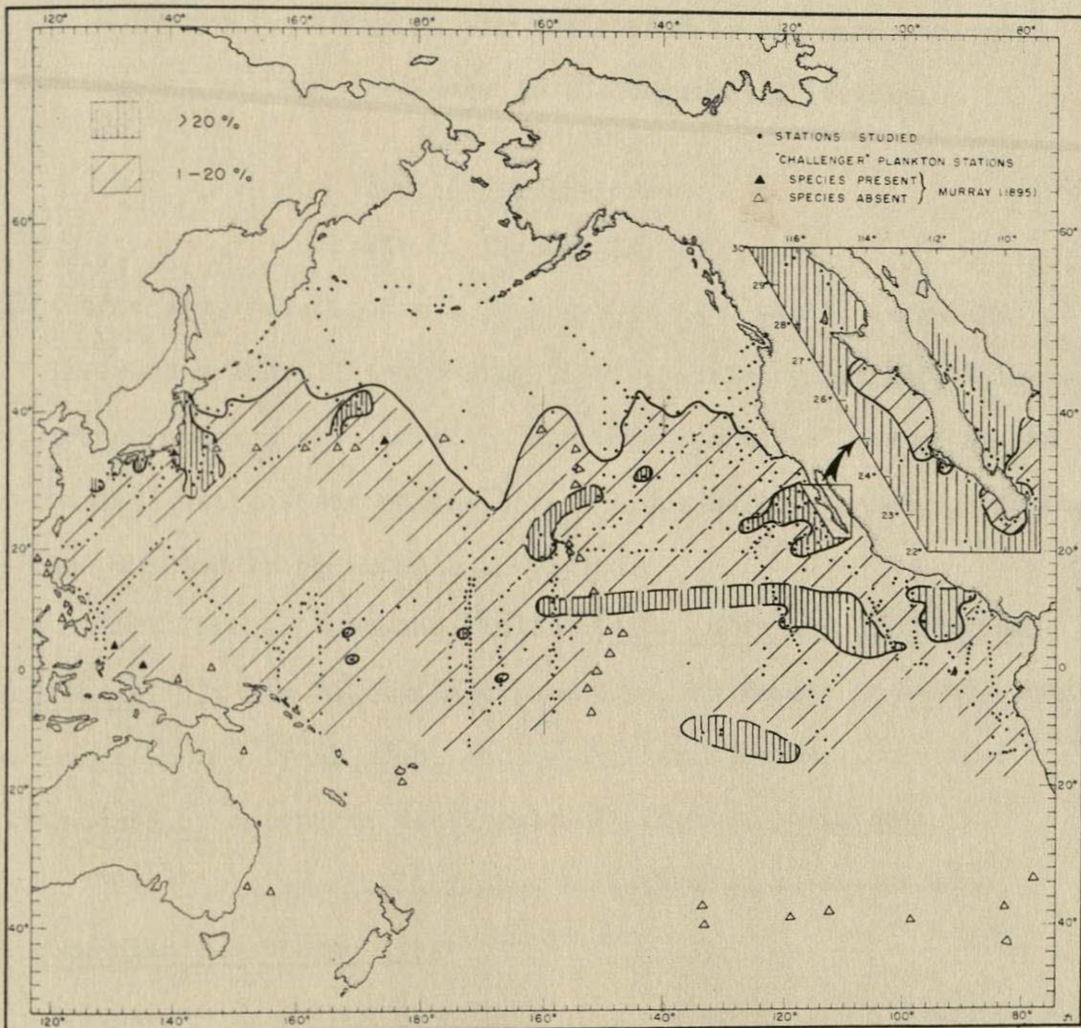
Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900), Heron-Allen and Earland (1922), Wiesner (1931), Schott (1935), and Phleger (1951). Brady (1884) records it from five plankton tows in the Pacific.

Previous reports from Recent sediments in the Pacific

Brady (1884), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1924, 1927), Butcher (1951), Hamilton

Figure 22. Distribution of *Globigerinoides rubra* (d'Orbigny) in per cent of total planktonic Foraminifera.



> 20 %
1 – 20 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

(1953), Cushman, Todd and Post (1954), and Asano (1957) record this species from sediments in the tropical and temperate regions of the Pacific.

Distribution in the present study

This species (fig. 23) is restricted to the warm regions, reaching its maximum frequency in the equatorial Pacific.

Globigerinoides sp.

(Plate 2, figures 16, 17)

Test trochoid, rotaliform; 4 chambers in last whorl, large and inflated gradually increasing in size; primary aperture a large arched opening with several secondary apertures located in the sutural depressions on the dorsal side; walls coarsely perforate and spinous in planktonic specimens.

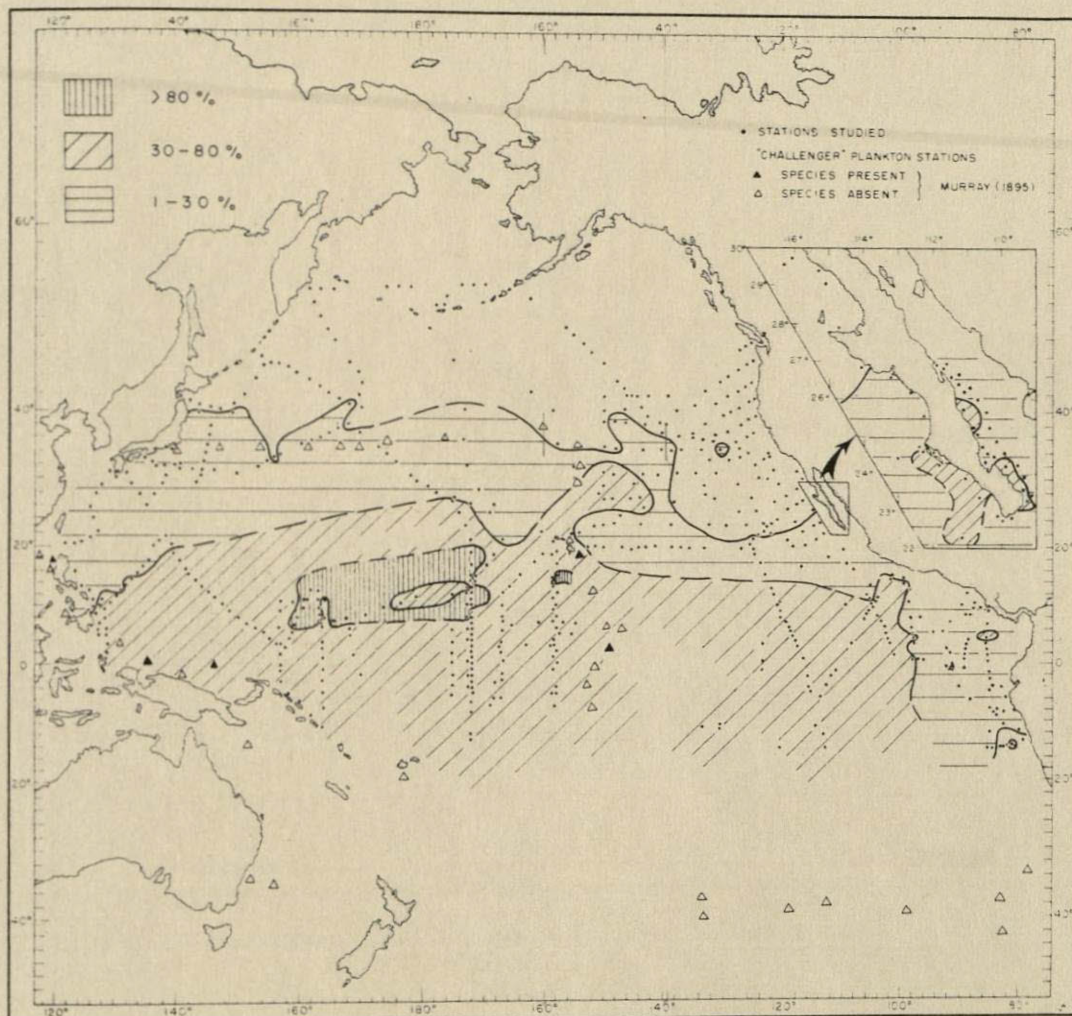
This form is somewhat similar to *G. rubra* and *Globigerina bulloides*. It may be distinguished from the former in having four chambers in the final whorl and by smaller accessory apertures. The accessory apertures distinguish it from *G. bulloides*.

There is a possibility that this form is a variant of *Globigerinoides conglobata*.

Distribution in the present study

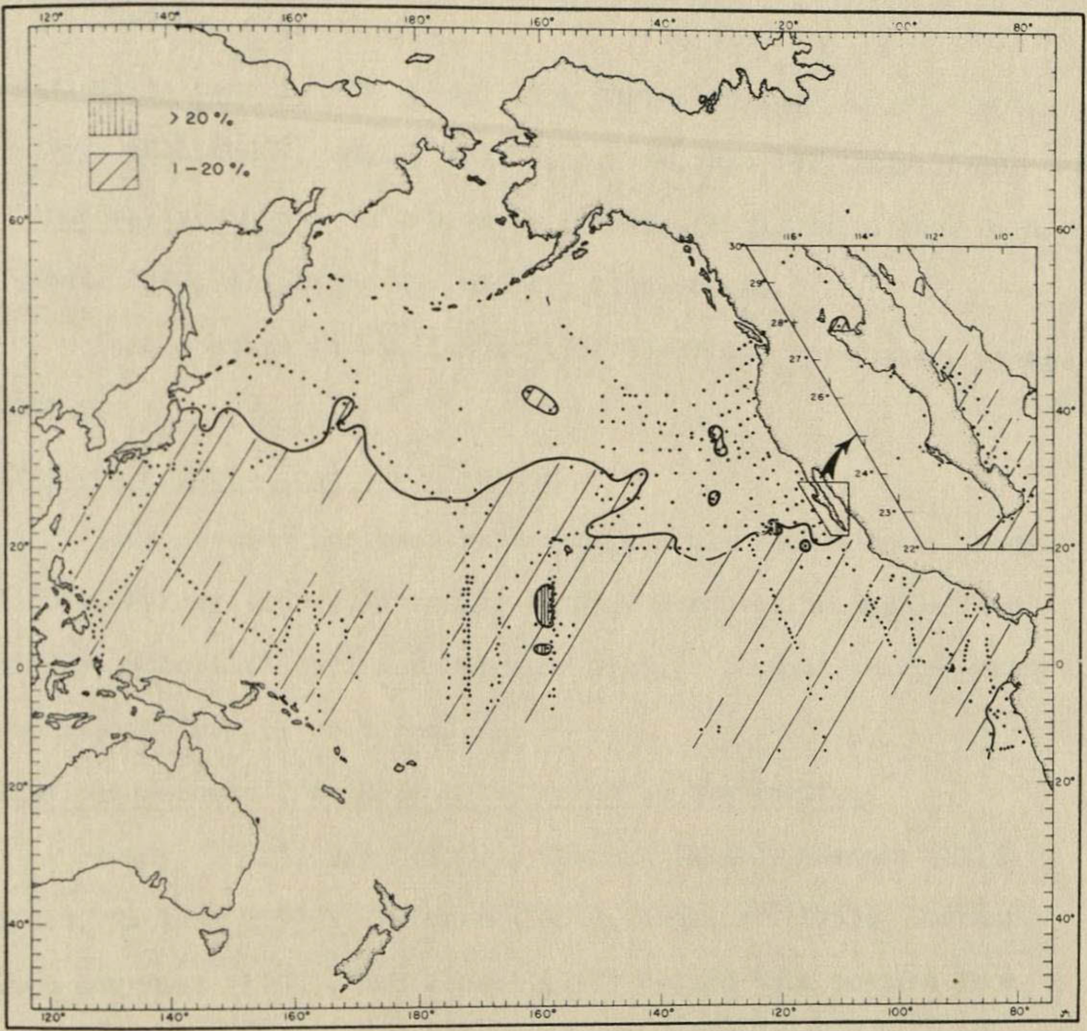
This species (fig. 24) is found throughout the tropical and temperate regions of the Pacific.

Figure 23. Distribution of *Globigerinoides sacculifera* (Brady) in per cent of total planktonic Foraminifera.



>80 %
30-80 %
1-30 %
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

Figure 24. Distribution of *Globigerinoides* sp. in per cent of total planktonic Foraminifera.



> 20 %.
1 - 20 %.

Globorotalia hirsuta (d'Orbigny)

(Plate 3, figures 1, 2)

Rotalia hirsuta d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, "Foraminifères," p. 131, pl. 1, figs. 37-39.

Pulvinulina canariensis Brady, 1884 (not d'Orbigny, 1839), Rept. Voy. CHALLENGER, Zool., vol. 9, p. 692, pl. 103, figs. 8-10.

Globorotalia hirsuta (d'Orbigny), Cushman, 1931, Bull. 104, U. S. Nat. Mus., pt. 8, p. 99, pl. 17, figs. 6 a-c.

This species is similar to that described by Phleger, et al. (1953).

Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900), Heron-Allen and Earland (1922), Schott (1935), and Phleger (1945). In the Pacific, Brady reports it from 11 stations.

Previous reports from Recent sediments in the Pacific

Brady (1884), Bagg (1908), Chapman (1910), Cushman (1915, 1921), Natland (1933), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) record this species from sediments of the tropical and warm temperate regions as follows: rare off Japan, the Philippines and the Marshall Islands; off Funafuti; frequencies of less than 1 per cent west of Hawaii (although Cushman considers it common between Hawaii and Japan); low frequencies off southern California.

Bagg (1908) believes it to be most abundant in the tropics while Brady (1884) states it to be more common in the warm temperate zone.

Distribution in the present study

This species (fig. 25) occurs at widely scattered localities throughout the tropical and warm temperate regions, being more abundant in the former.

Globorotalia menardii (d'Orbigny)

(Plate 3, figures 3, 4)

Rotalia menardii d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 273, no. 26; Modeles no. 10.

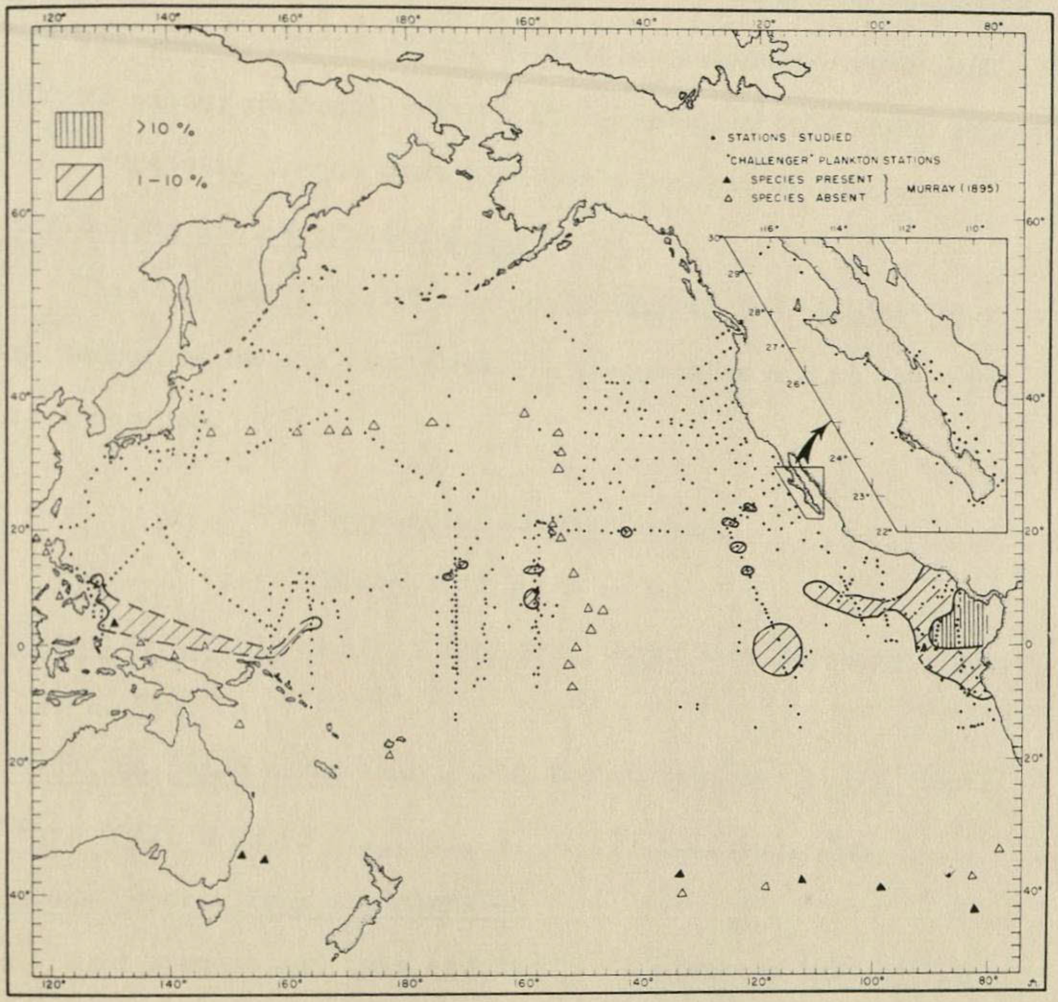
Pulvinulina menardii (d'Orbigny), Brady, 1884, Rept. Voy. CHALLENGER, Zool., vol. 9, p. 690, pl. 103, figs. 1, 2.

This species appears to form a continuous series with G. tumida although the end members are easily distinguished. It is separable by its flattened shape and lack of crystalline wall structure. Plate 3, figures 10, 11, 12 shows an intergrade which has been included with this form.

Previous reports from the plankton

This species has been reported from plankton tows by Owen (1868), Brady (1884), Murray (1897), Rhumbler (1900), Heron-Allen and Earland (1922), Wiesner (1931), Schott (1935), and Phleger (1951). Brady (1884) and Murray (1895) report it from 16 plankton tows in the North and South Pacific.

Figure 25. Distribution of *Globorotalia hirsuta* (d'Orbigny) in per cent of total planktonic Foraminifera.



>10 %
1 – 10 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

Previous reports from Recent sediments in the Pacific

Brady (1884), Picaglia (1893), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1925, 1927), Cushman and Wickenden (1929), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1954) report this species from sediments in the tropical regions of the Pacific as follows: common off southern Japan; abundant off the Philippines, the Marshall Islands and at Funafuti; frequencies of 3 per cent west of Hawaii.

Distribution in the present study

This species (fig. 26) is found only in the tropical and warm temperate zones. Its greatest frequencies are in the equatorial regions.

Globorotalia scitula (Brady)

(Plate 3, figures 5, 6)

Pulvinulina scitula Brady, 1882, Proc. Roy. Soc. Edinburgh, vol. 11, p. 716.

Pulvinulina patagonica Brady, 1884 (not d'Orbigny, 1839), Rept. Voy. CHALLENGER, Zool., vol. 9, p. 693, pl. 103, fig. 7

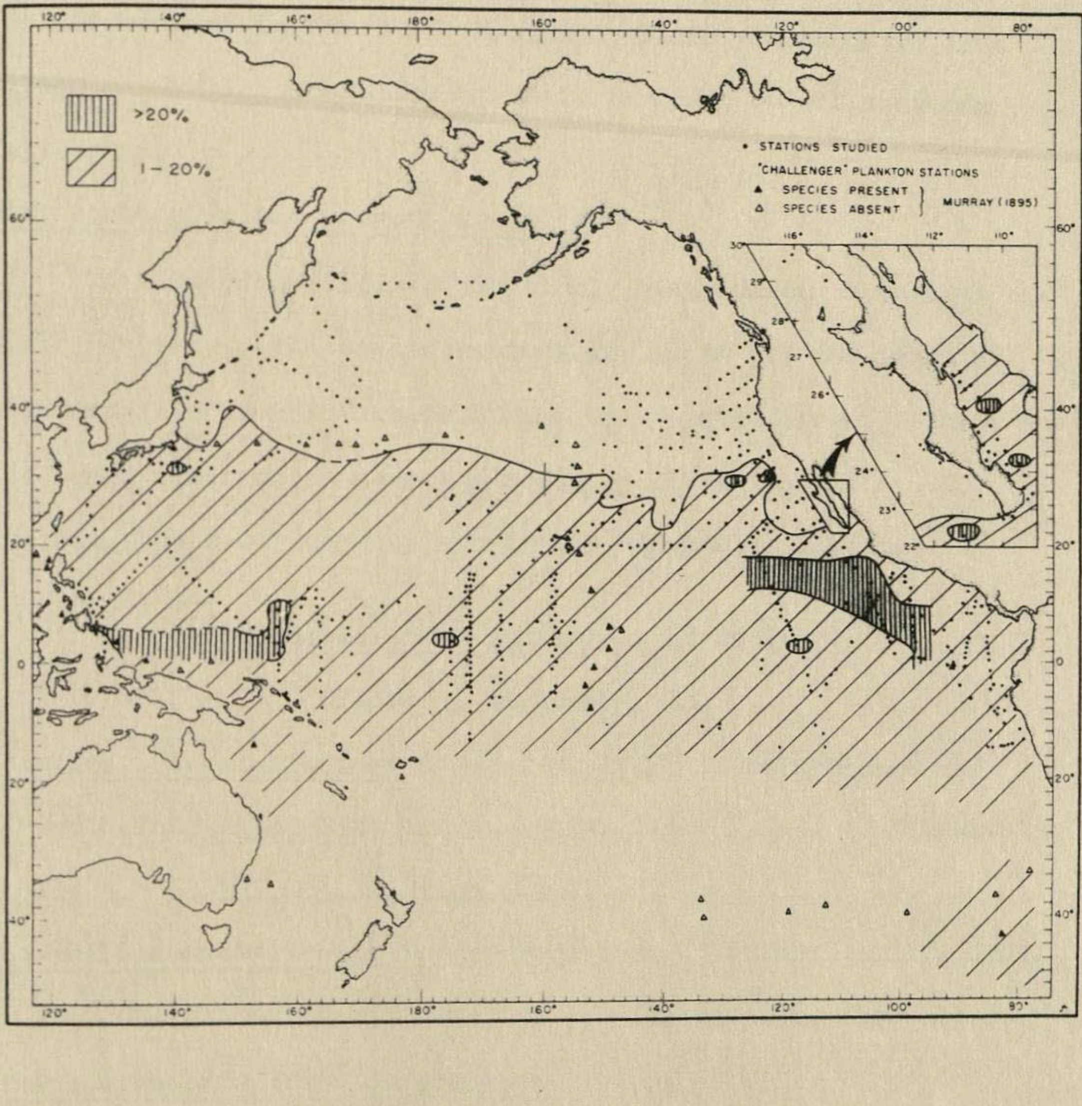
Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900), and Phleger (1945, 1951). There have been no previous records from the plankton of the Pacific Ocean.

Previous reports from Recent sediments in the Pacific

Brady (1884), Bagg (1908), Chapman (1910), Cushman (1915,

Figure 26. Distribution of *Globorotalia menardii* (d'Orbigny) in per cent of total planktonic Foraminifera.



>20%
1 - 20%
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

1927), and Hamilton (1953) record this species from sediments throughout the tropical and temperate regions of the Pacific as follows: from Funafuti and off Hawaii; frequencies of 1 per cent west of Hawaii. Cushman (1915) considers this species to be "rather common" in the North Pacific. It is not reported from Japan, the Philippines, the Marshall Islands, or off southern California.

Distribution in the present study

This species (fig. 27) is widely distributed throughout the North Pacific. High concentrations are found off the coast of Washington in the cold waters of the California Current. There are scattered occurrences near the boundary of the Kuroshio and Oyoshio, the Peru Current, and in the equatorial Pacific.

Globorotalia truncatulinoides (d'Orbigny)

(Plate 3, figures 7, 8)

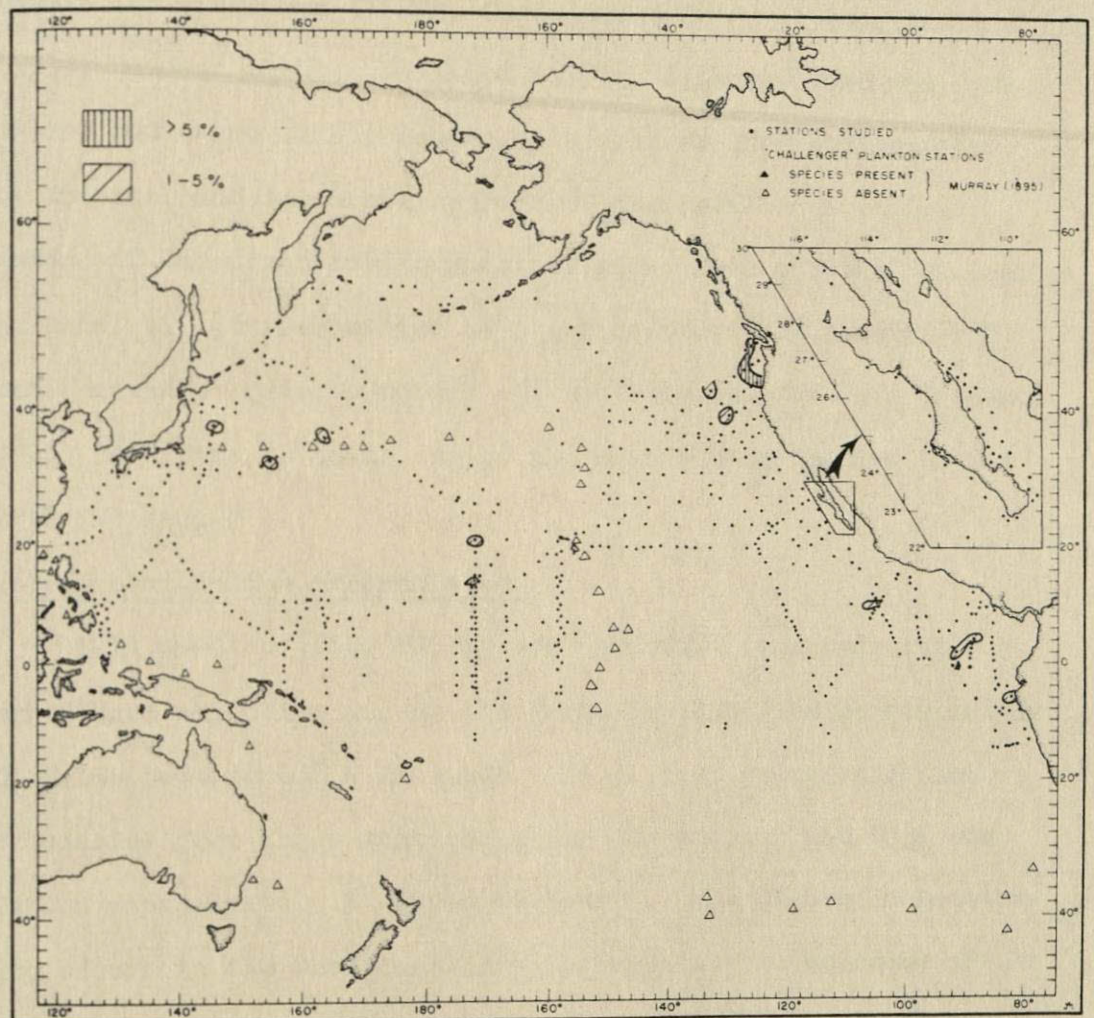
Rotalina truncatulinoides d'Orbigny, 1839, in Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, vol. 2, pt. 2, "Foraminifères," p. 132, pl. 2, figs. 25-27.

Pulvinulina michelineana Brady, 1884 (not d'Orbigny, 1840), Rept. Voy. CHALLENGER, Zool., vol. 9, p. 694, pl. 104, figs. 1, 2.

Previous reports from the plankton

This species has been reported from the plankton tows by Owen (1868), Brady (1884), Murray (1897), Rhumbler (1900), Wiesner (1931), Schott (1935), and Phleger (1945, 1951). Brady (1884) and Murray (1895) record it from 12 plankton tows in the North and

Figure 27. Distribution of <u>Globorotalia scitula</u> (Brady) in per cent of total planktonic Foraminifera.


>5 %
1-5 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)
120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°
116°
114°
112°
110°
30
29
28°
27°
26°
24°
23°
22°

South Pacific.

Previous reports from Recent sediments in the Pacific

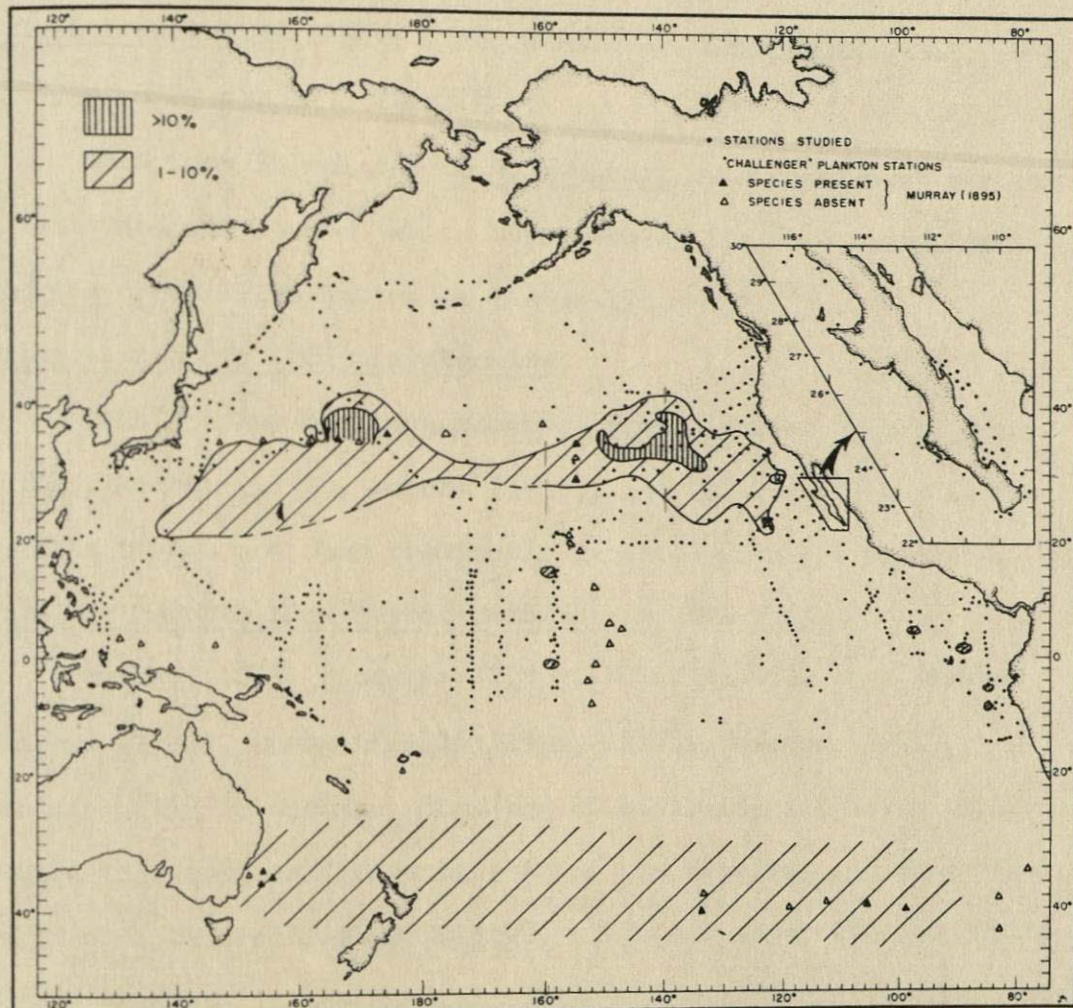
Brady (1884), Picaglia (1893), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1915, 1921, 1925, 1927), Cushman and Wickenden (1929), Cushman and Moyer (1930), Natland (1933), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) report this species from sediments of the tropical and temperate regions of the Pacific as follows: common off Japan and the Marshall Islands; from off the Philippines and Funafuti; at frequencies of 4 per cent west of Hawaii; off Juan Fernandez; rare to common off southern California. Cushman (1915) considers it to be one of the most common species in the North Pacific.

Distribution in the present study

This species (fig. 28) is most abundant in a relatively narrow band extending across the North Pacific from approximately 40° N latitude to 20° N latitude. It is also recorded at low frequencies from three stations along the equator and from one station approximately 5° south of Hawaii. The highest concentration occurs in the west central water mass at the boundary of the warm Kuroshio and the cold Oyashio Currents. Like G. inflata it appears to be primarily a central water species that is occasionally found in the transition region.

It is of interest that Globorotalia truncatulinoides occurs in approximately similar latitudinal ranges in both the North and South Pacific.

Figure 28. Distribution of Globorotalia truncatulinoides d'Orbigny in per cent of total planktonic Foraminifera.



>10%
1-10%
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

Globorotalia tumida (Brady)

(Plate 3, figures 9, 13)

Pulvinulina menardii d'Orbigny var. tumida, Brady, 1877, Geol. Mag., vol. 4, p. 294.

Pulvinulina tumida Brady, 1884, Rept. Voy. CHALLENGER, Zool., vol. 9, p. 692, pl. 103, figs. 4-6.

This form is related to G. menardii by a continuous series of intermediate forms. It is separable by its more tumid form and the crystalline nature of its wall.

Previous reports from the plankton

This species has been recorded from plankton tows by Brady (1884), Murray (1897), Schott (1935), and Phleger (1951. In the Pacific it has not been previously reported from the plankton.

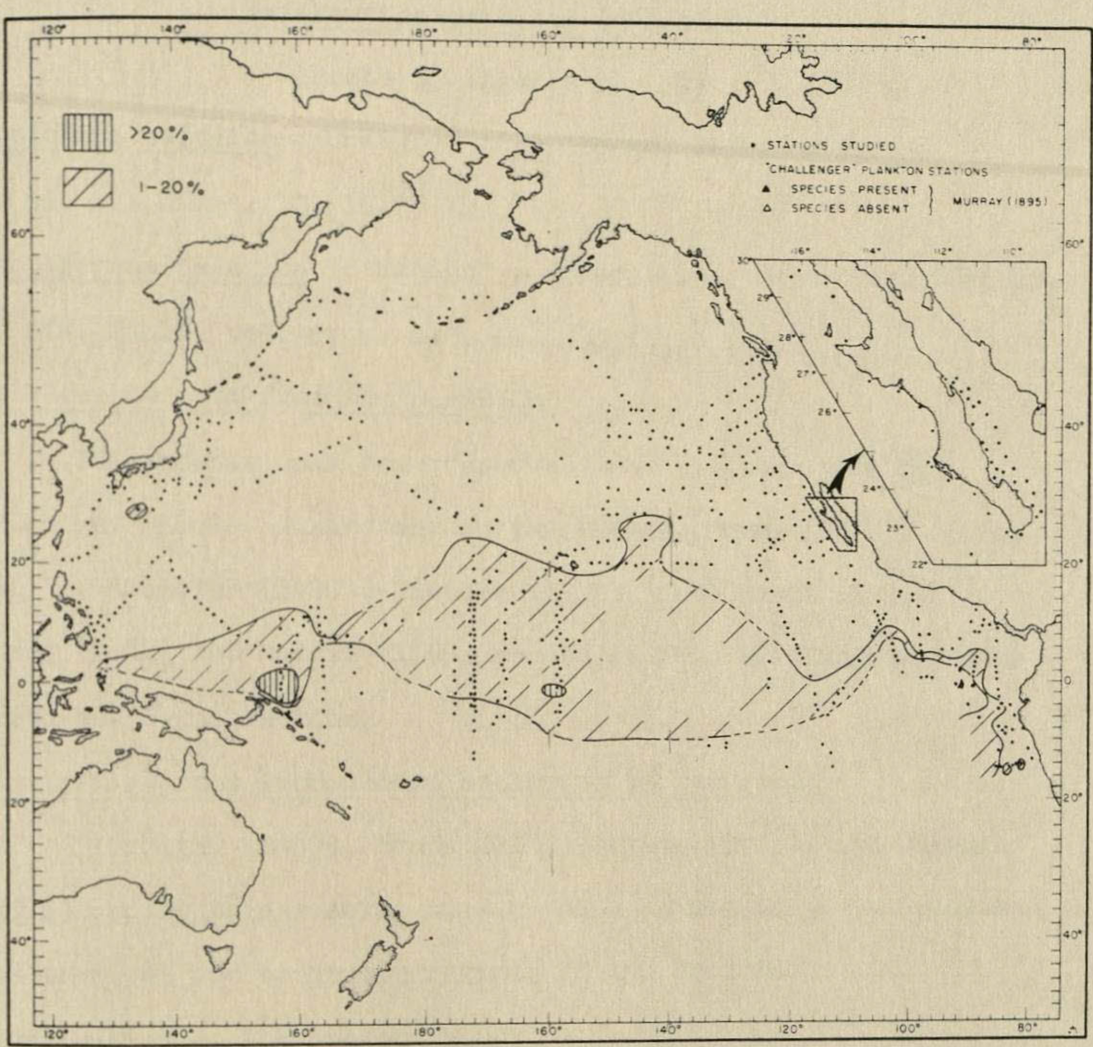
Previous reports from Recent sediments in the Pacific

Brady (1884), Picaglia (1893), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1915, 1921, 1927), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) report this species from sediments of the tropical and warm water regions of the Pacific as follows: from off Japan and the Philippines; abundant in the Marshall Islands and at Funafuti; frequency of 3 per cent west of Hawaii; rare off Central America and southern California.

Distribution in the present study

This species (fig. 29) is found only in the tropical regions. It appears to be less tolerant of cold temperatures than G. menardii

Figure 29. Distribution of *Globorotalia tumida* (Brady) in per cent of total planktonic Foraminifera.



>20%
1-20%
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)
120°
140°
160°
180°
100°
80°
60°
40°
20°
0

and is not found as far north as that species. The highest concentrations of *G. tumida* occur nearer the equator and farther west than the greatest abundance of *G. menardii*.

Hastigerina pelagica (d'Orbigny)

(Plate 3, figures 14, 15)

Nonionina pelagica d'Orbigny, 1839, Foram. Amér. Mérid., p. 27, pl. iii, figs. 13, 14.

Hastigerina pelagica (d'Orbigny), Brady, 1884, Rept. Voy. CHALLENGER, Zool., vol. 9, p. 613, pl. 83, figs. 1-8.

Previous reports from the plankton

This species has been recorded from plankton tows by d'Orbigny (1839), Tizard and Murray (1882), Brady (1884), Murray (1897), Rhumbler (1900), Wiesner (1931), and Schott (1935). Brady (1884) and Murray (1895) record it from 40 stations in the North and South Pacific.

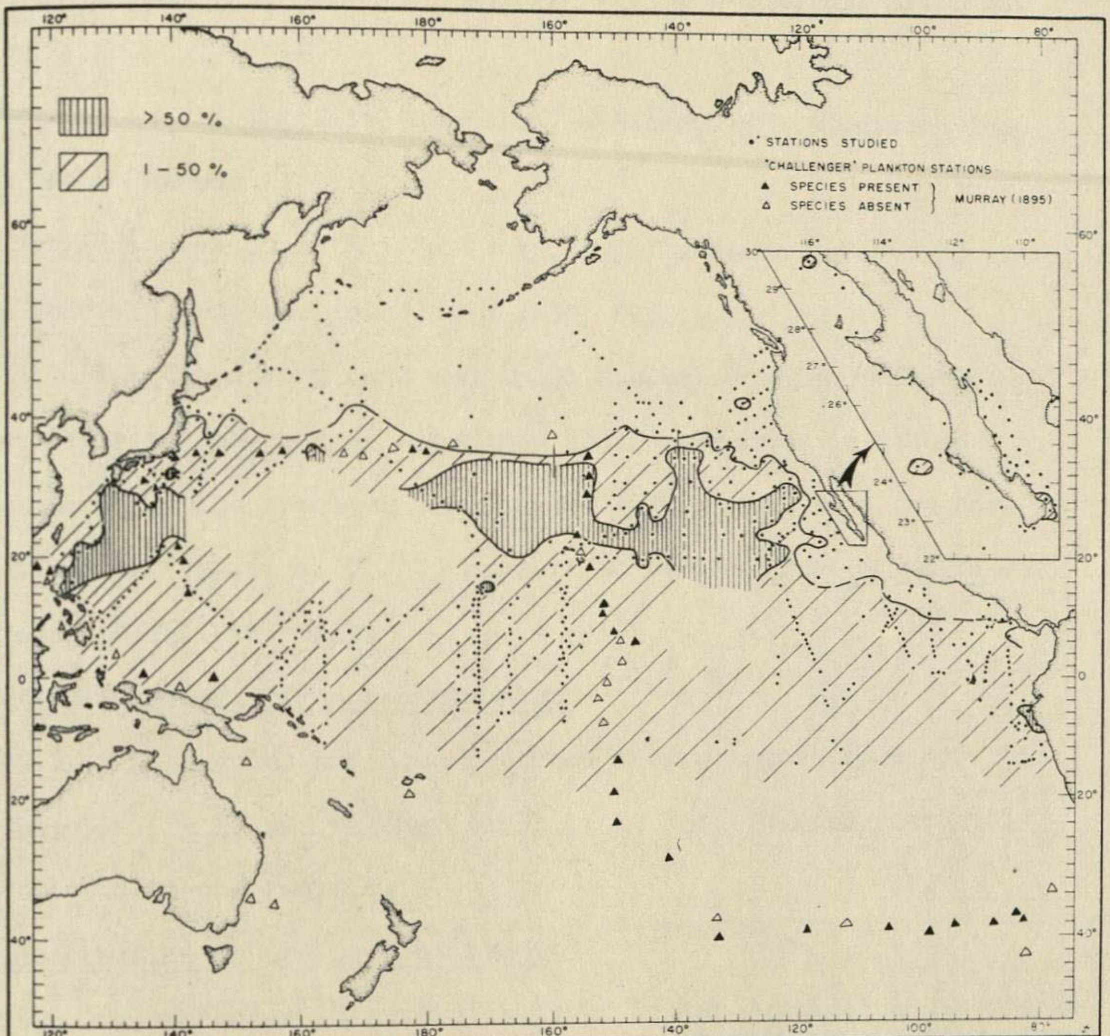
Previous reports from Recent sediments in the Pacific

D'Orbigny (1839), Brady (1884), Flint (1905), and Chapman (1910) report this species as very rare in sediments throughout the tropical and temperate regions of the Pacific.

Distribution in the present study

This species (fig. 30) is found widely distributed in the tropical and warm temperate regions. The greatest concentrations occur in the central oceanic regions. More than 700 specimens per 1000 M^3 occur near Hawaii.

Figure 30. Distribution of Hastigerina pelagica (d'Orbigny) in per cent of total planktonic Foraminifera.



> 50 %
1 - 50 %
STATIONS STUDIED
'CHALLENGER' PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

Hastigerinella rhumbleri Galloway

(Plate 3, figure 16)

Hastigerina digitata Rhumbler, 1911 (not Globigerina digitata Brady), Foram. Plankton-Exped., vol. 3, pt. 1, pl. 37, figs. 9a, b.

Hastigerinella digitata (Rhumbler) Wiesner, 1931, Deutsche Sud-Polar Exped.

Hastigerinella rhumbleri Galloway, 1933, A Manual of Foraminifera, Bloomington, Md., p. 333, pl. 30, fig. 9.

This is a very rare and fragile species which probably explains why there are no reports of its presence in bottom sediments. The specimen illustrated by Cushman, Todd and Post (1954, pl. 91, figs. 9, 10) appears to be the Globigerinella sp. reported in this study.

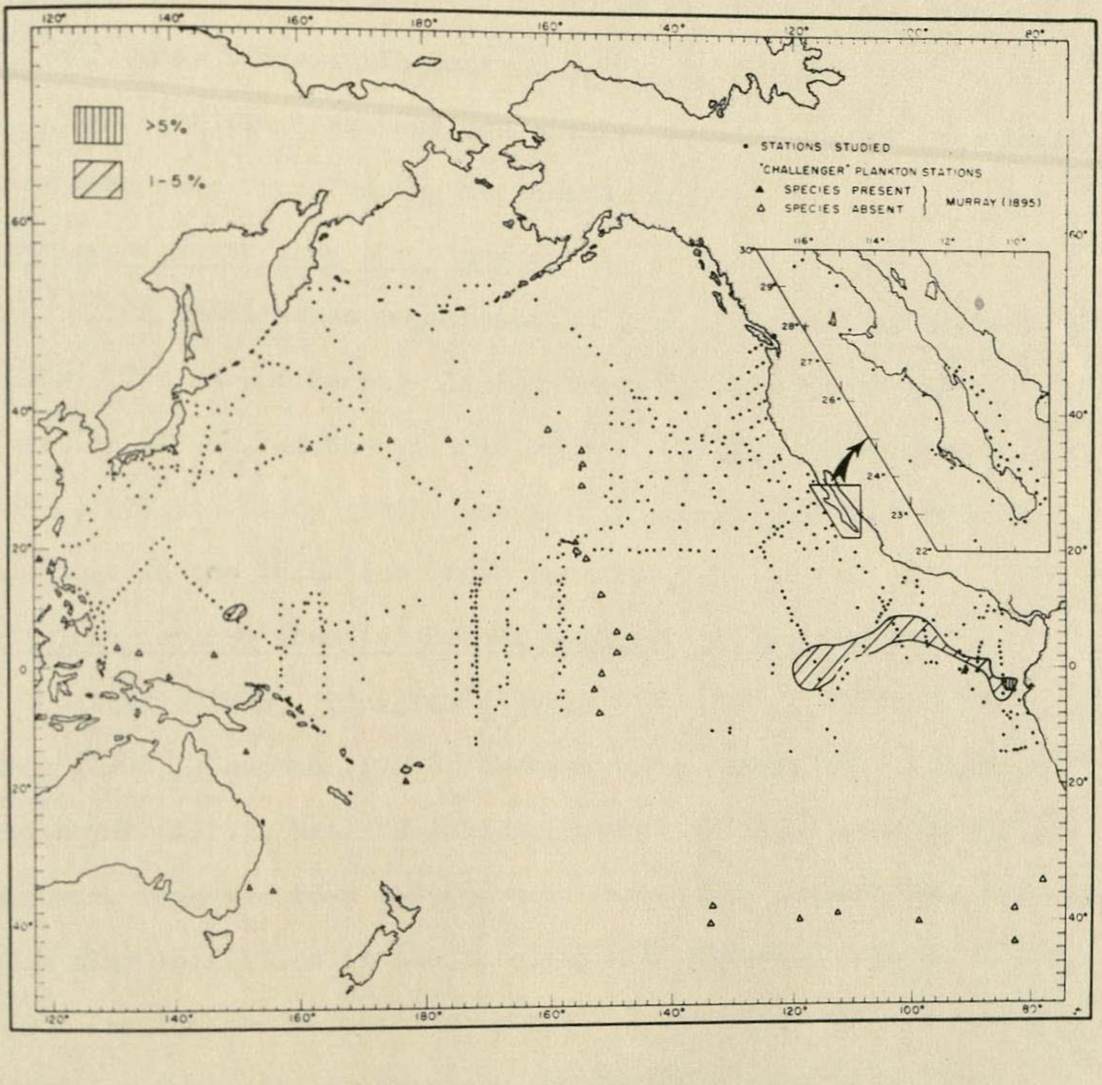
Previous reports from the plankton

This species has been reported from plankton tows by Rhumbler (1911) and Wiesner (1931). It has not been previously reported in the Pacific.

Distribution in the present study

This species (fig. 31) is found in the tropical and temperate regions of the Pacific. It occurs in the upper water layers at 12 stations in the equatorial region, all within 8° of the equator. Two deep occurrences (not shown in the surface distribution on fig. 30) lie outside of this region: one from a deep tow at the junction of the Kuroshio and Oyashio Currents, the other from a

Figure 31. Distribution of *Hastigerinella rhumbleri* Galloway in per cent of total planktonic Foraminifera.



>5%
1-5 %
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

deep open and closing haul off San Diego, California.

Orbulina universa d'Orbigny

(Plate 3, figures 17, 18)

Orbulina universa d'Orbigny, 1839 in De la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères," p. 3, pl. 1, fig. 1

Most of the specimens are similar to the type but occasionally specimens were found having two chambers.

Previous reports from the plankton

This species has been reported from plankton tows by Owen (1866), Tizard and Murray (1882), Brady (1884), Murray (1897), Rhumbler (1900), Wiesner (1931), Schott (1935), and Phleger (1945, 1951). Brady (1884) and Murray (1895) report it from 72 stations in the North and South Pacific.

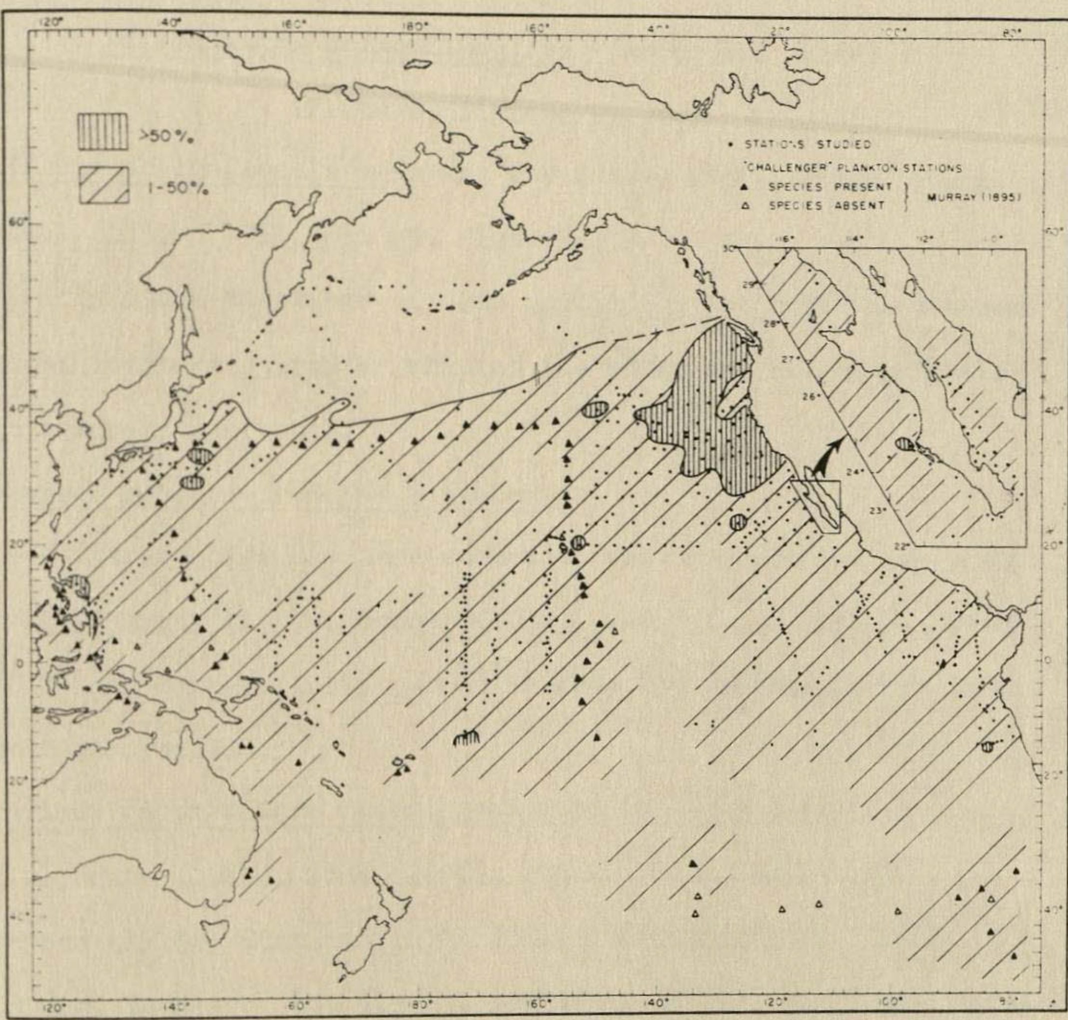
Previous reports from the Recent sediments in the Pacific

Brady (1884), Picaglia (1893), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1927), Cushman and Moyer (1929), Natland (1933), Butcher (1951), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) report this species from many localities in the tropical and temperate regions of the North Pacific as follows: common off Japan; rare off the Philippines; at Funafuti; abundant in the Marshall Islands; at frequencies of 4 per cent west of Hawaii; abundant off southern California.

Distribution in the present study

This species (fig. 32) is very widely distributed in the

Figure 32. Distribution of *Orbulina universa* d'Orbigny in per cent of total planktonic Foraminifera.



>50%
1-50%
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)

tropical and temperate regions. The highest concentration is recorded near Hawaii but high abundances were also noted within the cool California Current, along the equator, and near the boundary of the Kuroshio and Oyashio Currents.

Pulleniatina obliquiloculata (Parker and Jones)

(Plate 3, figures 19, 20)

Pullenia obliquiloculata Parker and Jones, 1865, Philos. Trans., vol. 155, p. 368, pl. 19, figs. 4a, b.

Immature specimens of this species do not have the crescent shaped aperture characteristic of the adult and are more lobate and coarsely perforate.

Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Schott (1935), and Phleger (1951). Brady (1884) and Murray (1895) record it from 13 stations in the North and South Pacific.

Previous reports from Recent sediments in the Pacific

Brady (1884), Goes (1896), Flint (1905), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1927), Hamilton (1953), Cushman, Todd and Post (1954), and Asano (1957) record this species from the tropical and warm temperate regions of the Pacific as follows: common off Japan and the Philippines; at Funafuti; abundant in the Marshall Islands; at frequencies of 3 per cent west of Hawaii becoming more abundant near Hawaii; at scattered localities off the west coast of North America. Cushman records this as "one of the most common and widely distributed species of the North Pacific."

Distribution in the present study

This species (fig. 33) is most common in the tropical region. The area of maximum abundance (> 1000 specimens/1000 M^3) lies in the center of the Pacific equatorial water mass south of Hawaii. The concentrations appear to diminish to the east and west.

Sphaeroidinella dehiscens (Parker and Jones)

(Plate 3, figures 21, 22, 23)

Sphaeroidina dehiscens Parker and Jones, 1865, Philos. Trans., vol. 155, p. 369, pl. 19, figs. 5 a-c.

Some of the specimens are difficult to distinguish from Globigerinoides sacculifera.

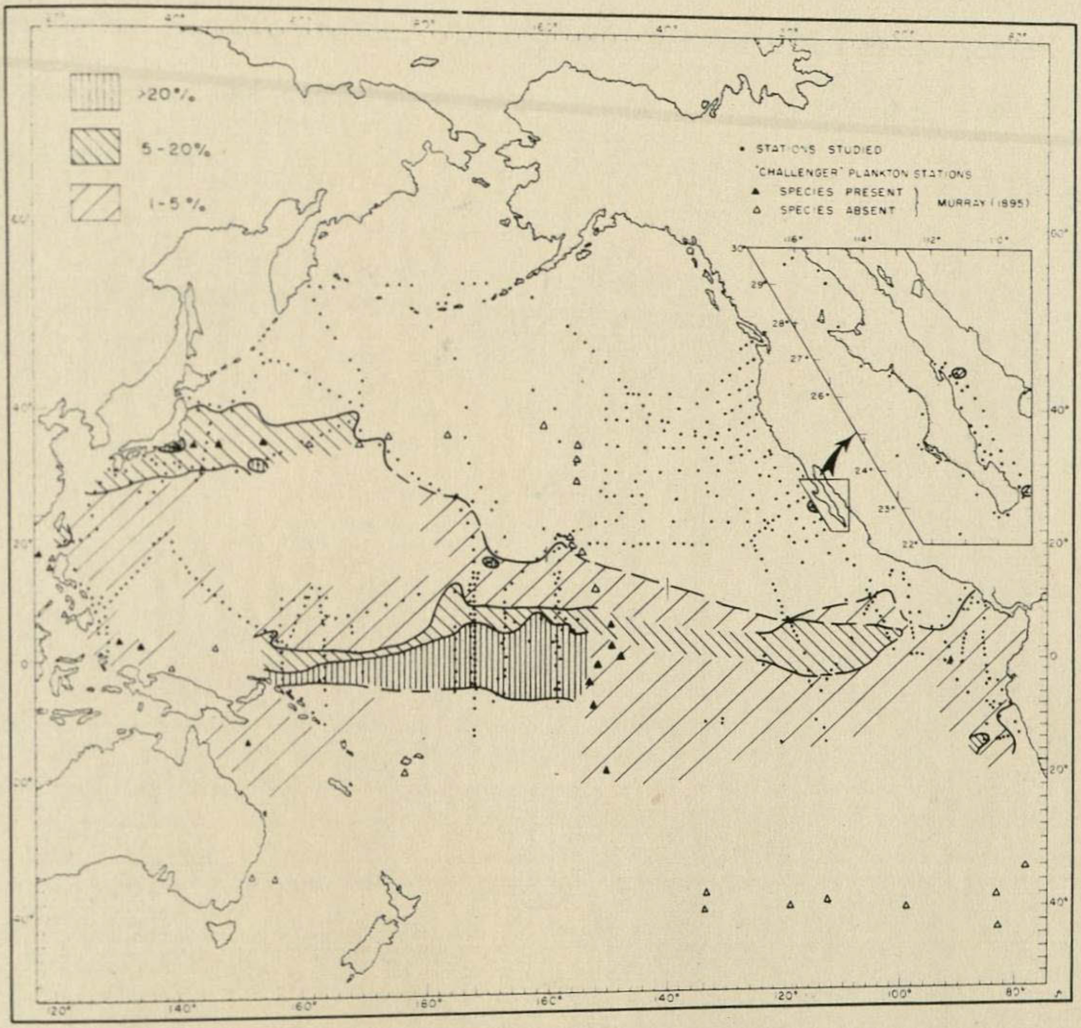
Previous reports from the plankton

This species has been reported from plankton tows by Brady (1884), Murray (1897), Rhumbler (1900), and Schott (1935). Brady (1884) and Murray (1895) record this form from five localities in the North and South Pacific.

Previous reports from Recent sediments in the Pacific

Brady (1884), Picaglia (1893), Goes (1896), Bagg (1908), Chapman (1910), Cushman (1914, 1921, 1925, 1927), Hamilton (1953), Cushman, Todd and Post (1954) report this species in the tropical regions of the Pacific as follows: common in the China Sea and east of the Philippines; from Funafuti; abundant in the Marshall Islands; frequencies less than 1 per cent west of Hawaii; common

Figure 33. Distribution of *Pulleniatina obliquiloculata* (Parker and Jones) in per cent of total planktonic Foraminifera.



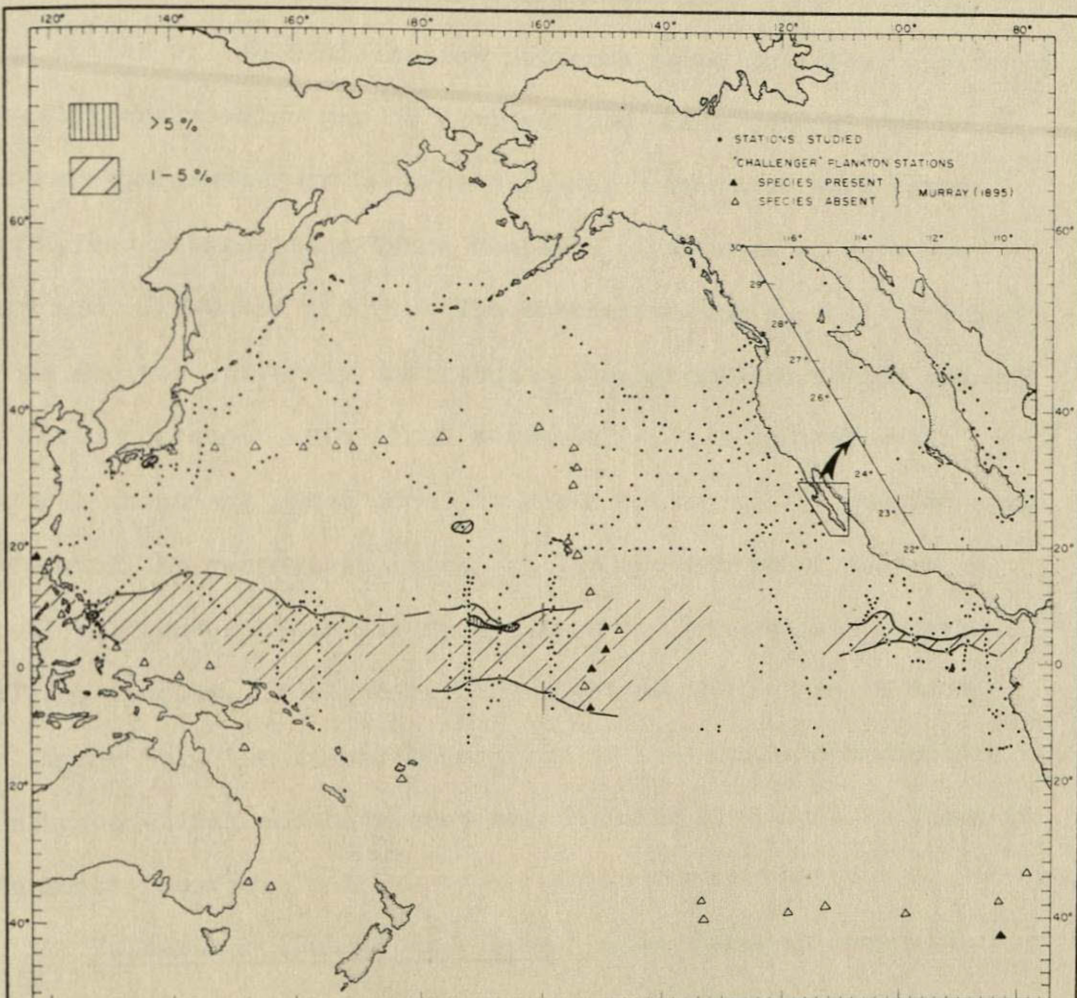
>20%
5-20%
1-5%
STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
SPECIES PRESENT
SPECIES ABSENT
MURRAY (1895)
120°
140°
160°
180°
160°
140°
120°
100°
80°
40°
20°
0
20°
40°
60°

at stations off Hawaii, very rare off Central America. It is not reported off Japan.

Distribution in the present study

This species (fig. 34) is most abundant in the center of the equatorial Pacific region. To the east and west the frequencies become less. One occurrence is recorded from the Kuroshio off southern Japan.

Figure 34. Distribution of *Sphaeroidinella dehiscens* (Parker and Jones) in per cent of total planktonic Foraminifera.



>5 %
1-5 %
• STATIONS STUDIED
"CHALLENGER" PLANKTON STATIONS
▲ SPECIES PRESENT
△ SPECIES ABSENT
MURRAY (1895)

DISTRIBUTION OF PLANKTONIC FORAMINIFERA IN THE PACIFIC

Geographic distribution of faunas

The distributions of the species in the surface water of the North and equatorial Pacific are shown in figures 8 to 34. Examination of the distribution patterns shows that the planktonic Foraminifera species may be divided into three general groups, a northern cold-water or Subarctic fauna, a southern warm-water fauna, and a transition fauna composed of species of both the warm and cold-water groups. The species making up the warm-water fauna are not uniformly distributed throughout the region and may be further grouped into minor assemblages. In general these natural groupings based upon the distribution of the species coincide with the geographic extent of the surface water masses as previously described. Figure 35 shows the generalized ranges of all the species. The geographic extent of the faunas is shown in figure 36. The faunal boundaries in the southern hemisphere are hypothetical and have been extrapolated from what is known in the North Pacific.

Cold-water (Subarctic) fauna. This fauna is composed of species that are restricted to the Subarctic region and also includes a few wide-ranging forms that extend into the warm-water region to the south. The following species have their highest frequencies in this region:

Figure 35. Generalized ranges of species.

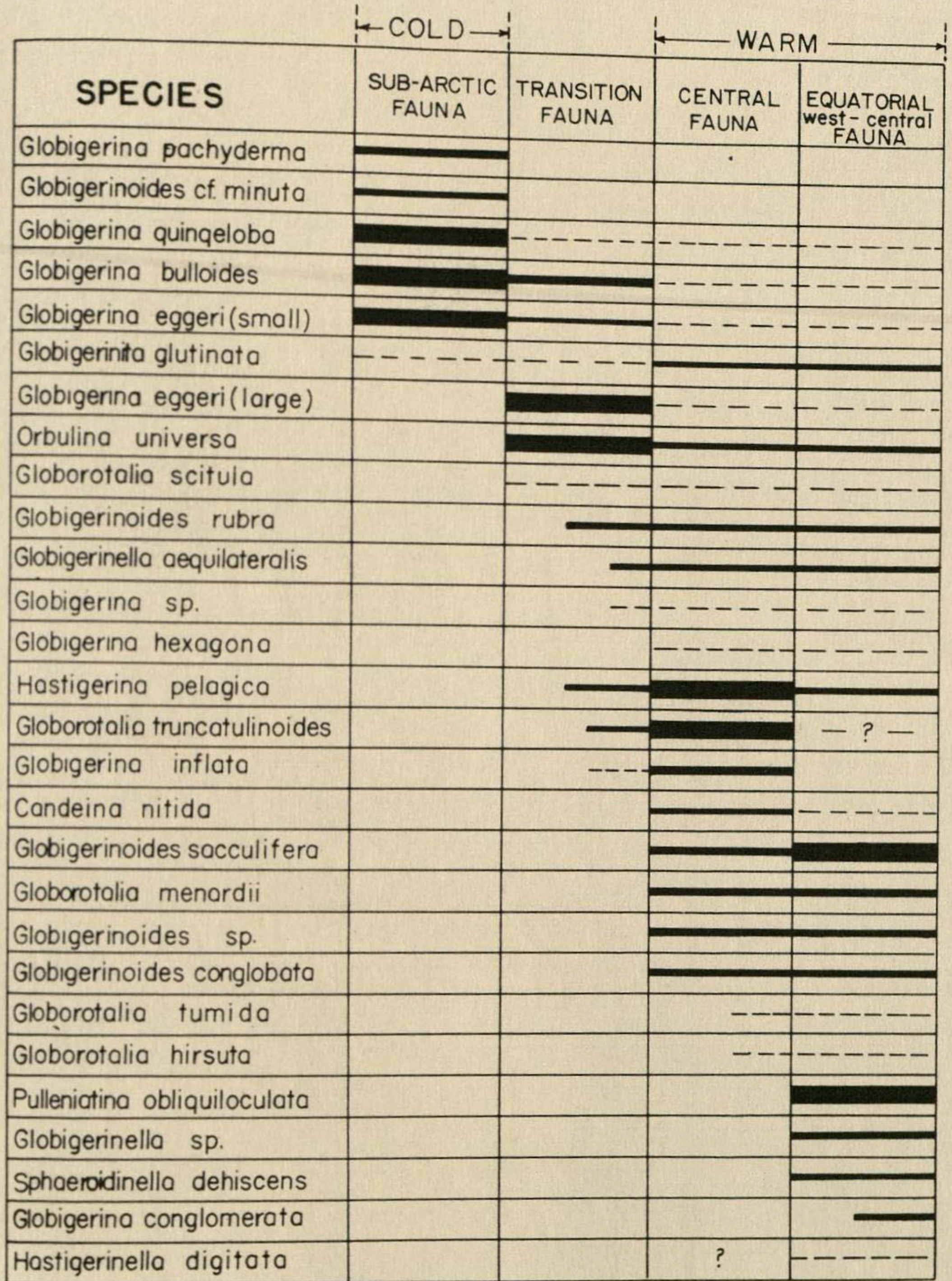
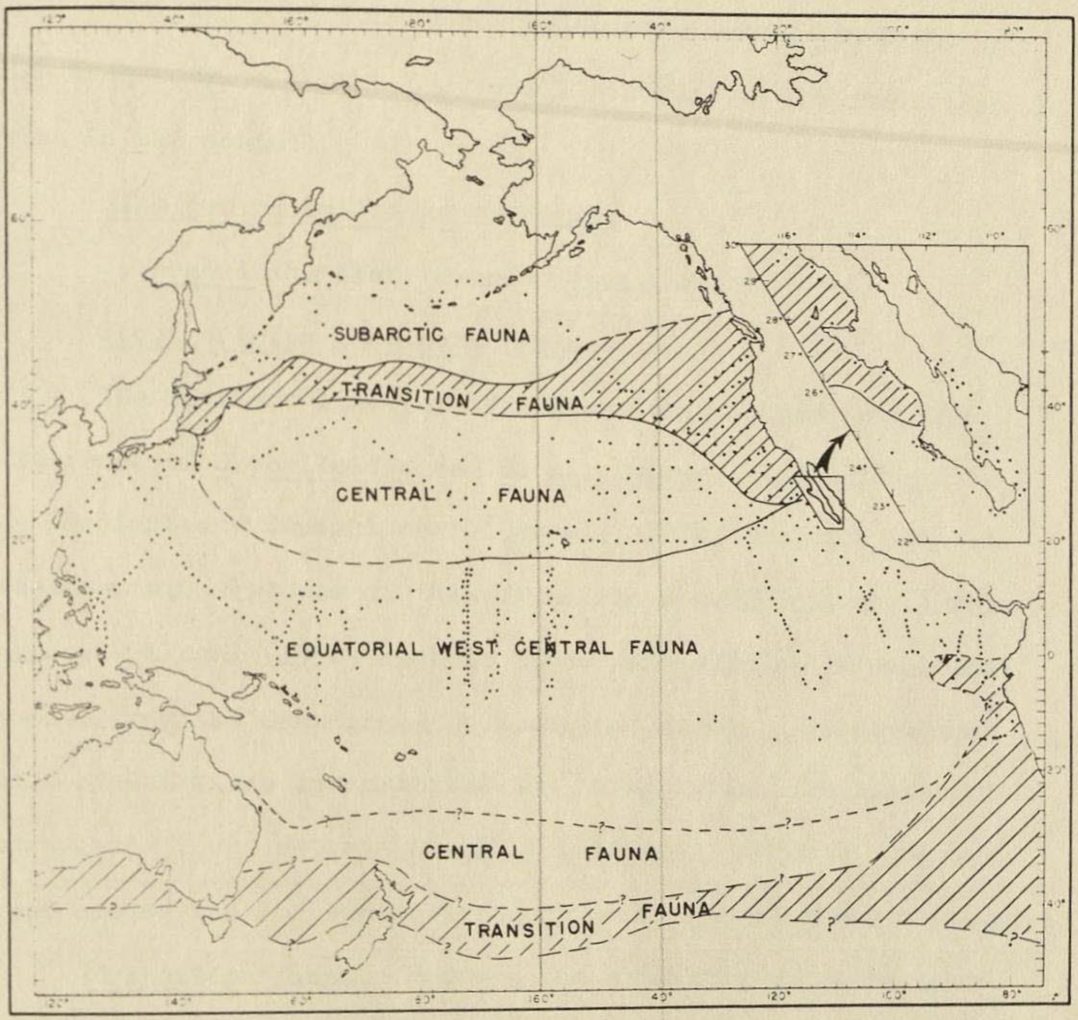

COLD
WARM
SPECIES
SUB-ARCTIC FAUNA
TRANSITION FAUNA
CENTRAL FAUNA
EQUATORIAL west - central FAUNA
Globigerina pachyderma
Globigerinoides cf. minuta
Globigerina quinqeloba
Globigerina bulloides
Globigerina eggeri (small)
Globigerinita glutinata
Globigerina eggeri (large)
Orbulina universa
Globorotalia scitula
Globigerinoides rubra
Globigerinella aequilateralis
Globigerina sp.
Globigerina hexagona
Hastigerina pelagica
Globorotalia truncatulinoides
Globigerina inflata
Candeina nitida
Globigerinoides sacculifera
Globorotalia menardii
Globigerinoides sp.
Globigerinoides conglobata
Globorotalia tumida
Globorotalia hirsuta
Pulleniatina obliquiloculata
Globigerinella sp.
Sphaeroidinella dehiscens
Globigerina conglomerata
Hastigerinella digitata
?
?

Figure 36. Generalized distribution of faunal assemblages.


SUBARCTIC FAUNA
TRANSITION FAUNA
CENTRAL FAUNA
EQUATORIAL WEST CENTRAL FAUNA
CENTRAL FAUNA
TRANSITION FAUNA

Globigerina pachyderma (Ehrenberg)

Globigerina cf. *G. dutertrei* d'Orbigny

Globigerina quinqueloba Natland

Globigerinoides cf. *G. minuta* Natland

The following forms occur with this fauna, sometimes in high frequency, although they are also found in the transition fauna to the south:

Globigerina bulloides d'Orbigny

G. eggeri Rhumbler (dwarfed specimens)

Globigerinita glutinata (Egger)

The northern limit of this group is not known but the occurrence of *G. bulloides* and *G. pachyderma* from sediments of the Beaufort and Chukchi Seas (Carsola, 1952) suggests that at least certain elements of this fauna range well into the Arctic region. Phleger (1952) reports these same species in sediment samples from the Canadian and Greenland Arctic. The southern limit of the fauna approximates the "polar-front" or subarctic convergence found between 40-45° N latitude. Where no distinct front occurs the 15° summer isotherm marks the southern boundary.

Transition fauna. Between the subarctic and warm-water regions lies an extensive area of faunal mixing. The characteristic fauna contains elements of both the northern Subarctic fauna and the warm-water faunas to the south and west. The species composition varies depending upon the distance from the original faunas and the degree of mixing.

The following species are commonly found in this region:

Globigerina bulloides d'Orbigny

Globigerina eggeri (large specimens) Rhumbler

G. quinqueloba Natland

Globigerinoides rubra (d'Orbigny)

Orbulina universa d'Orbigny

The northern boundary of the transition region is arbitrarily defined as the northern limit of the distribution of Orbulina universa and large specimens of G. eggeri. The southern boundary is marked by the appearance of equatorial species such as Globigerinoides sacculifera and Globorotalia menardii.

The 15° and 20° summer isotherms are closely associated with these limits north and south while the seaward edge of the California Current also marks the western boundary in the northeast Pacific. The geographic limits of this region are not fixed but appear to vary in response to seasonal changes. In the summer occasional specimens of Hastigerina pelagica, Globorotalia truncatulinoides, Globigerina inflata, and Globigerinella aequilateralis occur, especially in the southern portion but they appear to be "terminal emigrants" carried in by warm water from the regions to the south and west.

Although the transition fauna is best developed along the west coast of North America, there are also indications of its occurrence in other localities along the boundary of the cold and warm faunas. The species from Chinook stations 5 and 6 in the mid-Pacific and Transpac stations 52, 55, 56, and 60 northeast of Japan appear to belong to this group. The lack of closely spaced samples in these areas of rapid faunal change prevent more detailed delimitation of the areal extent of this fauna. There are indications of the presence of a transition fauna in the Peru Current, where the oceanographic conditions are similar to those of the California Current.

Warm-water faunas. The area covered by these faunas includes the equatorial region and the central regions of the North and South Pacific. The northern boundary corresponds to the southern limit of the transition region as defined above. The 20° isotherm associated with this boundary also presumably marks the southern extent of these faunas in the South Pacific.

Within this large region several minor faunal groups can be defined:

1. Central Water Assemblage. This group is found in both the western and eastern central water masses of the North Pacific but appears to be absent, at least in surface layers, from the equatorial region. Representative species of this assemblage are:

Globigerina inflata d'Orbigny

Globorotalia truncatulinoides (d'Orbigny)

2. Equatorial-west central assemblage. This group consists of those species that are limited to water of the most tropical character, which in this area is defined by the Pacific Equatorial and western North Pacific Central water masses. The following

species are restricted to this area:

Sphaeroidinella dehiscens (Parker and Jones)

Globorotalia tumida (H. B. Brady)

Globigerina conglomerata Schwager

Globigerinella sp.

Pulleniatina obliquiloculata (Parker and Jones)

One of these species (*Globigerina conglomerata*) may be limited to the Equatorial region since it has not yet been reported from the west central Pacific.

Mixed warm water fauna. Many species are found throughout the entire warm water region although they may occur in higher frequencies in either the Equatorial or the central assemblage.

The following species are more common in the central fauna although they also occur in the Equatorial west central region:

Hastigerina pelagica (d'Orbigny)

Cándeina nitida d'Orbigny

Globorotalia scitula (H. B. Brady)

The following species are more common in the Equatorial-west central region although they also occur in the central fauna:

Globigerinoides sacculifera (H. B. Brady)

Globigerinoides conglobata (H. B. Brady)

Globigerinella aequilateralis (H. B. Brady)

Globigerina hexagona Natland

Globorotalia menardii (d'Orbigny)

Globigerinoides rubra (d'Orbigny)

Globigerinoides sp.

Globigerinita glutinata (Egger)

Globorotalia hirsuta (d'Orbigny)

Hastigerinella rhumbleri Galloway

Geographic variations in abundance of planktonic Foraminifera

Figures 37 and 38 show the areal distributions of total populations of Foraminifera from coarse and fine meshed net samples. Figure 39 shows changes in the total population on one traverse crossing the Equatorial region. Examination of the figures shows that in general the various oceanographic regions support different concentrations of Foraminifera. The boundaries of these areas are generally similar to those defined for the faunal groups. The Subarctic region (north of 45° N latitude) is characterized by large total populations although the number of species is small. The greatest concentration at a single station (560 specimens per cubic meter) was found at Transpac station 24 in this region.

The transition region contains a greater number of species than in the Subarctic and has somewhat smaller populations than in the Subarctic region. At several stations near the mixing of the Kuroshio and Oyashio relatively small populations were recorded.

Samples from the Equatorial region have variable total populations. At localities in the Equatorial Current system and in certain localized areas such as the Gulf of California, extremely high populations are recorded from the coarse mesh net samples. Elsewhere the population may be relatively low. The few fine-mesh

Figure 37. Distribution of total planktonic Foraminifera from meter net samples.

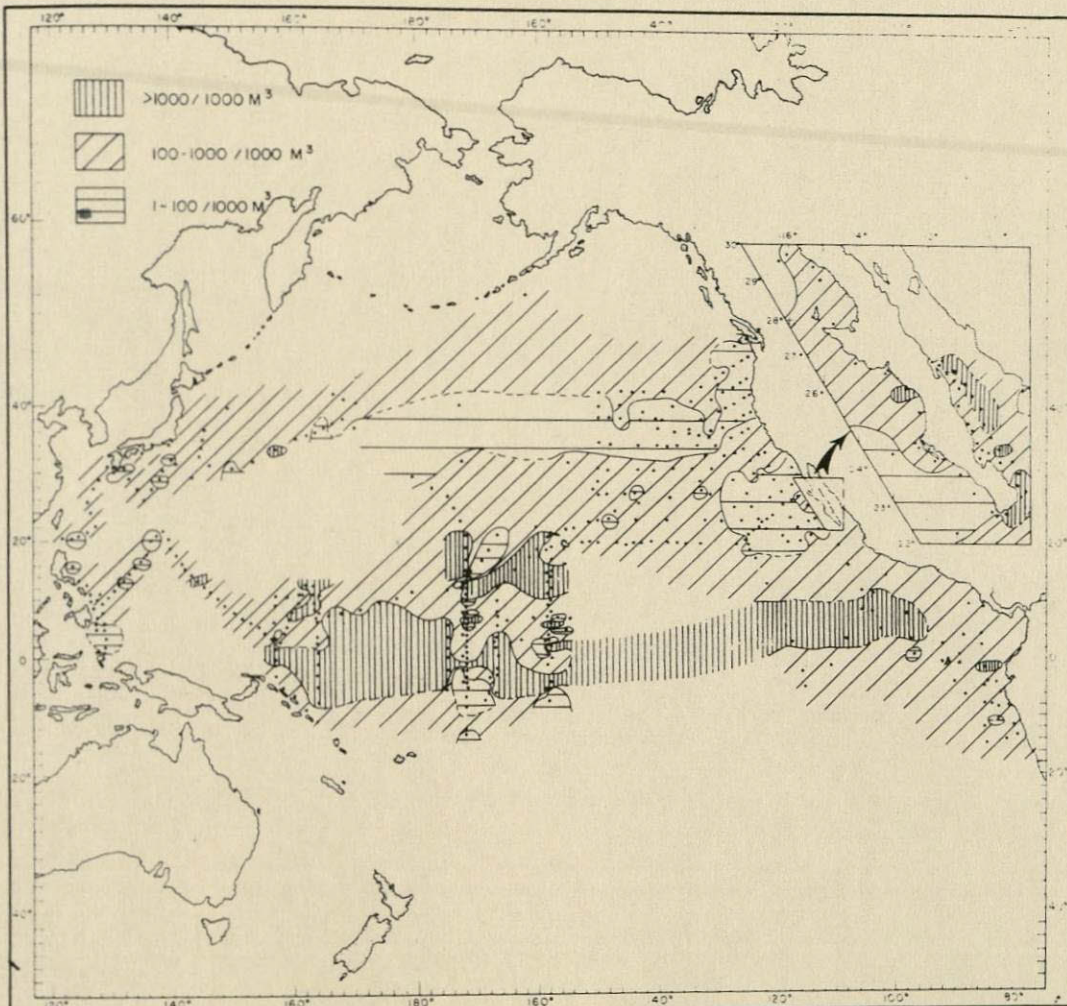
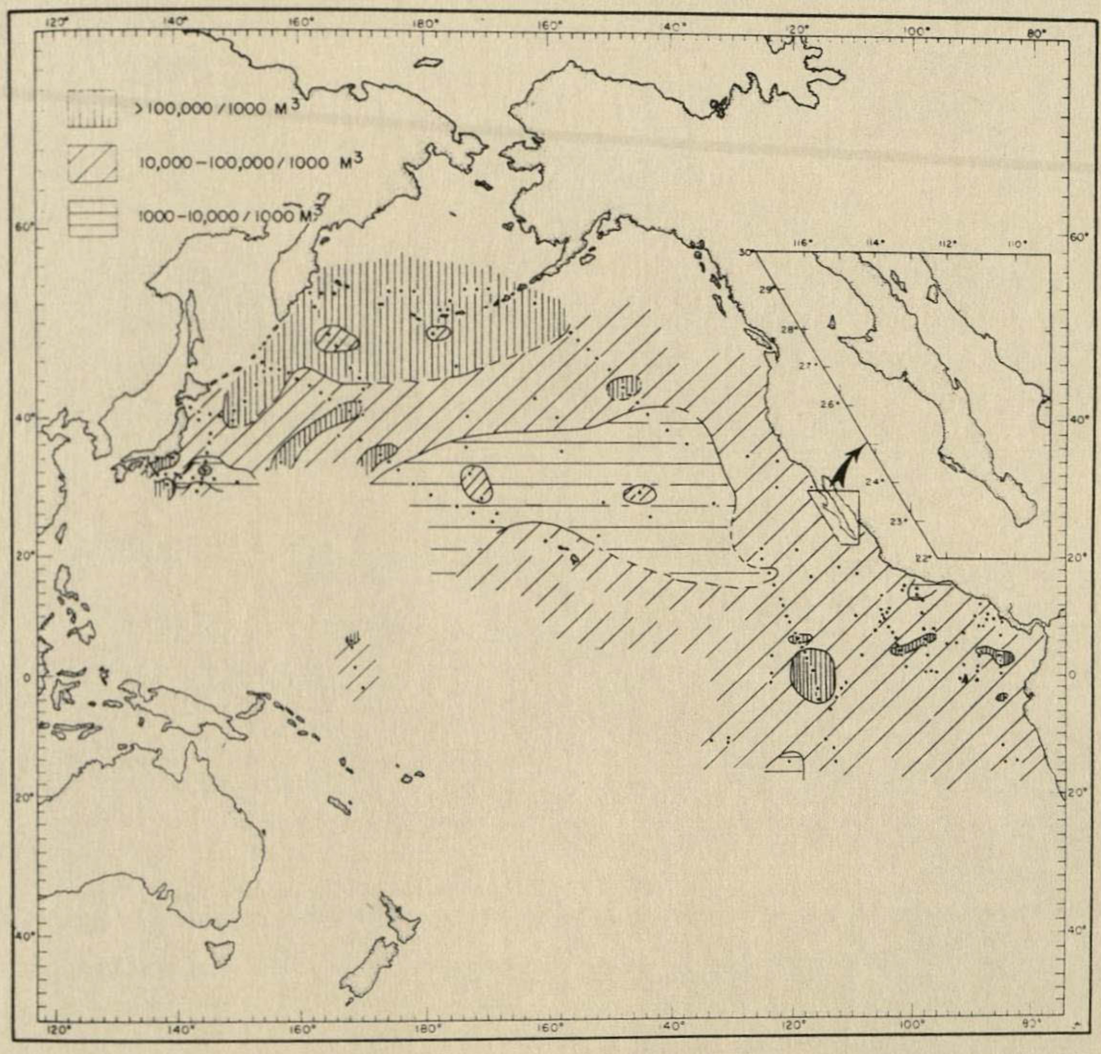

>1000 / 1000 M³
100-1000 / 1000 M³
1-100 / 1000 M³
120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°

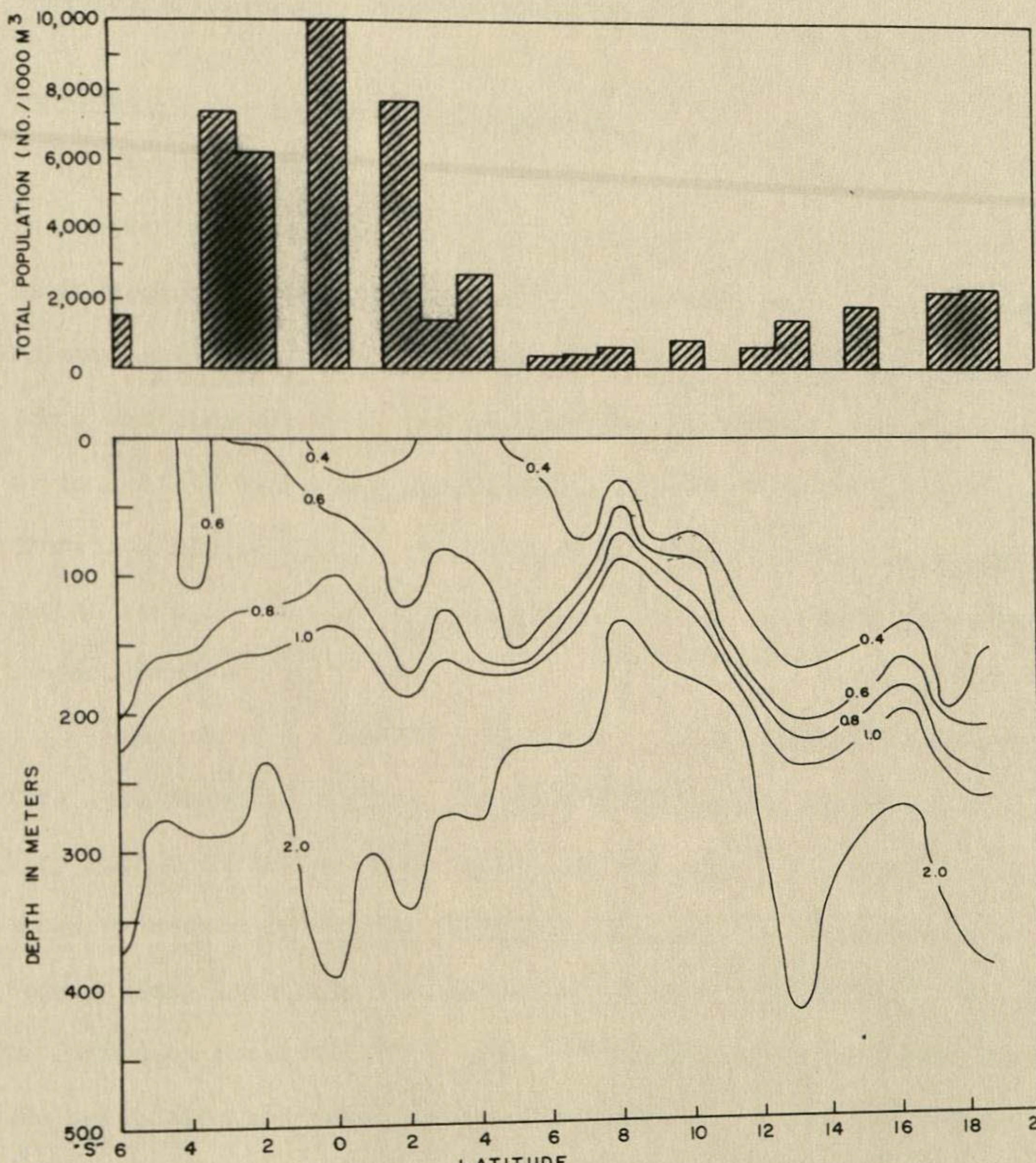
Figure 38. Distributions of total planktonic Foraminifera from Clarke-Bumpus and 17 cm. vertical net tows.



>100,000 / 1000 M3
10,000–100,000 / 1000 M3
1000–10,000 / 1000 M3
120°
140°
160°
180°
160°
140°
120°
100°
80°
60°
40°
20°
0
20°
40°
116°
114°
112°
110°
30
29°
28°
27°
26°
24°
23°
22°

Figure 39. Upper: Variations in abundance of total planktonic Foraminifera from one traverse across the equatorial region at 167° W.

Lower: Phosphate concentrations (µg-atoms P/L) for the same section. Equapac (Stranger) stations 1-27.



TOTAL POPULATION (NO./1000 M3)
10,000
8,000
6,000
4,000
2,000
0
DEPTH IN METERS
0
100
200
300
400
500
0.4
0.6
0.8
1.0
2.0
"S" 6
4
2
0
2
4
6
8
10
12
14
16
18
20°N
LATITUDE

net hauls in this region indicate lower total populations than in the Subarctic region.

The central water region generally supports the lowest Foraminifera concentrations throughout the entire area examined.

Vertical distribution of Foraminifera

A knowledge of the vertical range of planktonic Foraminifera in the water column is necessary for a better understanding of their regional distribution and for a better analysis of the complex relationships to their environment. Furthermore, in using planktonic Foraminifera from the sediments to interpret climatic conditions it is necessary to know what water depths are being interpreted. Phleger (1945, 1951) discussed these problems and suggested certain methods of attack, many of which were used in the present study.

Most of the previous samples of living planktonic Foraminifera were taken by shallow net tows and were not quantitative. Very little direct evidence was then available to support the ideas expressed by Murray (1897, p. 22) that the planktonic Foraminifera live only at the ocean surface. Murray's opinion was based on observation of the distribution of empty tests on the sea bottom and only partly on an analysis of net samples. Carpenter (1875) and Brady (1884), on the other hand, believed that the smaller and younger forms were to be found at the surface and that the larger, older ones lived on the bottom.

Little evidence was presented favoring either viewpoint and it was not until the work of Lohmann (1920) that more facts were made available. Lohmann, in analyzing water samples from the Atlantic, found more specimens of Globigerina in the upper 100 meters of water than at greater depths. The following table is taken from Lohmann's data:

Depth	Number of individuals
0 m	100
50 m	67
100 m	60
200 m	7
400 m	3

Schott (1935) presented the results of Nansen closing net samples taken by the Meteor Expedition in the Equatorial Atlantic Ocean. These data have been analyzed by Phleger (1945) as follows:

Depth in meters	No. of tows	Mean no. of spec./tow
0-100	71	489
100-200	7	8
200-400	13	24
400-600	19	10
600-800	12	11
800-1000	19	28

In these early studies on vertical distribution no distinction was made between the living Foraminifera and their empty tests. It is only the living organisms which should be considered when determining the true living environment since some dead or dying specimens sinking to the bottom would be expected at every depth. Phleger (1945, 1951) realized this problem and used a modification of the biuret test for protein in differentiating the living from the empty tests in plankton tows from the North Atlantic and the Gulf of Mexico. Phleger's data indicate a higher concentration of living and dead specimens in the upper 100 meters, although at some of his stations a greater concentration of living Foraminifera was found deeper.

Variations of total population with depth

Table 8 shows the data from detailed studies of vertical distribution from various locations in the Pacific. The following general conclusions have been drawn from these data:

1. The samples taken directly from the sea surface contained fewer specimens at most of the stations than were found at slightly lower depths.

2. The highest concentrations of Foraminifera occurred between 6 to 30 meters at most of the stations. At no station did the greatest concentration occur below 100 meters.

3. The depth of greatest decrease in number per cubic meter occurred between 50 and 100 meters at most of the stations.

4. Relatively low concentrations of specimens were noted below 1,000 meters.

Diurnal migration. Diurnal vertical migrations are well known in many planktonic animals. At night the highest concentrations of individuals are reported near the surface while in the daytime the greatest concentrations are in the deeper water (Sverdrup et al., 1942). Haeckel (1887) reported ascending and descending movements for Radiolaria but did not correlate these migrations with day and night changes. Owen (1868, pp. 148 and 156) reports that the highest concentrations of planktonic Foraminifera are found near the surface at night. Rhumbler (1911, chart A) compares night and day tows in the North Atlantic. Examination of this chart shows that in general the day tows have much higher concentrations of Foraminifera than the night stations. Allan Bé (personal communication) notes that in surface net tows off Bermuda, "Three night tows were 30-40% poorer than the seven day tows taken at the same place. A similar observation is true between 2 day tows and 1 night tow taken at the same location in the Caribbean."

A comparison has been made between the concentrations of total planktonic Foraminifera per cubic meter in surface hauls at day and night stations to discover whether a similar relationship holds true in the Pacific. The data have been obtained from King and Demond (1953) for the following cruises: POFI 2, 5, and 8. Data for POFI cruise 16 was taken from Hida and King (1955). Table 9 shows the results of this comparison. It will be noted that the ratio of Night/Day hauls in all cases is less than 1, indicating that there is greater concentration at the surface during the day.

POFI cruise 16 obtained data on concentration of total planktonic Foraminifera at the surface, in intermediate depths, and in deep water. Table 9 shows the surface Foraminifera during the day are generally more abundant than they are at night, but in the deep samples the night catches average more than the day samples. This suggests that Foraminifera ascend to the surface during the day and descend at night.

A possible mechanism for this may be found in the probable day and night differences in oxygen production by the symbiotic algae in the protoplasm. During the day the oxygen may be produced so rapidly that bubbles are formed, causing the Foraminifera to rise toward the surface. The utilization of oxygen for respiration during the night would result in an increase of specific gravity resulting in the sinking from the upper layers.

DISCUSSION

Ecologic factors

Each species tends to extend its range whenever possible by continuous pressure against its boundaries. The boundaries are to a large extent determined by the limiting effects of various environmental factors of which a large number exist. Food, oxygen, temperature, salinity, pH, dissolved inorganic and organic substances, and biological interactions are but a few of the possible factors having a direct effect upon the distribution of plankton organisms. For each species and for each environmental factor there exist maximum and minimum limits for survival and reproduction. When the range of tolerance is wide for many factors the species may live over an extensive geographic range; if the range is narrow the form usually is restricted to a smaller area.

In general the tolerance range for reproduction is more limited than for the survival of the adult forms. The finding of adult specimens in a certain area therefore does not necessarily indicate that the organism can reproduce there since currents may carry individuals into regions where the physical factors will not allow reproduction to occur.

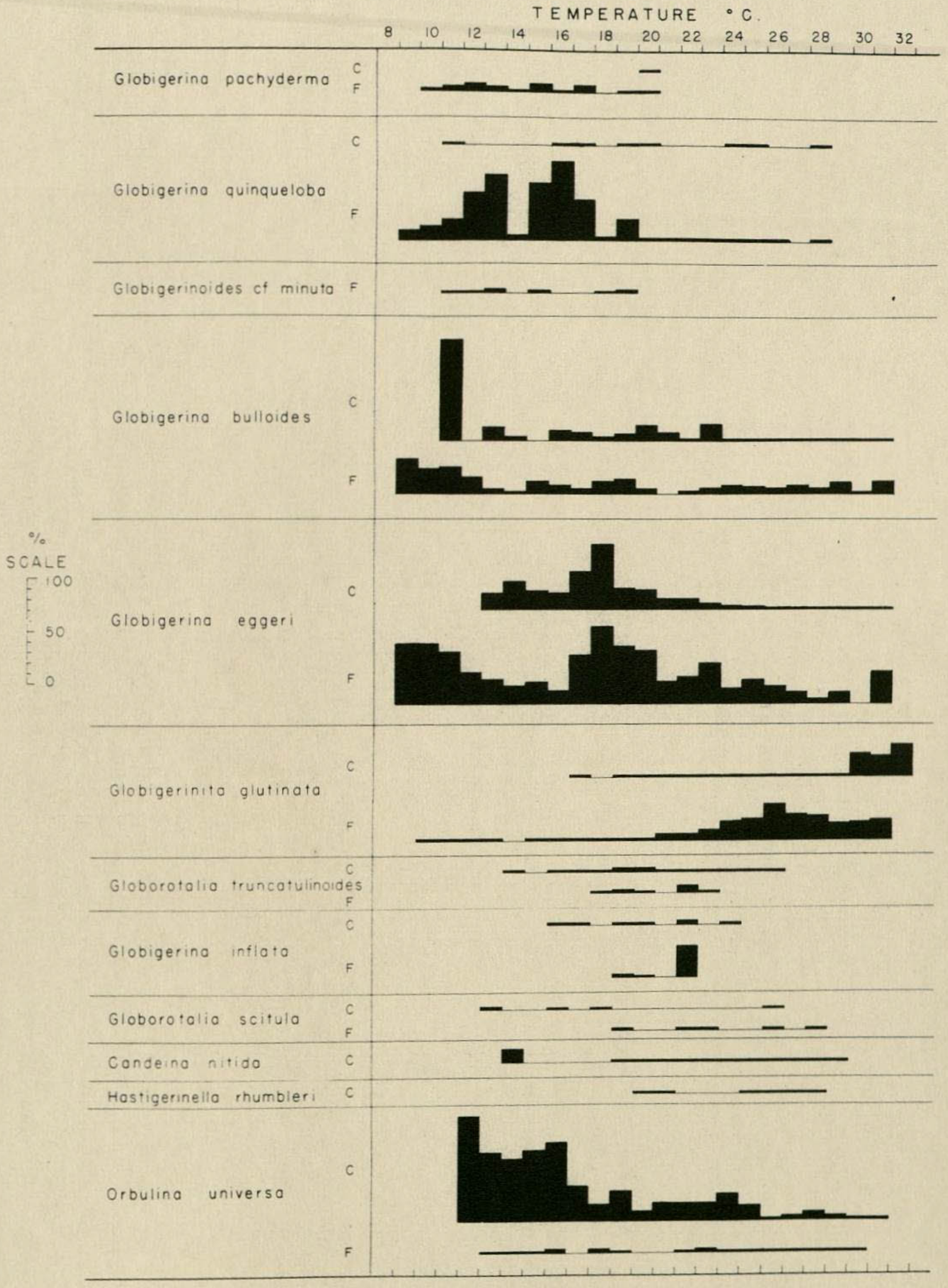
Only a few of the known environmental factors appear to be so variable as to affect the distribution of the planktonic Foraminifera in the region sampled. For example, oxygen concentrations are very close to saturation in the surface water, varying from approximately 4 to 6.5 ml. per liter. The oxygen content may reach lower values at certain localities such as the Gulf of California where oxygen concentrations of 0.17 ml/L have been reported at 100 meters. However, Sverdrup et al. (1942) state that even such low oxygen values as this are not known to be limiting to most planktonic organisms.

Temperature and salinity are believed to be the most important factors in the controlling of the distribution of the species of planktonic Foraminifera in this region although other factors have modifying effects. An indirect factor that controls the abundance by its effect upon the primary production of phytoplankton is the concentration of nutrient salts in the upper layers.

Temperature. The distribution of most of the species shows a general agreement with latitude but an even better correlation with sea surface temperatures. For example, in the western Pacific off Japan the northern boundary of the "warm" fauna (typified by Globorotalia menardii) occurs at about 40° N latitude but in the eastern Pacific the boundary is depressed further south to approximately 20° N latitude. This boundary generally follows the 20° surface isotherm.

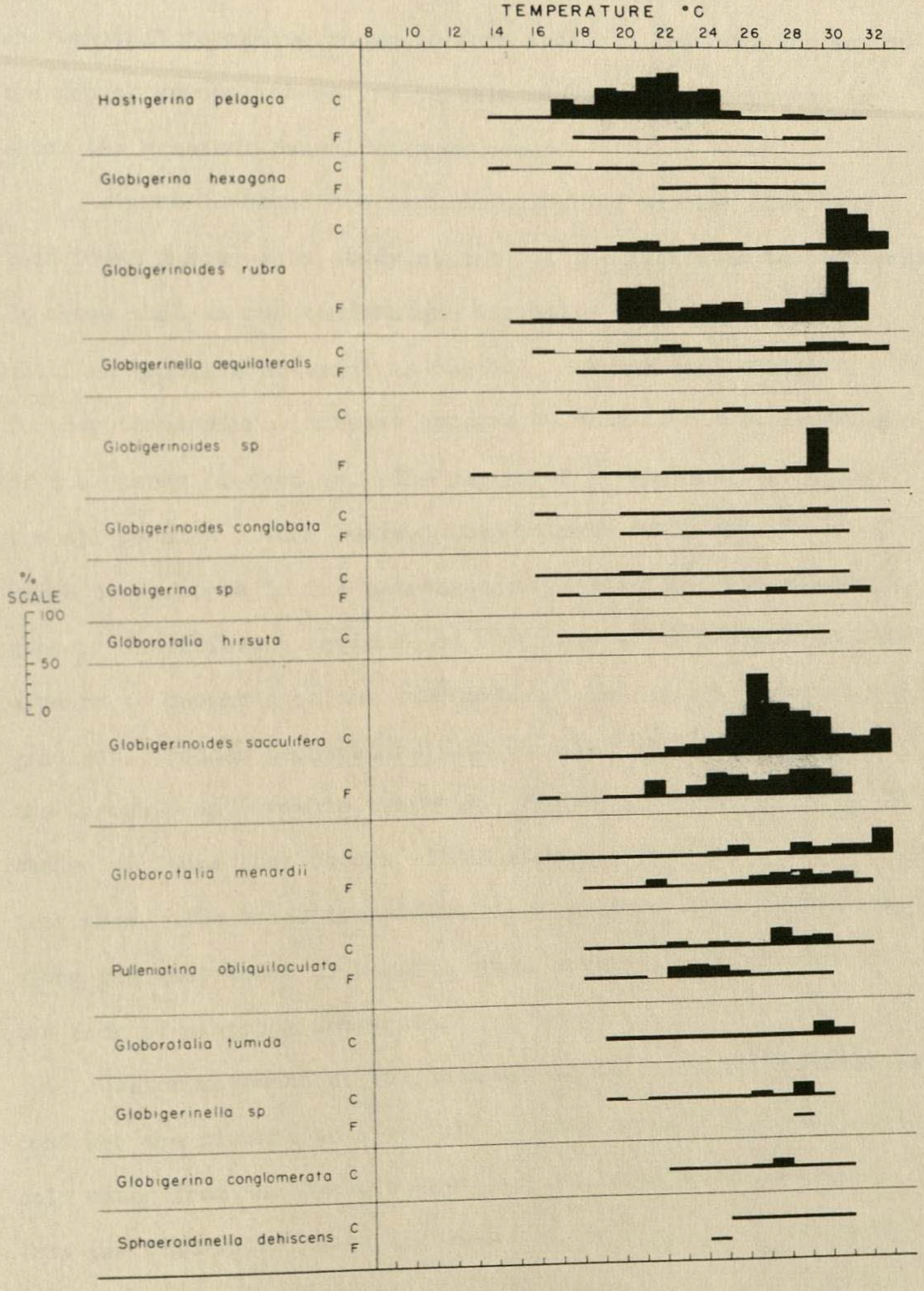
The temperature range of each form, based on surface temperatures observed when the specimens were collected, are shown in figures 40 and 41. The vertical axis represents the average frequency of each species at the indicated temperature within the range of sampling. It will be noted that there are no distinct temperatures which mark the boundaries of the various faunal

Figure 40. Frequency of abundance of planktonic Foraminifera at different temperatures. "C" refers to coarse mesh samples (> 0.55 mm.); "F" indicates fine mesh samples (> 0.14 mm.).



TEMPERATURE °C.
8 10 12 14 16 18 20 22 24 26 28 30 32
Globigerina pachyderma
Globigerina quinqueloba
Globigerinoides cf minuta
Globigerina bulloides
Globigerina eggeri
Globigerinita glutinata
Globorotalia truncatulinoides
Globigerina inflata
Globorotalia scitula
Candeina nitida
Hastigerinella rhumbleri
Orbulina universa
C
F
%
SCALE
100
50
0

Figure 41. Frequency of abundance of planktonic Foraminifera at different temperatures. "C" refers to coarse mesh samples (> 0.55 mm.); "F" indicates fine mesh samples (> 0.14 mm.).



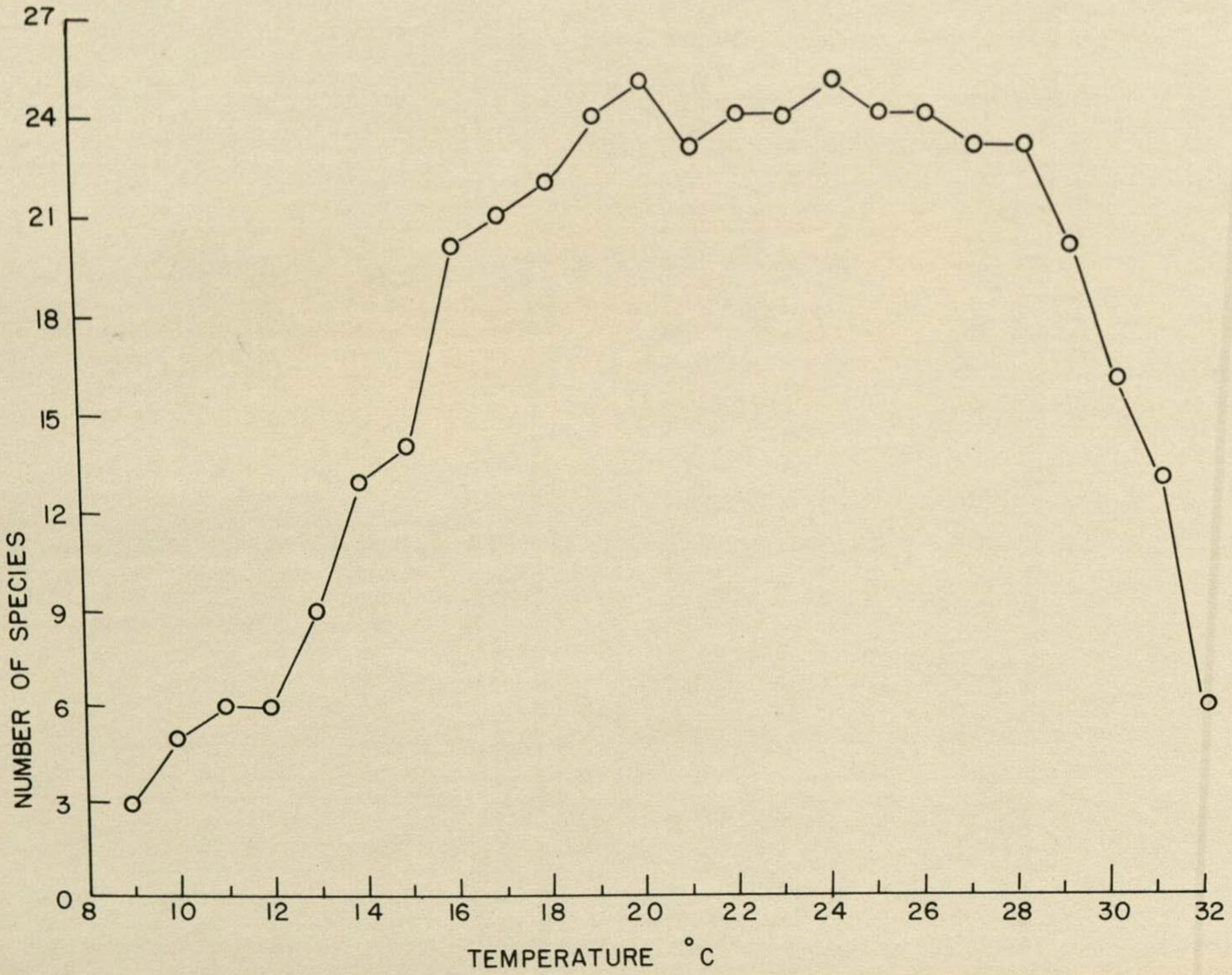
TEMPERATURE °C
8
10
12
14
16
18
20
22
24
26
28
30
32
Hastigerina pelagica
Globigerina hexagona
Globigerinoides rubra
Globigerinella aequilateralis
Globigerinoides sp
Globigerinoides conglobata
Globigerina sp
Globorotalia hirsuta
Globigerinoides sacculifera
Globorotalia menardii
Pulleniatina obliquiloculata
Globorotalia tumida
Globigerinella sp
Globigerina conglomerata
Sphaeroidinella dehiscens
C
F
%
SCALE
100
50
0

regions but that the ranges overlap to some extent. Although no one temperature can be shown to form a common boundary for any of the faunal groups, there are certain ranges of temperatures in which the greatest faunal changes occur.

Figure 42 shows the maximum number of species that have been found during this study at each of the indicated temperatures. It shows that as the temperature increases more species appear until an "optimum plateau" is reached. Beyond this plateau further temperature increase appears to result in a diminishing of the number of species. The region of greatest faunal change for all samples occurs between temperatures of 12 and 18° C. This range corresponds to the temperature range at the Arctic convergence. In different regions the sharpness of the faunal boundary appears to depend upon the steepness of the horizontal temperature gradient. Sudden temperature changes occur at the junction of the Kuroshio and Oyashio currents. Figure 43 shows the dramatic change of fauna that occurs within a relatively short distance in this area. The broad transition zone, with no sharp boundaries, along the west coast of North America appears to be related to the lack of a strong temperature gradient.

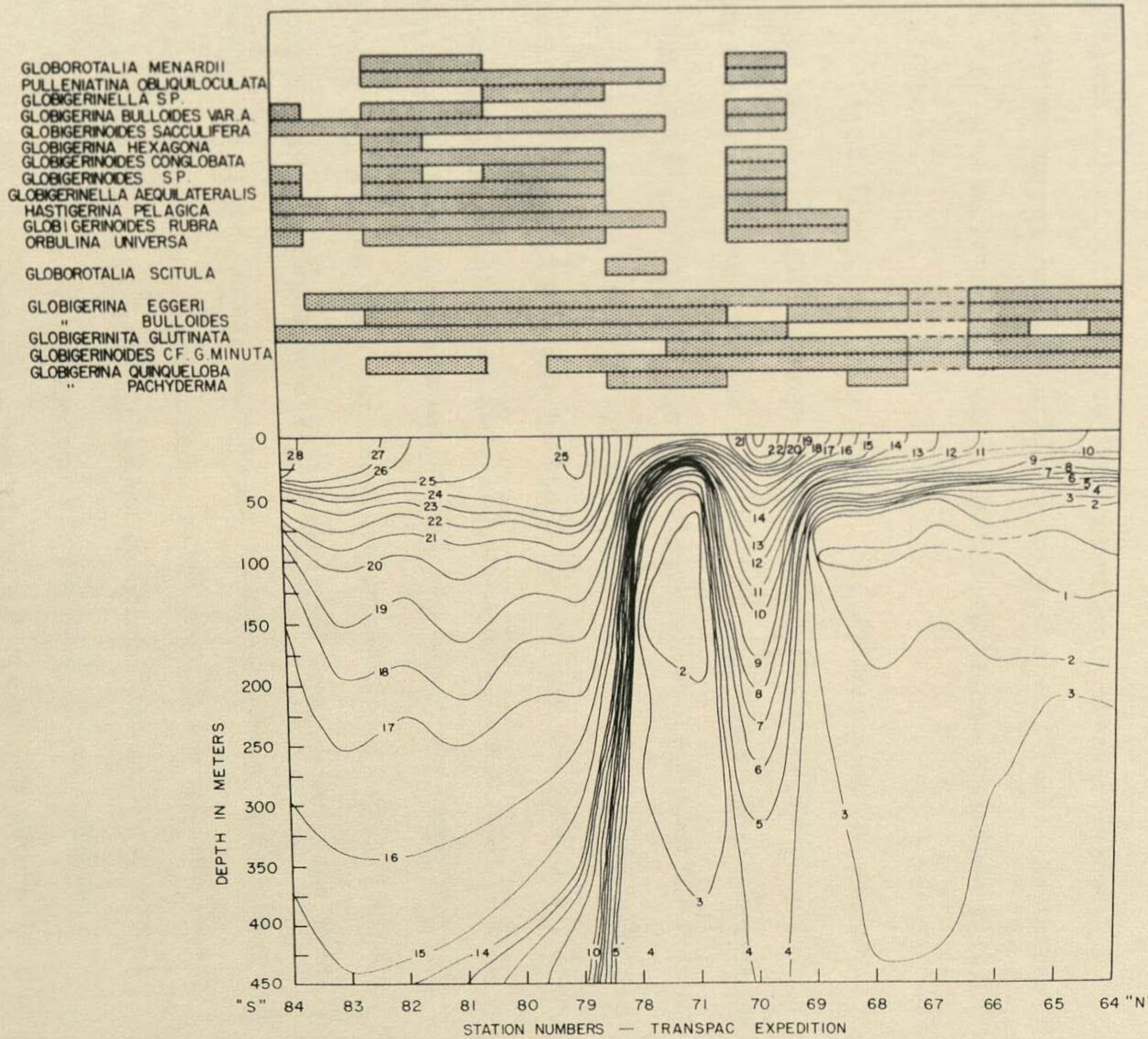
Water movement at the boundary of the warm and cold faunas confuses the picture to a certain extent. Figure 43 shows that cold water from the Oyashio underlies the warm Kuroshio and in this way cold water forms may be found to the south. Warm water species carried to the north can survive only if they remain in

Figure 42. Graph showing the maximum number of species found at the indicated temperatures.



NUMBER OF SPECIES
0
3
6
9
12
15
18
21
24
27
8
10
12
14
16
18
20
22
24
26
28
30
32
TEMPERATURE °C

Figure 43. Vertical section across boundary of Kuroshio and Oyashio Currents showing warm and cold faunal boundary. Upper: ranges of species; lower: temperature values (°C) for the same section.


GLOBOROTALIA MENARDII
PULLENIATINA OBLIQUILOCULATA
GLOBIGERINELLA SP.
GLOBIGERINA BULLOIDES VAR. A
GLOBIGERINOIDES SACCULIFERA
GLOBIGERINA HEXAGONA
GLOBIGERINOIDES CONGLOBATA
GLOBIGERINOIDES SP.
GLOBIGERINELLA AEQUILATERALIS
HASTIGERINA PELAGICA
GLOBIGERINOIDES RUBRA
ORBULINA UNIVERSA
GLOBOROTALIA SCITULA
GLOBIGERINA EGGERI
" BULLOIDES
GLOBIGERINITA GLUTINATA
GLOBIGERINOIDES CF. G. MINUTA
GLOBIGERINA QUINQUELOBA
" PACHYDERMA
DEPTH IN METERS
0
50
100
150
200
250
300
350
400
450
"S" 84
83
82
81
80
79
78
71
70
69
68
67
66
65
64 "N"
STATION NUMBERS — TRANSPAC EXPEDITION

the upper layer. Large-scale eddies are found where the mixing of the Kuroshio and Oyashio take place. Eddies of water, each with its characteristic plankton communities may from time to time break off from the main water masses and carry the contained organisms a limited distance into unsuitable areas. Eventually the eddies or patches of warm or cold water will reach the temperature of the surrounding water and the contained organisms will be affected.

Ekman (1953, p. 317) writes, "...As each species passes out of the temperature range within which it can reproduce, its final disappearance becomes a certainty, the actual place depending on the length of life of the individual and the rate of the current." When a warm water form is carried into cold waters it may maintain itself for limited periods although it may not successfully reproduce. Bigelow (1926) and Redfield and Beale (1940) have shown that certain species of Chaetognatha and other organisms are not immediately killed when carried into colder water but, if conditions are not too extreme, will even grow to a larger size than they do in their normal warm water habitat. Brady (1884) reported certain warm water species from sediments off the British Isles, indicating the transport of these specimens out of their normal habitat by northward extensions of the Gulf Stream. In the Pacific a similar "sterile distribution" presumably occurs in the extensions of the Kuroshio into northern latitudes. This "cold tolerance" of planktonic forms and the difficulty of identifying very young stages make it difficult to define precisely the reproductive boundaries of each species.

The physiological effects of different temperatures upon living planktonic Foraminifera are not known since these forms have not been successfully cultured in the laboratory. It is possible that generalized information may be gained by controlled study of the effect of temperature upon benthonic species. Laboratory studies (Bradshaw, 1957) on Streblus beccarii var. tepida (Cushman) indicate that a decrease in temperature results in a slower rate of growth, increased time to sexual maturity, and a larger size than was found in specimens kept at normal environmental temperatures. Lowering the temperature below 10° C. appeared to halt the reproductive process indefinitely although the organisms remained alive and healthy.

Salinity. Salinity is usually not considered to be as important an ecologic factor as temperature in the open sea. However, very little is known of the effect of salinity upon oceanic plankton and it may be that relatively slight changes of salt content are important for such forms.

There appears to be a general relationship between the distribution of species of planktonic Foraminifera and surface salinities. There is the same southward depression of salinity values in the eastern Pacific as was noted in the temperature distribution. There is also a steep salinity gradient across the sharp faunal boundary off Japan and more gradual changes off the west coast of North America.

The following species appear to be confined to water of relatively high salinity (> 33.5°/oo): Pulleniatina obliquiloculata, Globorotalia menardii, Globorotalia hirsuta, Globigerinella sp., Globigerinoides conglobata, Hastigerinella, Globorotalia tumida, and Sphaeroidinella dehiscens.

The following species are limited to salinities of less than 35°/oo: Globigerina pachyderma, Globigerinoides minuta.

Another species group which is more abundant in the high salinity fauna but is not necessarily confined to high salinities (since it occurs also at salinities as low as 32.5°/oo) is as follows: Globigerinoides sp., G. rubra, Hastigerina pelagica, Globigerina hexagona, Candeina nitida, Globigerinella aequilateralis, Globigerinoides sacculifera, Globigerina sp., Globigerinita glutinata. The following species occur at salinities as low as 32.0°/oo: Orbulina universa, G. eggeri, G. bulloides.

Ecologic water masses. The variations of temperature and salinity are so closely associated that it has not been possible, on the basis of present field studies, to determine which factor may be more important in the observed distributions. Until the effects of the two can be separated it may be best to consider them together.

Simultaneous plots of temperature and salinity have been used by physical oceanographers as convenient descriptions of oceanographic water masses and as aids in differentiating one from another. Seasonal and local variations, however, limit the strict use of these defined water masses to depths deeper than 100 to 200 meters. The upper limit of the traditional water masses thus lies below the depth of maximum concentration of Foraminifera as indicated by this study. The need for a more comprehensive concept of the biological environment has led to the generalization of an ecologic water mass. This has been defined by Phleger (1954) as "any body of water which has a uniform ecologic effect and supports a uniform assemblage of organisms."

Although the temperature and salinity relationship of such a water mass is of obvious importance in limiting the distribution of species, other factors under certain circumstances undoubtedly play an important role. The nature and amount of food and chemical constituents, the pH, oxygen, hydrostatic pressure, turbidity, turbulence, and biological interactions are several factors which may be of ecologic significance.

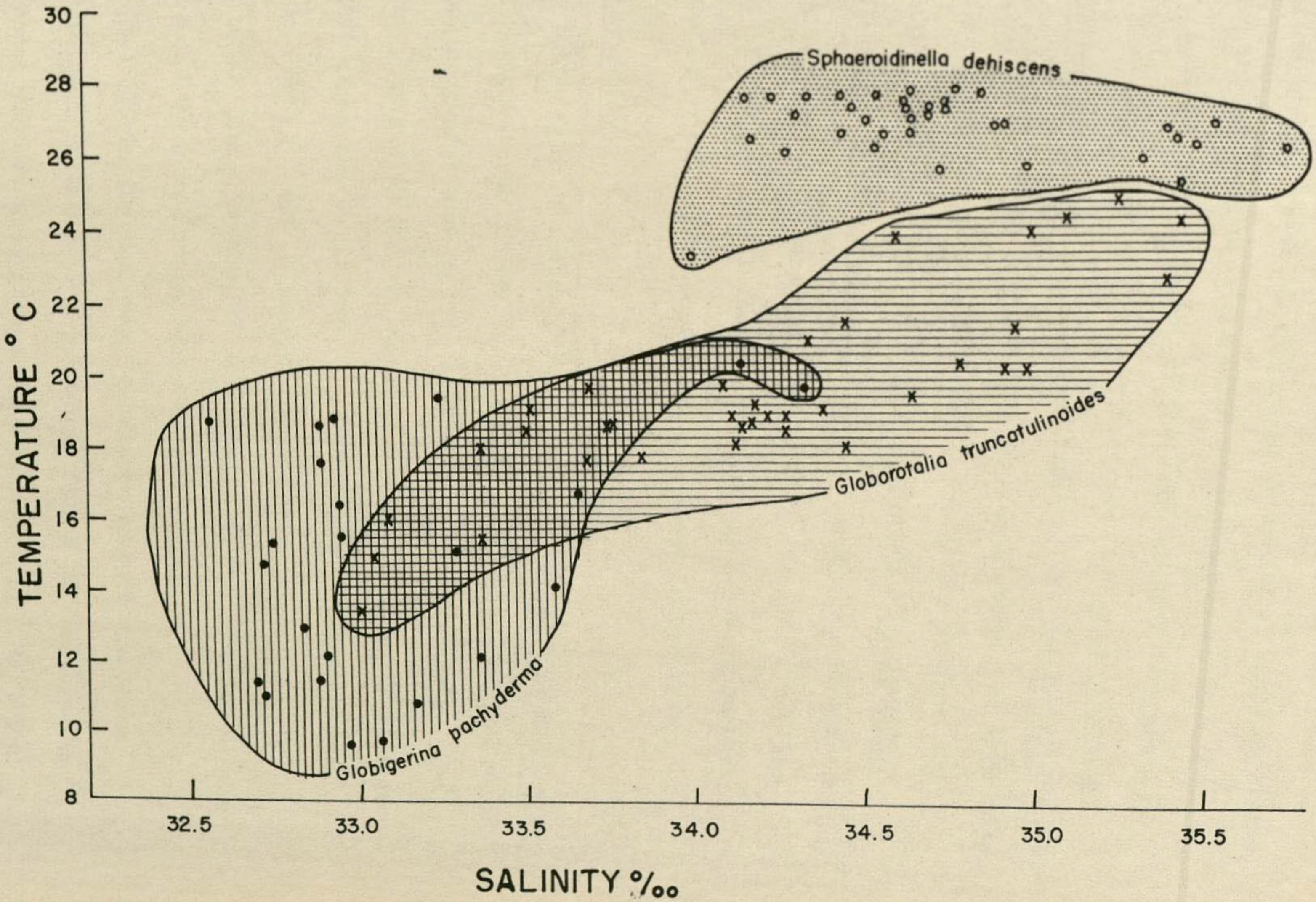
Various workers, Bigelow (1926), Frazer (1954), Johnson (1939, 1949, 1954, 1956), Russell (1935), and Russell and Hastings (1933) have utilized planktonic organisms as indicators of water movements and to recognize bodies of water of varying but usually limited extent. Indicator organisms are often so sensitive to changes in physical-chemical properties that they have been used to identify water masses where traditional oceanographic techniques fail.

Frazer (1955) has given a good description of the use of planktonic organisms as indicators of different water masses. He writes, "Each of the above water masses has a typical plankton fauna (see Russell, 1939, and earlier works), which varies within certain limits, in the abundance and in the proportions of its constituent species from year to year. As these organisms are transported further from their natural habitat they gradually die as their limit of tolerance is reached, and they are replaced by other species through mixing either with other oceanic streams or with coastal water. The fauna of an incoming water mass thus gradually changes along its length; for example, few of the oceanic species noted off Scotland normally reach Northwestern Norway (Wilborg, 1954). The degree of survival of the original fauna gives a measure of the purity of the inflow, and the relative life of the species less tolerant to various factors may give an indication of the type of dilution or change involved."

Bieri (1957), Brinton (1957), and Hida (1957) have used species of chaetognaths, euphausiids, and pteropods, respectively, to recognize large faunal regions in the Pacific that appear to be closely related to the surface oceanographic water masses.

The temperature and salinity values of the water inhabited by three species of Foraminifera, each illustrating one of the major faunal groups, are shown in figure 44. The different groupings describe the temperature and salinity values for the surface water at the stations where each of the indicated species occurred. It will be noted that the surface values fall outside

Figure 44. Temperature and salinity relations of the surface water inhabited by three species of planktonic Foraminifera.


Sphaeroidinella dehiscens
Globorotalia truncatulinoides
Globigerina pachyderma
TEMPERATURE ° C
SALINITY ‰
30
28
26
24
22
20
18
16
14
12
10
8
32.5
33.0
33.5
34.0
34.5
35.0
35.5

the limits of the "defined" water masses as shown on figure 6. Nevertheless, there still appears to be a natural division of the values into several clusters which in general represents the surface water overlying each of the water masses. One group of high temperature and salinity, illustrated by Sphaeroidinella dehiscens, appears to be closely related to the Equatorial Pacific water mass. A second group with lower temperatures and salinities, typified by Globigerina pachyderma, represents a surface manifestation of the Pacific Subarctic water, while Globorotalia truncatulinoides illustrates a third grouping of intermediate values related to the central water mass. There is a certain amount of overlapping of these groups but it is believed that they reflect real differences in the character of the water.

Boundary zones

Mixtures of planktonic Foraminifera species from different faunal regions occur in various localities. The transition region between the "warm" and "cold" water faunas is an extensive area of mixing, extending across the entire North Pacific. This region is widest along the California Coast where it covers almost 20° of latitude. West of 140° W longitude its width decreases to a narrow zone. The sharpness of this region at the junction of the Kuroshio and Oyashio currents is shown in figure 43.

Hida (1957) found a wide transition zone in the North Pacific between subarctic and subtropic faunas of chaetognaths and pteropods on two traverses along longitudes 157° 30' W and

180°. He found the summer boundaries of this zone at 33° N and 45° N latitude and indications that in winter the northern boundary moved slightly to the south. Summer surface temperatures and salinities corresponding to this region ranged from 26° C to 8.5° C and from 35°/oo to 33.6°/oo from south to north. In the northwest Pacific Bogorov and Vinogradov (1955) working with crustacean plankton found a sharp boundary between a boreal (Subarctic) and a tropical faunal region similar to that found in the present study. They found the summer boundary zone to vary between 40° and 45° N depending upon the meandering of the Kuroshio waters. In the same area Brodski (1955) working with copepods found a transition region between the faunas of the temperate and subtropic zones lying between the 15° C and 18° C surface water isotherms at about the same position as that of Bogorov and Vinogradov.

Abundance of total planktonic Foraminifera

The Foraminifera form a significant fraction of the total number of zooplankton organisms. King and Demond (1953) presented data from 210 plankton samples taken on traverses during four cruises in the Equatorial Pacific showing that the Foraminifera make up an average of from 1.3 to 9.9 per cent of the total number of zooplankton organisms although they constitute a small fraction of the total mass of zooplankton. Marked seasonal changes in the relative numerical importance of the Foraminifera is indicated by the change in average percentage composition from 1.8, 3.0, and 2.5 per cent in the three fall and winter cruises to 8.6 per cent in summer. In the winter cruises the most abundant zooplankton group was Copepoda, followed by Chaetognatha, Tunicata, Euphausiacea, Siphoniphora, and Foraminifera. In summer (cruise 5) Foraminifera increased in numerical importance becoming the third most numerous group, exceeded only by Copepoda and Chaetognatha. At two of their stations (7 and 9) Foraminifera made up 60 and 58 per cent of the total number of zooplankters, exceeding even the copepods. It should be remembered that these values are limited to the relatively large forms retained by the meter net. When finer mesh nets are used the relative numerical importance of the Foraminifera becomes even greater. Hida and King (1955) using Clarke-Bumpus samplers with nets of 0.31 mm. aperture report that Foraminifera are the second most abundant zooplankton group during the summer in the Equatorial Pacific.

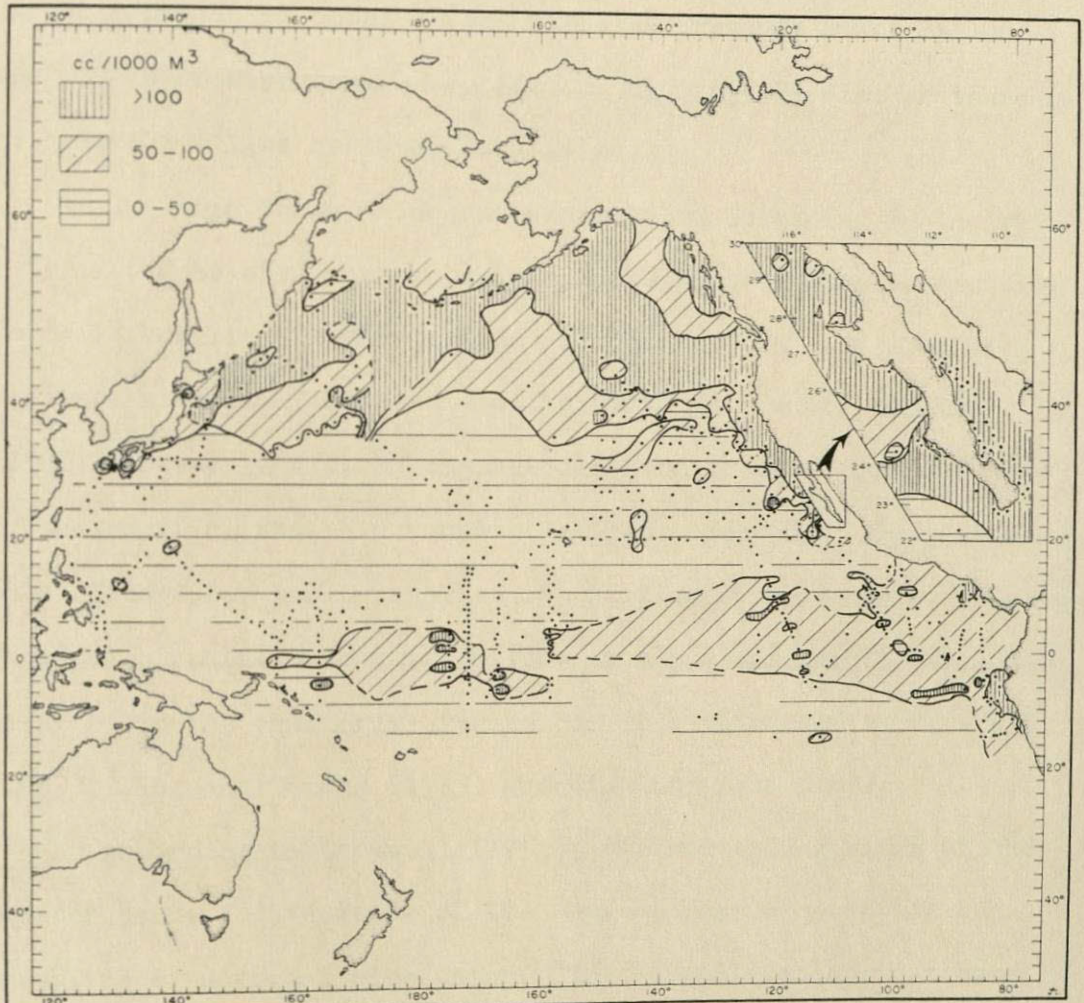
The observed occurrence of Foraminifera in the plankton at any time reflects a complex interaction of physical-chemical and biological factors. The need for sufficient quantities of the right food is obvious if the Foraminifera are to compete effectively with other organisms. Since the food of planktonic Foraminifera consists of other plankters, notably phytoplankton and copepods, their concentration is controlled in part by the same factors that control the bulk of the zooplankton.

Phytoplankton is the most important primary source of food in the surface waters but a direct correlation is not always found at the same locality between it and the abundance of the zooplankton.

The relationship between zooplankton and phytoplankton abundance and environmental factors, especially the amount of phosphate, has been investigated by many workers, including Marshall and Orr (1927), Marshall, Nicolls and Orr (1934), Hardy and Gunther (1935), Jesperson (1935), and Steeman-Nielson (1937). This relationship is complex but it is generally believed that when broad areas are examined the standing crop of zooplankton will reflect the primary production of phytoplankton. In tropical and temperate climates the abundance of phytoplankton is thought to be limited by essential nutrients (NO_3^-, $PO_4^{\equiv}$, etc.) which are not uniformly distributed in the sea. The concentration of inorganic phosphate may be taken as an index of potential fertility since there is generally a constant relationship between the various nutrient salts. The greatest concentration of inorganic phosphate occurs below the depth inhabited by living phytoplankton. It is only when nutrients are brought into the lighted layers that they can be utilized by the plants. Land runoff supplies some of these nutrients in coastal regions but the major source of supply over most of the ocean is vertical transport by physical processes of upwelling, turbulence, overturn, etc. The distribution of phosphate values in the surface water (fig. 7) is a reflection of these processes.

The total zooplankton volumes (fig. 45) and the concentration of total Foraminifera in the upper layers (figs. 37 and 38) appear to show a general relationship to the distribution of inorganic phosphate. The regions of high abundance of Foraminifera

Figure 45. Distribution of zooplankton volumes in the surface layers.
Data from expeditions of the Scripps Institution of Oceanography, Johnson (in press), University of Washington, and University of British Columbia.



cc /1000 M3
>100
50-100
0-50

(equatorial, subarctic and along the west coast) are also areas of high phosphate concentration. These rich regions are in marked contrast with the relatively low concentrations of Foraminifera and phosphate in the centers of the great current gyrals. The abrupt increase of total Foraminifera at Transpac stations 108 and 109 is probably caused by factors causing the similar increase of plankton volume at those localities.

The high Foraminifera concentrations occurring in the vicinity of the equator are probably related to the relatively greater overall fertility in this region as compared with the sterile regions immediately adjacent to the north and south. Graham (1941) showed, in a study of phytoplankton from the oceanic areas of the Pacific, that his richest samples occurred in regions where subsurface water was brought to the surface by vertical circulation. Vertical circulation and its effect on the abundance of total zooplankton in the equatorial region has been discussed by Cromwell (1953), King and Demond (1953) and King and Hida (1957).

According to Cromwell (1953), the prevailing winds at the equator cause a divergence of the surface layers resulting in upwelling of nutrient-rich water. This fertilization is sooner or later followed by extensive phytoplankton development and eventually by large zooplankton populations. A zone of convergence and associated sinking of the surface waters is expected to concentrate the zooplankton so that the highest numbers of individuals occur in the convergent zone. During south or southeast winds the convergence is believed to occur north of the equator, and south of the equator during a north or northeast wind. Since the prevailing winds in this region are east and southeasterly, the maximum concentration of zooplankton generally is expected north of the equator.

Variations of total population with depth

The determination of the vertical distribution of the various Foraminifera species is made difficult by the presence of tests of Foraminifera at all depths from the surface to the bottom sediments. The ecological relationships of planktonic Foraminifera obviously should be determined from specimens that are capable of carrying out their complete life cycle and not from specimens which are dead or incapable of reproductive activities. It is very doubtful that species that have their highest concentrations in the relatively warm surface layers will be equally active at the low temperatures found at the greatest depths sampled, especially since these same species do not occur in surface waters having equally low temperatures. A more probable explanation for this phenomenon has been proposed by Ekman (1953, p. 317). He suggests an expatriation area in the deep sea which is outside of the normal reproductive zone. A species in this unfavorable position would soon die out were it not continuously restocked from the normal habitat above.

In the present study the largest specimens of many species were frequently found in the deepest samples. Similar observations have been reported by Murray (1895). The larger size may be due to continued growth of the organism when reproductive processes are halted. Various examples of this in benthonic Foraminifera and other zooplankters were shown on page 161. The observation of Phleger (1951, p. 35) that the numbers of empty tests increase with depth may be further evidence that reproduction is restricted to the upper layers since Foraminifera usually utilize all of their protoplasm in the production of young.

The use of cytoplasmic stains to determine the presence or absence of protoplasm may be of little help in deciding whether or not a given specimen is in its reproductive region. This is because some protoplasm might be expected in the sterile expatriation zone also. Furthermore, although staining will distinguish tests containing protoplasm from empty ones there is no assurance that the protoplasm is actively living rather than dead proteinaceous material in various stages of disintegration. It seems doubtful that organic material would break down immediately at great depths because of the cold temperatures, high pressures. The low concentrations and sporadic occurrence of pelagic bacteria (ZoBell, 1946, pp. 123 and 67) in the deep sea where they are only found attached to floating particles suggest the conditions for their optimum development are not fulfilled. Assuming a sinking rate of 2.11 cm/sec. for Foraminifera of 0.4 mm. diameter, Schott (1935) has calculated that it would take approximately two days for a test to sink to a depth of 4,000 meters. At the end of this time, under conditions allowing minimal decomposition, sufficient protoplasm may remain to give a positive protein reaction. Carpenter (1875), Lohmann (1903), Parker (1954), and Uchio (personal communication) have reported finding protoplasm in planktonic Foraminifera tests taken from the ocean bottom. The most likely explanation of this fact is that the remains sank to the bottom before the protoplasm had time to decompose completely.

Temperature may be the most critical factor in limiting the bathymetric distribution of various species but other factors such as the amount and quality of food and possible effects of pressure undoubtedly are important. It is obvious that much more study and laboratory experimentation are required before the depth limits can be more accurately defined.

Possible faunal changes with depth

All but one of the species considered by Cushman (1950, p. 45) to be planktonic have been sampled in the present study from the upper layers of water. The fact that most tows were oblique from approximately 200 meters to the surface prevents detailed study of the depth ranges of individual species throughout most of the Pacific.

A series of closing net tows were taken at various depths in the vicinity of San Diego, California to determine if there were any restricted vertical distributions of various species in the upper layers. The results of these net hauls are shown in table 8. These data indicate no good evidence of the restriction of the listed species to particular depths. Similar results are indicated in the data by Phleger (1951) for the Gulf of Mexico and by Bé (personal communication) from the North Atlantic.

Some workers have postulated that various species are restricted to different depth levels. Emiliani (1954) has attempted to show the temperatures that prevailed at the time the calcium carbonate of the test was deposited by the use of temperatures derived from the isotopic composition of skeletons of planktonic Foraminifera. He has concluded that the Foraminifera lived at the depths where these temperatures are found at the present time. This technique is based on the assumption that planktonic Foraminifera deposit calcium carbonate in equilibrium with the water. This is not necessarily true since exchange may occur between the oxygen liberated by the symbiotic organisms known to occur in many species of planktonic Foraminifera and the calcium carbonate which is being deposited. Problems of this type have been discussed by Emiliani (1955, p. 544) and by Epstein and Lowenstam (1953).

Emiliani (op. cit., p. 545) notes that his isotopic temperatures represent the weighted average temperature of shell deposition of the foraminiferal population. Several hundred tests of each species were required to make up the 5 mg. of calcium carbonate required for each temperature determination and these tests were taken from core sections several centimeters in thickness representing periods of approximately 1,000 years. It seems rather hazardous to use average isotopic temperatures over such a long time period when the range of variations of these temperatures is unknown. It is probable that minor fluctuations of climate have occurred intermittently since the last glacial period.

Taylor, Bigelow and Graham (1957) have shown that fluctuations of climate since 1900 are related to changes in the distribution of certain marine species. Various warm and cold species of planktonic Foraminifera also probably vary their geographic range in response to climatic trends. Certain cold water species may be absent from an area during warm periods but are abundantly represented during cold periods.

Emiliani (1955, p. 545) recognizes the importance of seasonal variations in temperature and notes that "isotopic temperatures obtained from pelagic Foraminifera are probably close to the yearly mean at low latitudes, where seasonal temperature variation is small. Beyond the tropics, where this variation becomes important, the isotopic temperature is probably close to the summer mean." The distribution of marine organisms, however, is not governed by mean temperatures as was pointed out by Hutchins (1947). The temperature extremes are undoubtedly most important in determining the distribution of various planktonic species. Limited seasonal studies of planktonic Foraminifera show that in areas of marked seasonal change a different fauna may be present at different times of the year. Such seasonal changes in other planktonic organisms are well known and have usually been related to changes in the temperature of the water. Thus the empty tests of certain species found on the bottom may reflect the temperatures at certain periods only and not the mean temperatures as suggested by Emiliani.

Bandy (1956, p. 187) has suggested the minimum water depths at which certain species of planktonic Foraminifera live in the Gulf of Mexico. These depths are not based on the study of the Foraminifera in plankton samples but upon the depths at which their tests were found on the sea floor. The upper limits of the same species from plankton tows taken in the present study and by Phleger (1951, tables 2-9) do not agree with Bandy's findings. Many species listed by Bandy below specified depths were found at or nearer the surface in the above plankton studies. A more reasonable explanation for Bandy's data may be the following. The order of occurrence of the tests of different species from shallow to greater depths in the Gulf of Mexico corresponds approximately to the order of abundance of those species in the sediments as listed by Parker (1954, p. 477). Thus in shallow water samples, which usually contain small numbers of planktonic specimens, the most common form would be more likely to be found than would the rarer species. The probability of finding uncommon forms increases in deep water, then, simply because of the greater number of planktonic tests in the sample.

<u>Tropical submergence</u>. Although there are no reliable data indicating restricted vertical distributions in the upper layers of the temperate regions, there is some evidence that cold water

species that live at the surface in the subarctic and temperate zones may live at lower temperatures below the warm surface water in the equatorial regions. This is true of many other planktonic organisms such as copepods, siphonophores, polychaetes, amphipods, chaetognaths, and radiolarians (Ekman, 1953, pp. 252 and 321). In view of this widespread occurrence in other invertebrate groups it would be surprising if planktonic Foraminifera did not exhibit this phenomenon, at least to a limited extent. "Tropical submergence" would be expected to influence primarily the cold water group such as Globigerina pachyderma, Globigerina bulloides, Globigerinoides cf. G. minuta, Globigerina quinqueloba, Globigerina cf. G. dutertrei, but also perhaps the temperate stenothermal species such as Globorotalia truncatulinoides and Globigerina inflata. Eurythermal species such as Globigerina eggeri and Globigerinita glutinata can apparently tolerate warm temperatures and need not migrate into deeper waters to survive.

The lack of deep open and closing tows in the tropical Pacific prevents a thorough test of this hypothesis. However, occasional specimens of several of the above species such as Globigerina bulloides, G. quinqueloba, Globigerinoides cf. G. minuta and Globorotalia truncatulinoides have been found in deep oblique tows from the equatorial and warm temperate regions. This indicates the possibility that they may occur in that area at greater depths. An alternative possibility is that they occur in the upper layersbut at very low concentration. More extensive work on vertical distribution in the tropical regions is needed to decide this point.

Data from many deep open and closing hauls from 100 to 1000 meters depth in the Equatorial Atlantic were presented by Schott (1935, p. 62). *Globigerina bulloides* and *G. inflata* (both temperate forms) were found in the deep tows but were not present in the surface waters (0 to 100 meters) of the same region. Schott interpreted this as indicating submergence into colder waters for these normally cold water species. His data suggest that *Globorotalia truncatulinoides* also may exhibit tropical submergence since it was found at 200 to 400 meters depth and not in the upper layers of the Equatorial Atlantic.

Relationship to surface sediments

The distribution of the various species of planktonic Foraminifera in the sediments of the Pacific is not known in the same detail as in the Atlantic Ocean sediments. With a few exceptions, notably Hamilton (1953) and Butcher (1951), the work was primarily descriptive and the relative proportion of each species to the total number of Foraminifera in each sample was not given. Questionable identifications of forms decreases the value of some of the early work. These problems are discussed under each species in an earlier section.

The distribution of the species of living Foraminifera from plankton tows agrees essentially with their reported occurrences in the bottom sediments. When more reliable information is obtained concerning identifications of species and their relative abundances in the sediments, some apparent differences may be eliminated or further discrepancies appear.

Globigerina inflata has not been found in the surface plankton to the extent that its presence in the sediments of the Pacific would indicate. Several reasons for this may be: (1) the species is becoming extinct in the Pacific, (2) a restricted seasonal occurrence which may explain its absence in many of the plankton tows, and (3) a very limited temperature tolerance, thereby restricting its presence in the surface waters to a narrow thermal range. Its widespread southerly extension in the sediments of the temperate region would then be explained by submergence to remain within the required temperature limits. Schott (1935) found this species in his deeper tows but not from the warmer surface waters of the Gulf of Guinea. His explanation was that this species was bipolar and occurred in low latitudes only by submergence into the colder waters. On the basis of all present evidence this explanation seems to be the most likely one for the apparent scarcity of this species in the plankton of the upper layers of the Pacific.

Two other species have been found in the plankton that have been rarely or never reported from the sediments. These are Hastigerina pelagica and Hastigerinella rhumbleri. The former is one of the most abundant while the latter is one of the rarest species in the plankton of the central areas of the Pacific. Both species are noteworthy in having very thin test walls. Their apparent absence in bottom deposits therefore may be due to solution or breakage of the calcareous tests after death.

Differential solution of the tests plays an important part in the observed distribution of planktonic Foraminifera in the bottom sediments. This process has been discussed by Schott (1935) and Phleger, Parker and Peirson (1953). The result is that in regions where solution is taking place the faunal assemblage found on the sea floor may differ markedly from the living fauna in the surface waters. Unless this fact is recognized, mistaken conclusions may be drawn concerning the true environment of the assemblage.

The total abundance of Foraminifera, as revealed by the standing crops found in the present study, is of interest in considering problems relating to the distribution of calcareous sediments in the Pacific. Revelle (1944) has reviewed many of the facts relating to $CaCO_3$ precipitation and solution in this area. He believes that solution effects and masking by non-calcareous materials are most important in explaining the scarcity of lime in the North Pacific. It may be equally true, however, that there is actually less biological precipitation of $CaCO_3$. The factors favoring the formation of $CaCO_3$ by Foraminifera are imperfectly known but high temperature and salinity and low CO_2 content are probably of primary importance. The results of the present study substantiate the importance of high temperature and high salinity and also the importance of inorganic nutrients in the production of large Foraminifera populations. Although the high nutrient content of the subarctic water may allow larger populations of dwarfed Foraminifera, apparently the other physical-chemical conditions (notably low temperature and low salinity) are such that larger calcareous skeletons cannot be secreted. It is only when all the factors are optimal (e.g., high temperature and salinity, low CO_2 and high nutrient content) that the maximum concentration of Foraminifera and hence the greatest production of $CaCO_3$ may be expected.

Both Revelle (1944) and Arrhenius (1950) point out the importance of the equatorial current system in influencing the deposition of $CaCO_3$ in that area. Revelle (1944, p. 103) says, "The rather sharp, relatively straight northern boundary of the high calcium carbonate area of the southeast Pacific between longitudes 90° and 155° west almost exactly parallels the average southern limit of the Counter Equatorial Current and does not follow the depth contours. (Compare also with Schott's map, 1934, of salinity in the Pacific, from which it may be seen that this boundary follows closely the 34.5 per mille isohaline)."

Arrhenius (1950, p. 85) has shown on the basis of bottom material collected by the Swedish Deep Sea Expedition that the component of Foraminifera, Radiolaria, and diatoms and also the rate of sedimentation increases markedly below the convergence. North of the convergence found at about latitude 4° N the frequency of organic remains in the sediment decreases to a clay, poor in fossils and with a low rate of sedimentation (0-0.4 cm. per 1,000 years). He writes (op. cit., p. 85), "The boundary between the calcium carbonate ooze and the red clay area is astonishingly sharp and the diffusion caused by lateral transport of settling particles and by the seasonal changes in the path of the current system is obviously not big enough to disturb the general distribution pattern."

Recent extensive studies of the equatorial current system as previously discussed show certain features that should be considered in relation to the model used by Arrhenius. The major difference is that the recent studies by Cromwell (1953) show no indication of a divergence at the boundary of the Counter Current and the North Equatorial Current. The presence of a divergence at the equator has been substantiated however and a zone of convergence has been recognized although the latter appears to be of a transitory nature depending upon the direction of the wind and is not a permanent feature related to the current system.

In general, whenever a well-marked convergence was reported, the highest concentration of Foraminifera occurred within approximately 5° north and south of the equator. The high concentrations of Foraminifera that were found on several traverses north of the boundary between the North and South Equatorial Currents appear to be related to the absence of a well-marked convergence on those particular crossings.

The variations in the concentration of Foraminifera shown by the present study (see figs. 37, 38, and 39) are therefore in essential agreement with the observations of the bottom sediments made by Revelle and Arrhenius.

SUMMARY

1. The greatest numbers of Pacific planktonic Foraminifera occur in the upper 100 meters of water, with the maximum concentration occurring between 6 and 30 meters at most of the stations examined. Small populations were found below 1,000 meters. More Foraminifera were found in the surface layers during the day than at night. Most species are randomly distributed throughout the upper levels. There is no indication of restricted depth ranges of the abundant species.

2. The planktonic Foraminifera in the North and equatorial Pacific can be grouped into four faunas. The subarctic fauna is composed of a few species having generally restricted distributions but also includes some species that occur in neighboring faunas. The northern extent of this group is unknown but studies of bottom sediments indicate that certain elements range high into the Arctic. The southern limit of this region approximates the 15° summer isotherm. A transition fauna is found between the subarctic fauna and the warm water faunas to the south. It is composed of species that belong to both warm water and cold water groups. The 15° and 20° summer isotherms limit this fauna to the north and south while the seaward boundary of the California Current marks its farthest extent to the southeast. The warm-water group comprises several minor ones. The equatorial-west central fauna appears to occur only in the area occupied by the Pacific equatorial and west north Pacific central water masses while the

central fauna is limited to the central regions. Distributions of the faunas appear to be correlated with surface temperatures and salinities.

3. The various oceanographic regions appear to support different concentrations of planktonic Foraminifera. The highest populations per unit volume of water were found in the subarctic and at a few localities in the equatorial region. The smallest populations occurred in the central oceanic regions. Comparisons of foraminiferal abundance with total zooplankton volumes and with the concentration of inorganic phosphate in the surface water show fairly good correlation. This suggests that the numbers of Foraminifera are influenced by the same factors that govern the fluctuations of other zooplankton organisms.

4. The distributions of most of the species of living planktonic Foraminifera agree essentially with those of their empty tests in the bottom sediment. Certain thin-walled species, however, that are common in the plankton have been rarely reported from bottom sediments in the same area. Their absence in the bottom sediments is attributed to the dissolution and/or breakage of their fragile calcareous tests after death.

5. The high standing crops of living planktonic Foraminifera found in the subarctic regions do not appear to be compatible with the relatively low calcium carbonate content of the underlying sediments. Various reasons are proposed for this discrepancy. The smaller average size of the colder water planktonic Foraminifera

together with their probably slower rates of reproduction and growth may result in a smaller rate of production of calcium carbonate than occurs in the warmer regions. Furthermore, the addition of large quantities of non-calcareous materials in high latitudes masks the calcium carbonate in the sediments, thus reducing the relative importance of planktonic Foraminifera.

6. The high standing crops of larger specimens together with a probably higher rate of supply make the region between the equatorial divergence and convergence an area of rapid production of calcium carbonate. The greater production of calcium carbonate in this region is reflected by a correspondingly high rate of sedimentation in the bottom sediments.

PLATE 1

Figures	
1, 2, 3, 4.	Globigerina bulloides d'Orbigny. X 67. (1, 4) Shellback, sta. 136; (2, 3) Transpac sta. 32.
5, 8, 9. 10.	Globigerina eggeri Rhumbler. X 65. (5, 10) adult specimens. (8, 9) juvenile specimens. Transpac sta. 13.
6, 7.	Globigerina conglomerata Schwager. (6) X 47. (7) X 31. Equapac sta. 21.
11, 12, 13, 14, 15.	Globigerina hexagona Natland. X 65. (11, 12) Shellback sta. 76; (13, 14, 15) Variant form. Shellback sta. 61.
16, 17, 18.	Globigerina inflata d'Orbigny. X 65. Transpac sta. 108.
19, 26, 27, 28.	Globigerina sp. X 47. Equapac-s sta. 21.
20, 21, 22, 23.	Globigerina pachyderma (Ehrenberg) (20, 21) X 102; Transpac sta. 32. (22, 23) Variant forms, X 65. Transpac sta. 22.
24, 25	Globigerina quinqueloba Natland. X 102. Transpac sta. 15.

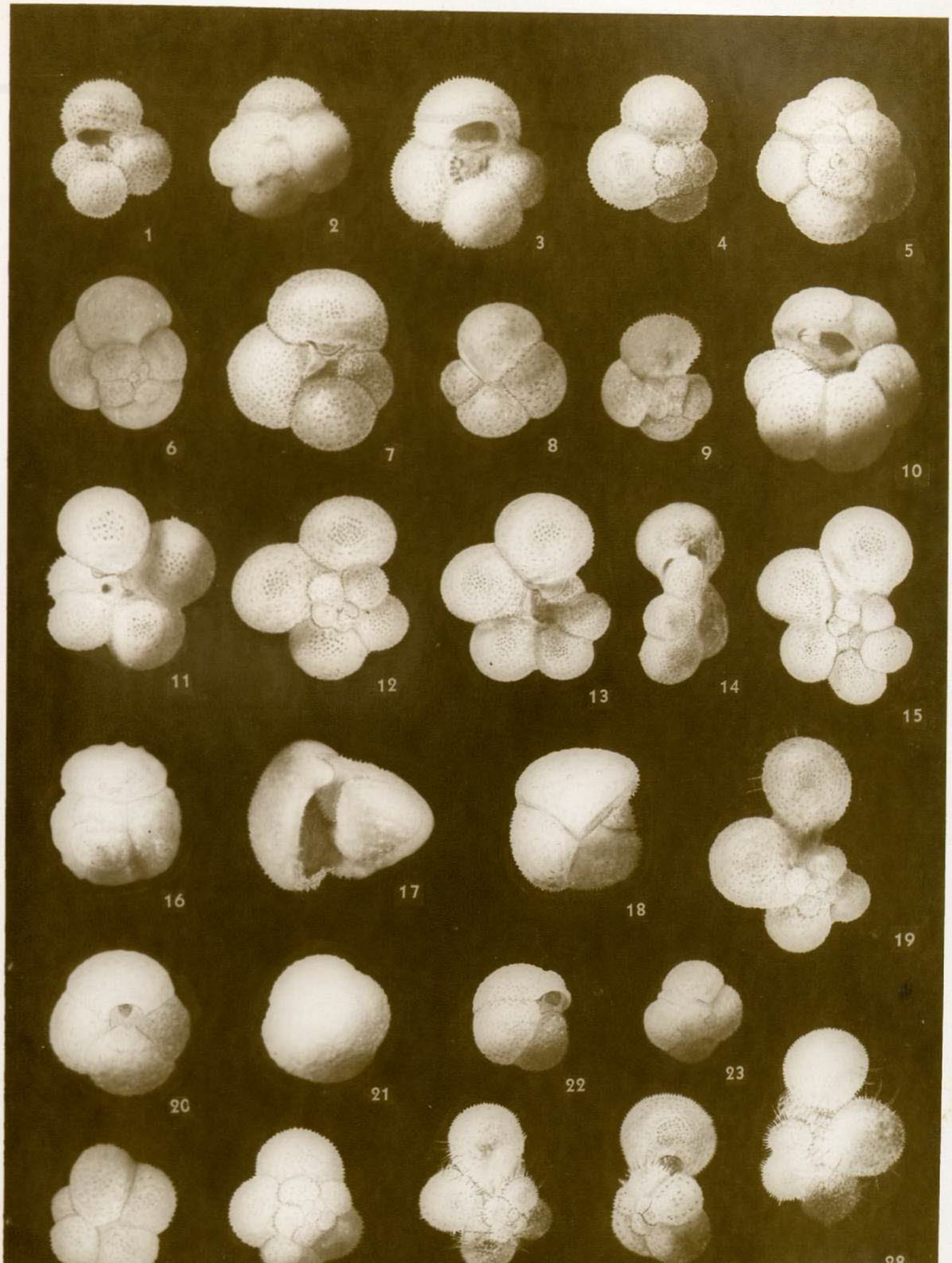

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PLATE 2

Figures

1, 2.	Globigerinella aequilateralis (Brady). X 47. Equapac-s sta. 21
3, 4.	Globigerinella sp. X 31. Troll sta. 14
5, 6.	Globigerinoides conglobata (Brady). X 47 Troll sta. 17A.
7, 8.	Globigerinita glutinata (Egger). X 65. POFI-5 sta. 20.
9, 10, 11.	Globigerinoides cf. G. minuta Natland. X 102. Transpac sta. 51.
12, 13.	Globigerinoides rubra (d'Orbigny). X 65. Equapac-s sta. 21.
14, 15, 18.	Globigerinoides sacculifera (Brady). X 47. Shellback sta. 80.
16, 17.	Globigerinoides sp. X 47. Shellback sta. 30.
19.	Candeina nitida d'Orbigny. X 47. Troll sta. 16A.


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PLATE 3

Figures	
1, 2.	*Globorotalia hirsuta* (d'Orbigny). X 47. Shellback sta. 175.
3, 4.	*Globorotalia menardii* (d'Orbigny). X 47. Shellback sta. 80.
5, 6.	*Globorotalia scitula* (Brady). X 102. Shellback sta. 154.
7, 8.	*Globorotalia truncatulinoides* (d'Orbigny). X 47. Transpac, sta. 115
9, 10, 11, 12, 13.	*Globorotalia tumida* (Brady). X 47. (9, 10) Norpac sta. 154.5. (10, 11, 12) Variant form. Equapac-s sta. 36.
14, 15.	*Hastigerina pelagica* (d'Orbigny). X 47. Shellback sta. 80.
16.	*Hastigerinella rhumbleri* Galloway. X 47. Shellback sta. 80.
17, 18.	*Orbulina universa* d'Orbigny. X 31. Troll sta. 14.
19, 20.	*Pulleniatina obliquiloculata* (Parker and Jones). X 65. Equapac-s sta. 21.
21, 22, 23.	*Sphaeroidinella dehiscens* (Parker and Jones). (21, 22) X 47. (23) Variant form; X 31. Equapac-s sta. 21.


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TABLE 1. Location of stations and miscellaneous data

V = 17 cm net (vertical tow from indicated depth to surface)

C = Clarke-Bumpus Sampler (oblique tow from indicated depth to surface)

M = Meter net (oblique tow from indicated depth to surface)

Cruise and Station	Net	Latitude	Longitude	Date	Time	Sample Depth (M)	Vol. Water (M^3)
TransPac				1953	LST		
1	V	33°57'N	122°28'W	7-23	2036	0-50	1
3	C	35°05'N	127°38'W	7-25	2159-2214	0-143	8.52
3	V	35°05'N	127°38'W	7-25	0250-0252	0-50	1
5	M	35°47'N	131°44'W	7-27	0450-0503	0-135	445
6	M	36°09'N	133°20'W	7-27	1644-1658	0-115	411
7	M	36°21'N	134°53'W	7-28	1655-1715	0-170	251
8	M	36°44'N	137°23'W	7-29	0817-0832	0-145	500
8	C	36°44'N	137°23'W	7-29	0817-0832	0-143	5.85
9	M	37°00'N	140°01'W	7-29	2133-2159	0-170	524
10	M	38°22'N	141°23'W	7-31	0242-0258	0-120	362
10	C	38°22'N	141°23'W	7-31	0250-0302	0-143	4.25
11	M	39°36'N	142°33'W	8-1	0110-0150	0-170	801
12	V	40°27'N	143°32'W	8-2	1557-1633	0-50	1
13	C	41°54'N	145°13'W	8-3	0436-0451	0-143	5.62
14	V	42°58'N	146°15'W	8-3	2020-2052	0-50	1
15	C	44°02'N	147°29'W	8-4	0550-0604	0-143	7.34

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
15	V	44°02'N	147°29'W	8-4	0525-0527	0-50	1
17	C	46°00'N	149°54'W	8-5	0610-0626	0-143	4.48
18	C	47°14'N	151°43'W	8-6	1015-1032	0-143	4.32
18	V	47°14'N	151°43'W	8-6	1015-1032	0-50	1
19	V	48°14'N	153°20'W	8-6	1115-1117	0-50	1
20	C	49°30'N	154°56'W	8-7	1220-1237	0-143	5.79
20	V	49°30'N	154°56'W	8-7	0900-0905	0-50	1
21	V	50°25'N	156°37'W	8-8	0145-0150	0-50	1
24	M	53°15'N	161°55'W	8-9	1127-1141	0-180	417
24	C	53°15'N	161°55'W	8-9	1130-1149	0-143	8.17
24	V	53°15'N	161°55'W	8-9	1415-1417	0-50	1
27	V	54°00'N	170°03'W	8-13	0927-0930	0-50	1
28	C	53°60'N	171°40'W	8-13	2332-2346	0-143	6.14
29	V	54°00'N	173°16'W	8-14	1147-1150	0-50	1
31	V	53°16'N	175°38'W	8-15	1200-1204	0-50	1
32	C	52°29'N	176°09'W	8-15	2140-2155	0-143	5.05
33	V	52°20'N	176°58'W	8-24	2000-2002	0-50	1
36	V	54°01'N	177°58'W	8-26	1030-1035	0-50	1
37	V	53°59'N	176°55'E	8-27	1950-1603	0-50	1
38	V	53°59'N	174°49'E	8-28	1330-1347	0-50	1
42	V	53°32'N	166°11'W	9-1	0600-0616	0-50	1
43	V	53°36'N	163°42'W	9-1	2340-2342	0-50	1

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
44	V	53°41'N	161°56'W	9-2	1500-1502	0-50	1
45	V	52°23'N	163°15'W	9-3	0901-0903	0-50	1
47	V	49°50'N	165°49'W	9-5	0025-0028	0-50	1
48	C	48°46'N	166°48'W	9-5	1239-1254	0-143	6.32
50	C	46°16'N	168°52'W	9-6	1549-1604	0-143	5.55
50	V	46°16'N	168°52'W	9-6	1445-1450	0-50	1
51	C	45°06'N	170°08'W	9-7	1149-1203	0-143	5.22
51	V	45°06'N	170°08'W	9-7	1115-1120	0-50	1
52	C	43°28'N	170°37'W	9-8	0418-0433	0-143	5.45
52	V	43°28'N	170°37'W	9-8	0400-0403	0-50	1
53	V	42°08'N	169°28'W	9-8	1525-1528	0-50	1
54	M	40°34'N	170°02'W	9-9	1829-1900	0-170	810
55	M	41°19'N	168°20'W	9-9	0618-0634	0-169	463
55	C	41°19'N	168°20'W	9-9	0620-0635	0-143	5.51
55	V	41°19'N	168°20'W	9-9	0645-0650	0-50	1
56	M	41°49'N	166°39'W	9-10	0626-0640	0-135	530
56	C	41°49'N	166°39'W	9-10	0626-0641	0-143	6.12
56	V	41°49'N	166°39'W	9-10	0615-0620	0-50	1
57	V	42°41'N	164°57'W	9-11	1700-1702	0-50	1
58	C	43°23'N	163°13'W	9-12	0904-0919	0-143	5.70
59	V	44°06'N	161°39'W	9-13	1830-1832	0-50	1
60	C	44°46'N	159°55'W	9-13	1617-1631	0-143	5.51
61	C	45°15'N	158°20'W	9-14	0803-0818	0-143	5.87

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
61	V	45°15'N	158°20'W	9-14	0900-0902	0-50	1
62	C	45°58'N	156°52'W	9-14	2234-2249	0-143	5.35
63	C	46°23'N	155°29'W	9-15	0530-0545	0-143	5.45
63	V	46°23'N	155°29'W	9-15	0545-0547	0-50	1
64	V	46°54'N	153°55'W	9-15	2215-2245	0-50	1
65	V	45°30'N	154°20'W	9-16	1030-1032	0-50	1
66	V	44°09'N	152°57'W	9-17	0900-0902	0-50	1
68	C	42°02'N	150°33'W	9-18	1645-1700	0-171	5.07
69	V	40°54'N	149°26'W	9-19	0400-0402	0-50	1
70	M	39°44'N	148°24'W	9-19	0049-0130	0-165	449
70	V	39°44'N	148°24'W	9-19	1845-1847	0-50	1
71	C	40°05'N	156°45'W	9-20	1924-1937	0-61	2.46
71	V	40°05'N	156°45'W	9-20	1130-1132	0-50	1
72	C	40°25'N	145°29'W	9-20	0542-0557	0-163	4.10
73	C	40°53'N	143°52'W	9-21	1645-1700	0-143	1.22
73	V	40°53'N	143°52'W	9-21	1630-1632	0-50	1
74	V	41°22'N	142°18'W	9-22	0300-0302	0-50	1
76	V	39°56'N	143°38'W	9-28	2130-2132	0-50	1
78	C	37°59'N	146°01'W	9-30	0510-0525	0-143	5.56
78	V	37°59'N	146°01'W	9-30	0500-0502	0-50	1
79	M	26°23'N	145°30'W	9-30	1659-1713	0-190	240
79	C	26°23'N	145°30'W	9-30	1659-1713	0-51	4.00
80	M	35°04'N	145°08'W	10-1	0246-0250	0-112	430

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
80	C	35°04'N	145°08'W	10-1	0246-0301	0-166	4.89
81	M	34°06'N	144°36'W	10-2	0211-0306	0-127	450
81	C	34°06'N	144°36'W	10-2	0211-0306	0-155	5.31
82	M	33°00'N	144°15'W	10-2	1603-1614	0-129	464
82	C	33°00'N	144°15'W	10-2	1603-1614	0-153	6.47
83	V	31°08'N	143°41'W	10-3	0800-0802	0-50	1
84	M	30°09'N	143°16'W	10-3	2005-2019	0-153	468
84	C	30°09'N	143°16'W	10-3	2006-2021	0-129	5.09
86	C	32°27'N	140°37'W	10-5	1951-2006	0-129	5.93
89	M	34°22'N	138°40'W	10-15	2024-2044	0-138	703
89	V	34°22'N	138°40'W	10-15	1930-1932	0-50	1
92	V	32°45'N	137°48'W	10-16	1245-1247	0-50	1
93	M	33°25'N	135°06'W	10-24	0151-0205	0-110	565
93	V	33°25'N	135°06'W	10-24	0345-0347	0-50	1
94	C	33°00'N	135°57'W	10-24	1133-1148	0-143	4.58
94	V	33°00'N	135°57'W	10-24	1015-1017	0-50	1
95	V	32°23'N	137°07'W	10-24	1057-1121	0-50	1
96	M	31°44'N	138°00'W	10-25	0815-0830	0-115	434
96	C	31°44'N	138°00'W	10-25	0815-0830	0-143	1.68
96	V	31°44'N	138°00'W	10-25	0800-0802	0-50	1
98	M	32°03'N	141°04'W	10-26	0933-0948	0-155	421
98	C	32°03'N	141°04'W	10-26	0933-0947	0-123	4.33
99	V	31°55'N	142°12'W	10-26	2015-2020	0-50	1

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
100	C	32°14'N	144°02'W	10-29	0055-0109	0-163	5.74
101	M	32°10'N	145°53'W	10-29	1532-1547	0-165	418
101	C	32°10'N	145°53'W	10-29	1200-1220	0-143	5.02
101	V	32°10'N	145°53'W	10-29	1230-1235	0-50	1
103	M	31°49'N	149°58'W	10-30	2234-2249	0-175	458
103	C	31°49'N	149°58'W	10-30	2234-2249	0-143	3.8
105	M	33°10'N	153°00'W	10-31	2130-2145	0-175	362
106	C	33°34'N	154°29'W	11-1	1502-1540	0-153	14.85
106	V	33°34'N	154°29'W	11-1	1445-1450	0-50	1
108	M	34°45'N	157°40'W	11-2	1322-1337	0-115	491
108	C	34°45'N	157°40'W	11-2	1322-1337	0-164	5.61
108	V	34°45'N	157°40'W	11-2	1230-1235	0-50	1
110	M	35°40'N	160°43'W	11-3	1314-1328	0-85	486
111	M	36°04'N	162°14'W	11-4	0015-0030	0-155	411
112	M	36°35'N	163°46'W	11-4	1050-1104	0-135	499
112	C	36°35'N	163°46'W	11-4	1050-1104	0-149	5.96
112	V	36°35'N	163°46'W	11-4	1030-1035	0-50	1
113	M	37°28'N	165°16'E	11-5	0432-0447	0-150	380
114	M	37°54'N	166°57'E	11-5	1936-1951	0-160	462
114	C	37°54'N	166°57'E	11-5	1936-1951	0-118	5.44
115	M	38°32'N	168°32'E	11-6	0510-0525	0-165	394
116	M	37°40'N	170°06'E	11-7	0553-0607	0-105	415
116	C	37°40'N	170°06'E	11-7	0553-0608	0-164	3.38

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
116	V	37°40'N	170°06'E	11-7	0530-0536	0-50	1
118	C	35°37'N	172°44'E	11-8	0926-0941	0-115	4.94
118	V	35°37'N	172°44'E	11-8	1030-1036	0-50	1
120	C	33°23'N	175°13'E	11-9	0651-0706	0-143	4.85
120	V	33°23'N	175°13'E	11-9	0930-0937	0-50	1
122	C	31°37'N	178°12'E	11-10	1640-1655	0-134	5.44
123	M	30°37'N	179°30'E	11-11	0355-0411	0-130	524
124	C	29°39'N	179°10'W	11-10	1618-1633	0-153	3.76
125	M	28°38'N	178°02'W	11-11	0521-0536	0-142	457
126	C	27°58'N	175°02'W	11-13	0257-0312	0-153	5.44
128	C	26°59'N	171°55'W	11-14	0313-0328	0-134	5.02
130	C	25°52'N	168°43'W	11-15	0654-0708	0-143	4.75
135	M	22°50'N	160°06'W	11-18	0514-0529	0-151	405
135	C	22°50'N	160°06'W	11-18	0514-0529	0-131	2.97
136	M	21°42'N	156°19'W	11-21	2214-2243	0-375	793
137	C	23°05'N	152°02'W	11-22	2205-2229	0-144	4.33
138	M	24°27'N	147°32'W	11-23	2202-2228	0-345	769
139	M	25°48'N	142°43'W	11-24	2205-2239	0-320	895
139	C	25°48'N	142°43'W	11-24	2205-2239	0-310	8.85
141	M	28°14'N	133°38'W	11-26	2204-2229	0-325	641
141	C	28°14'N	133°38'W	11-26	2204-2229	0-315	6.87
142	M	29°31'N	128°47'W	11-27	2204-2229	0-300	788

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
143	M	29°31'N	128°47'W	11-28	2204-2229	0-415	738
143	C	29°31'N	128°47'W	11-28	2204-2229	0-415	4
Chinook				1956	LST		
1	V	ca. 30°N	ca.145°W	7-6	1530-1532	0-50	1
1	M	32°38'N	154°50'W	7-11	0156-0201	0-130	472
2	M	28°42'N	151°47'W	7-8	0036-0051	0-91	555
2	V	28°42'N	151°47'W	7-8	0500-0501	0-50	1
4	V	34°09'N	157°17'W	7-12	2300-2301	0-50	1
5	V	39°56'N	158°39'W	7-15	1200-1201	0-50	1
6	V	42°33'N	162°09'W	7-17	1300-1301	0-50	1
10	V	50°21'N	178°36'W	7-29	2300-2301	0-50	1
11	V	46°28'N	174°29'W	7-31	1900-1901	0-50	1
12	M	40°28'N	173°04'W	8-3	0056-0110	0-100	523
12	V	40°28'N	173°04'W	8-3	0100-0101	0-50	1
13	V	36°11'N	173°14'W	8-5	0537-0538	0-50	1
14	M	32°37'N	172°21'W	8-6	0046-0101	0-94	573
14	V	32°38'N	172°21'W	8-6	0300-0301	0-50	1
15	V	28°38'N	170°49'W	8-8	0022-0023	0-50	1
16	V	26°22'N	168°58'W	8-8	1700-1701	0-50	1
Norpac				1955	LST		
6	M	48°11'N	125°05'W	9-2	0037-0048	0-97	484
7	M	47°55'N	126°04'W	9-1	1854-1909	0-132	464
8	M	47°36'N	126°59'W	9-1	1401-1415	0-126	494

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
15	M	46°03'N	125°09'W	8-15	2156-2211	0-107	438
16	M	45°42'N	125°59'W	8-16	0429-0444	0-106	492
17	M	45°08'N	127°22'W	8-16	1236-1250	0-119	423
18	M	44°31'N	128°53'W	8-17	0016-0030	0-132	380
19	M	43°50'N	130°30'W	8-17	0900-0914	0-88	472
20	M	42°58'N	132°34'W	8-17	2146-2200	0-131	391
22	M	42°15'N	139°01'W	8-19	1641-1655	0-129	399
23	M	42°20'N	142°39'W	8-20	1006-1020	0-112	415
23.5	M	42°20'N	144°30'W	8-20	1956-1610	0-123	524
24	M	42°17'N	146°16'W	8-21	0351-0406	0-92	445
24-42	M	40°26'N	146°37'W	8-21	1556-1610	0-119	499
26	M	43°46'N	125°10'W	8-10	1912-1925	0-125	566
27	M	43°25'N	125°58'W	8-10	1141-1156	0-133	469
28	M	42°46'N	127°32'W	8-10	0156-0210	0-104	606
29	M	42°03'N	129°19'W	8-9	1101-1116	0-130	425
30	M	41°13'N	131°07'W	8-9	0021-0035	0-125	382
31	M	40°28'N	132°57'W	8-8	1235-1250	0-122	396
32	M	40°27'N	137°20'W	8-19	0251-0305	0-104	431
33	M	41°45'N	124°29'W	8-6	0959-1014	0-134	544
34	M	41°31'N	125°05'W	8-6	1426-1440	0-119	416
35	M	40°37'N	127°03'W	8-7	0146-0157	0-122	386
36	M	40°00'N	128°41'W	8-7	1241-1251	0-99	404
37	M	39°27'N	129°55'W	8-7	2056-2110	0-87	416

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
38	M	38°34'N	132°34'W	8-11	0846-0900	0-128	456
40	M	38°34'N	139°35'W	8-14	1446-1500	0-142	427
41	M	38°39'N	142°59'W	8-15	1336-1350	0-142	470
42	M	38°37'N	146°29'W	8-22	0241-0255	0-143	419
42.5	M	38°35'N	148°16'W	8-22	1156-1210	0-121	520
43	M	38°35'N	149°59'W	8-24	1536-1550	0-130	376
43-25	M	40°19'N	150°00'W	8-25	0631-0645	0-112	354
44	M	39°30'N	124°30'W	8-7	1126-1141	0-130	453
45	M	39°00'N	125°36'W	8-8	0516-0530	0-136	380
46	M	38°20'N	127°05'W	8-8	2234-2250	0-128	477
47	M	37°20'N	129°16'W	8-9	1816-1831	0-142	411
48	M	36°42'N	131°22'W	8-10	1256-1310	0-134	422
49	M	36°53'N	134°46'W	8-12	0456-0510	0-127	429
52	M	37°17'N	124°21'W	8-24	2210-2226	0-132	422
53	M	36°49'N	125°57'W	8-24	0746-0801	0-142	388
54	M	35°40'N	127°49'W	8-23	0756-0810	0-139	420
55	M	34°51'N	130°09'W	8-22	1031-1045	0-129	422
56	M	34°51'N	133°27'W	8-20	1005-1021	0-131	478
57	M	34°51'N	136°45'W	8-19	0456-0511	0-133	444
57.5	M	34°52'N	138°24'W	8-18	1611-1626	0-138	550
58	M	34°52'N	140°04'W	8-18	0346-0400	0-134	477
59	M	34°53'N	143°23'W	8-17	0046-0101	0-138	440
60	M	35°08'N	148°00'W	8-23	0851-0906	0-115	421

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
61	M	35°07'N	149°40'W	8-23	1742-1755	0-129	402
65	M	34°13'N	125°54'W	9-1	0726-0741	0-146	412
66	M	33°33'N	127°16'W	9-1	2346-0001	0-109	498
67	M	33°04'N	128°45'W	9-2	1326-1341	0-135	376
68	M	33°02'N	132°15'W	8-21	0746-0800	0-132	443
71	M	33°49'N	121°51'W	9-5	2241-2255	0-135	430
72	M	33°09'N	123°13'W	9-5	0955-1011	0-135	411
73	M	32°29'N	124°35'W	9-4	1846-1901	0-131	438
76	M	31°08'N	130°59'W	9-1	0506-0520	0-139	357
77	M	31°08'N	134°10'W	8-30	0826-0840	0-131	397
78	M	31°12'N	137°19'W	8-29	0841-0855	0-137	394
79	M	31°09'N	140°29'W	8-28	1016-1030	0-134	396
80	M	31°08'N	143°39'W	8-27	1436-1451	0-137	399
81.5	M	31°10'N	148°24'W	8-26	0306-0321	0-144	416
82	M	31°12'N	150°07'W	8-25	1611-1625	0-135	398
87	M	31°25'N	121°58'W	9-4	0856-0910	0-140	408
88	M	30°24'N	124°01'W	9-3	1536-1550	0-134	398
91	M	29°17'N	132°57'W	8-31	0156-0211	0-133	397
93	M	31°31'N	117°06'W	9-15	0316-0331	0-141	378
96	M	29°41'N	120°44'W	9-16	1556-1610	0-139	315
98	M	27°26'N	125°31'W	8-14	1926-1940	0-135	433
100	M	27°26'N	131°38'W	8-17	1916-1930	0-138	408
102	M	27°26'N	137°44'W	8-20	0746-0801	0-140	353

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
104	M	27°28'N	144°00'W	8-22	0646-0700	0-133	380
104.5	M	27°28'N	145°24'W	8-22	1546-1600	0-142	426
105.5	M	27°26'N	148°29'W	8-23	1416-1431	0-139	447
106	M	27°25'N	150°00'W	8-24	0451-0505	0-149	353
106-82	M	29°02'N	150°01'W	8-24	1551-1606	0-137	430
108	M	29°43'N	116°02'W	9-20	2336-2351	0-126	401
109	M	29°35'N	116°20'W	9-20	1836-1851	0-131	391
110	M	28°56'N	117°38'W	9-20	0641-0655	0-130	370
111	M	27°56'N	119°35'W	9-18	1956-2010	0-140	362
112	M	26°53'N	121°39'W	9-18	0241-0256	0-135	425
113	M	25°34'N	124°21'W	8-13	2242-2256	0-135	434
114	M	25°34'N	127°22'W	8-15	1631-1645	0-119	477
118	M	27°14'N	116°30'W	8-11	0321-0336	0-142	489
119	M	26°31'N	117°54'W	8-11	1811-1825	0-135	518
120	M	25°52'N	119°06'W	8-12	0516-0530	0-136	456
122	M	23°32'N	123°08'W	8-14	1051-1105	0-130	452
123	M	23°43'N	126°14'W	8-15	2336-2351	0-133	456
124	M	23°31'N	129°19'W	8-17	1156-1211	0-136	551
125	M	23°40'N	132°15'W	8-19	0516-0530	0-127	458
127	M	23°40'N	138°16'W	8-21	1126-1140	0-132	460
129	M	23°42'N	143°58'W	8-23	0341-0356	0-135	477
130.5	M	23°51'N	148°37'W	8-24	0840-0856	0-140	551
131	M	23°45'N	150°00'W	8-24	2226-2240	0-134	496

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
131.5	M	22°34'N	154°01'W	8-25	2126-2140	0-136	621
133	M	25°49'N	114°47'W	8-10	2056-2110	0-131	343
135	M	24°06'N	118°01'W	8-12	0431-0445	0-125	523
137	M	21°54'N	112°14'W	8-13	2036-2050	0-129	427
142	M	24°25'N	113°02'W	9-16	0446-0511	0-135	454
143	M	23°60'N	113°44'W	9-16	1241-1256	0-141	479
144	M	23°27'N	114°57'W	9-16	2206-2220	0-139	413
145	M	22°26'N	116°48°W	9-13	0226-0241	0-139	502
146	M	21°22'N	118°40'W	9-12	1056-1111	0-139	430
149	M	19°56'N	126°52'W	9-9	2256-2310	0-135	437
151	M	20°00'N	132°45'W	9-8	0456-0510	0-134	443
152	M	20°04'N	135°32'W	9-7	1041-1055	0-135	426
152.5	M	20°06'N	137°02'W	9-7	0111-0125	0-149	463
153	M	20°07'N	138°22'W	9-6	1331-1345	0-139	415
154	M	20°01'N	141°16'W	9-5	1931-1946	0-138	558
154.5	M	20°00'N	142°56'W	9-5	0746-0801	0-139	564
155	M	19°58'N	144°15'W	9-4	2156-2210	0-135	439
155.5	M	19°58'N	145°38'W	9-4	1026-1041	0-133	549
156	M	20°02'N	147°08'W	9-4	0056-0110	0-135	407
157	M	20°03'N	150°02'W	9-3	0321-0335	0-133	436
157A	M						
157B	M	20°06'N	153°06'W				

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
160	M	22°04'N	113°12'W	9-14	1926-1940	0-138	393
161	M	21°24'N	114°26'W	9-14	0956-1010	0-142	414
162	M	20°22'N	116°20'W	9-13	1636-1650	0-139	394
Gulf of Calif.				1952	LST		
1	M	22°50'N	109°55'W	9-30	0108-0116	0-68	261
2	M	22°53'N	109°45'W	9-30	0308-0316	0-66	278
5	M	23°20'N	109°22'W	9-30	0936-0944	0-69	299
6	M	23°36'N	109°26'W	9-30	1205-1213	0-66	298
9	M	24°11'N	109°56'W	9-30	1803-1811	0-68	294
11	M	24°30'N	110°16'W	9-30	2205-2213	0-68	288
12	M	24°36'N	110°26'W	10-1	0011-0019	0-69	276
13	M	24°21'N	110°30'W	10-2	2043-2051	0-69	322
15	M	24°47'N	110°38'W	10-3	0115-0123	0-69	314
16	M	25°04'N	110°46'W	10-3	0358-0405	0-66	348
17	M	25°17'N	110°55'W	10-3	0643-0650	0-67	320
19	M	25°43'N	111°10'W	10-3	1043-1051	0-69	309
22	M	26°13'N	111°08'W	10-3	2301-2308	0-70	293
23	M	26°25'N	111°19'W	10-4	0158-0206	0-67	311
24	M	26°38'N	111°30'W	10-4	0458-0506	0-70	310
25	M	26°51'N	111°42'W	10-4	0733-0741	0-68	290
27	M	26°54'N	111°34'W	10-4	2208-2216	0-67	286
28	M	26°39'N	111°15'W	10-5	0204-0212	0-70	320

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
29	M	26°21'N	110°59'W	10-5	0603-0610	0-72	298
30	M	26°03'N	110°42'W	10-5	1003-1011	0-69	313
31	M	25°39'N	110°32'W	10-5	1405-1413	0-68	306
32	M	25°17'N	110°24'W	10-5	1804-1812	0-70	317
33	M	24°55'N	110°10'W	10-5	2203-2211	0-69	320
34	M	24°36'N	109°55'W	10-6	0208-0215	0-68	311
35	M	24°16'N	109°38'W	10-6	0603-0611	0-69	291
36	M	23°53'N	109°26'W	10-6	1002-1010	0-70	307
37	M	23°27'N	109°20'W	10-6	1408-1415	0-71	326
153.16	M	22°55'N	110°07'W	9-29	2138-2153	0-138	497
150.19	M	23°24'N	110°39'W	9-29	1502-1515	0-114	441
147.20	M	23°56'N	111°04'W	9-29	0916-0931	0-137	577
143.26	M	24°19'N	111°48'W	9-29	0141-0148	0-63	240
140.30	M	24°46'N	112°24'W	9-28	0104-0114	0-91	364
M.Bay#2	M	24°33'N	111°52'W	9-28	1315-1325		119
S.M.Bay	M	24°44'N	112°12'W	9-28	0320-0330		78
137.23	M	25°34'N	112°19'W	9-27	1818-1825	0-55	224
133.21	M	26°13'N	112°33'W	9-27	0906-0910	0-33	169
130.26	M	26°37'N	113°14'W	9-27	0249-0253	0-35	149
127.34	M	26°55'N	114°06'W	9-26	1936-1944	0-70	275
121.34	M	27°55'N	114°45'W	9-24	1424-1429	0-42	141
115.30	M	29°05'N	115°08'W	9-22	0518-0525	0-63	298
113.30	M	29°22'N	115°18'W	9-21	1659-1703	0-29	166

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
Shellback				1952	LST		
1	V	30°44'N	118°24'W	5-18	1100-1102	0-100	2
5	M	25°18'N	121°41'W	5-20	1331-1356	0-281	904
6	M	24°18'N	122°29'W	5-20	2055-2120	0-277	966
7	M	23°30'N	122°55'W	5-21	0541-0606	0-266	897
8	M	22°37'N	123°25'W	5-21	1235-1256	0-269	968
9	M	21°43'N	123°58'W	5-21	2131-2156	0-256	918
10	M	20°52'N	124°28'W	5-22	0352-0415	0-319	873
10	V	20°52'N	124°28'W	5-22	0445-0447	0-100	2
11	M	20°00'N	124°56'W	5-22	1229-1313	0-474	1735
12	M	19°05'N	124°38'W	5-22	1921-1946	0-320	909
12	V	19°05'N	124°38'W	5-22	1830-1832	0-100	2
13	M	18°06'N	124°14'W	5-23	0432-0503	0-261	1255
15	M	16°14'N	123°34'W	5-24	0951-1015	0-301	691
15	V	16°14'N	123°34'W	5-24	0830-0832	0-100	2
17	V	14°26'N	122°49'W	5-25	0305-0307	0-100	798
20	M	11°52'N	121°55'W	5-26	1326-1351	0-277	1080
20	V	11°52'N	121°55'W	5-26	1300-1302	0-100	2
21	V	10°36'N	121°27'W	5-27	0345-0347	0-100	2
22	V	9°54'N	121°02'W	5-27	1320-1322	0-100	2
23	V	8°44'N	120°44'W	5-28	0030-0032	0-100	2
25	V	6°50'N	119°55'W	5-28	2230-2232	0-100	2
26	V	5°52'N	119°20'W	5-29	0945-0947	0-100	2

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
27	V	5°02'N	119°21'W	5-30	0100-0102	0-100	2
28	V	4°06'N	119°07'W	5-30	1045-1047	0-100	2
29	V	3°11'N	118°54'W	5-30	1845-1847	0-100	2
30	M	2°18'N	118°29'W	5-31	0336-0402	0-312	832
30	V	2°18'N	118°29'W	5-31	0325-0327	0-100	2
32	V	0°34'N	117°32'W	5-31	2120-2122	0-100	2
35	M	2°19'S	116°50'W	6-2	0206-0231	0-290	1098
35	V	2°19'S	116°50'W	6-2	0030-0032	0-100	2
37	V	4°06'S	116°06'W	6-2	1815-1817	0-100	2
38	M	5°09'S	115°41'W	6-3	0337-0402	0-189	1248
41	V	6°08'S	114°30'W	6-4	1610-1612	0-100	2
44	V	3°38'S	112°49'W	6-5	1830-1832	0-100	2
46	V	1°56'S	111°48'W	6-6	1045-1047	0-100	2
47	M	1°00'S	111°24'W	6-6	1751-1816	0-224	1070
47	V	1°00'S	111°24'W	6-6	1715-1717	0-100	2
51	M	2°16'N	109°12'W	6-8	0201-0226	0-308	1044
51	V	2°16'N	109°12'W	6-8	0245-0247	0-100	2
56	V	6°41'N	106°32'W	6-10	0405-0407	0-100	2
57	M	7°25'N	105°55'W	6-10	1225-1250	0-189	1248
58	V	8°13'N	105°27'W	6-10	2215-2217	0-100	2
59	V	9°05'N	104°54'W	6-11	0700-0702	0-100	2
60	V	9°35'N	104°28'W	6-11	1400-1402	0-100	2
61	M	10°45'N	103°47'W	6-12	0028-0053	0-219	1049

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
61	V	10°45'N	103°47'W	6-12	2345-2347	0-100	2
65	M	14°00'N	101°34'W	6-13	0741-0806	0-284	1051
66	V	14°53'N	101°03'W	6-13	1645-1647	0-100	2
69	V	14°29'N	99°03'W	6-18	0945-0947	0-100	2
70	V	13°34'N	99°22'W	6-18	2000-2002	0-100	2
73	V	10°30'N	98°51'W	6-19	2025-2027	0-100	2
76	M	7°46'N	98°19'W	6-20	1849-1905	0-321	765
76	V	7°46'N	98°19'W	6-20	1935-1937	0-100	2
78	V	5°46'N	97°52'W	6-21	1630-1632	0-100	2
79	V	4°44'N	97°31'W	6-22	0200-0202	0-100	2
80	M	3°48'N	97°34'W	6-22	1746-1811	0-331	866
81	V	2°42'N	97°28'W	6-23	0330-0332	0-100	2
84	M	0°06'S	96°52'W	6-24	1000-1025	0-205	1043
100	M	7°26'S	89°31'W	6-30	2306-2331	0-308	834
105	M	5°18'S	85°04'W	7-2	2206-2231	0-318	765
108	M	4°03'S	82°14'W	7-4	0131-0156	0-286	910
111	M	5°46'S	81°56'W	7-10	0526-0551	0-314	877
114	M	7°38'S	83°16'W	7-11	0256-0321	0-314	871
119	M	8°38'S	82°22'W	7-12	1416-1441	0-314	788
122	M	8°20'S	80°37'W	7-13	1016-1041	0-312	825
126	M	10°26'S	81°53'W	7-14	1436-1501	0-302	1063
129	M	10°59'S	80°01'W	7-15	0830-0856	0-311	795
133	M	12°38'S	78°29'W	7-21	0151-0216	0-280	998

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
136	M	13°26'S	80°30'W	7-21	2141-2206	0-323	898
138	V	14°01'S	81°47'W	7-22	1130-1132	0-100	2
139	M	14°09'S	82°26'W	7-22	2116-2146	0-299	930
141	V	14°33'S	84°06'W	7-23	1116-1141	0-100	2
142	M	14°59'S	85°03'W	7-23	1939-2004	0-321	870
145	M	11°58'S	85°00'W	7-24	2331-2356	0-232	1250
145	V	11°58'S	85°00'W	7-24	2015-2017	0-100	2
149	M	8°07'S	84°58'W	7-26	0200-0226	0-176	1126
154	V	2°59'S	85°00'W	7-27	1515-1517	0-100	2
155	M	1°56'S	85°00'W	7-27	2351-0016	0-311	906
158	V	1°02'N	85°00'W	7-28	2130-2155	0-100	979
159	V	2°08'N	84°54'W	7-29	0550-0552	0-100	2
160	M	3°00'N	85°00'W	7-29	1845-1910	0-326	942
160	V	3°00'N	85°00'W	7-29	1805-1807	0-100	2
161	V	3°58'N	85°01'W	7-30	0130-0132	0-100	2
162	M	4°55'N	85°01'W	7-30	1020-1045	0-282	997
164	V	7°05'N	84°59'W	7-31	0315-0317	0-100	2
166	M	9°02'N	85°02'W	7-31	2305-2331	0-283	1110
166	V	9°02'N	85°02'W	7-31	2230-2232	0-100	2
168	V	9°28'N	85°38'W	8-4	0915-0917	0-100	2
170	M	9°06'N	88°32'W	8-5	0121-0146	0-305	918
171	V	8°12'N	88°38'W	8-5	0844-0846	0-100	2
175	M	4°12'N	89°03'W	8-6	1902-1927	0-290	980

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
175	V	4°12'N	89°03'W	8-6	2005-2005	0-100	2
176	V	3°10'N	89°08'W	8-7	0351-0416	0-100	2
178	V	1°10'N	89°28'W	8-7	1730-1732	0-100	2
179	M	0°18'N	89°40'W	8-8	0155-0220	0-318	906
179	V	0°18'N	89°40'W	8-8	1243-1245	0-100	2
181	M	3°00'N	90°06'W	8-9	0924-0949	0-299	984
186	V	0°59'N	91°45'W	8-11	1530-1532	0-100	2
187	M	1°40'N	92°05'W	8-12	0644-0709	0-296	1005
191	V	0°01'N	96°06'W	8-13	1631-1637	0-100	2
192	V	0°01'N	97°07'W	8-14	2350-2400	0-100	2
193	V	0°01'N	98°16'W	8-14	0714-0723	0-100	2
196	V	1°00'N	100°30'W	8-15	0600-0610	0-100	2
198	V	2°50'N	101°28'W	8-16	0035-0043	0-100	2
199	V	3°54'N	101°56'W	8-16	0936-0938	0-100	2
200	M	5°04'N	102°32'W	8-16	2336-0001	0-297	799
200	V	5°04'N	102°32'W	8-16	2245-2247	0-100	2
201	V	6°00'N	103°00'W	8-17	0745-0753	0-100	2
202	V	7°02'N	103°29'W	8-17	2000-2002	0-100	2
203	M	8°05'N	103°54'W	8-18	0350-0415	0-306	891
203	V	8°05'N	103°54'W	8-18	0328-0336	0-100	2
205	V	10°06'N	105°02'W	8-19	0411-0412	0-100	2
206	V	11°00'N	105°29'W	8-20	2045-2047	0-100	2
207	M	12°07'N	106°02'W	8-21	0546-0611	0-301	879

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
211	M	16°00'N	107°57'W	8-22	1659-1724	0-303	909
214	M	19°01'N	109°30'W	8-23	1726-1751	0-306	842
217	M	22°18'N	111°09'W	8-24	1806-1830	0-328	795
<u>Shuttle</u>				<u>1952</u>	<u>LST</u>		
S- 3	V	20°59'N	119°17'W	4-24	2308	0-50	1
S- 6	V	16°51'N	117°03'W	4-27	1717	0-100	2
S- 9	V	18°30'N	112°18'W	4-30	1430	0-100	2
S-15	V	17°18'N	108°56'W	5-6	1918	0-100	2
S-29(P1)	V	10°19'N	109°17'W	5-13	1200	0-100	2
S-29(P2)	V	10°19'N	109°17'W	5-13	1205	0-100	2
S-29(P3)	V	10°19'N	109°17'W	5-13	1211	0-400	8
S-41	V	13°39'N	104°51'W	5-17	1414	0-100	2
S-48(P1)	V	12°51'N	98°19'W	5-23	1818	0-100	2
S-48(P2)	V	12°51'N	98°19'W	5-23	1825	0-100	2
S-48(P3)	V	12°51'N	98°19'W	5-23	1834	0-100	2
S-51(P1)	V	8°16'N	96°09'W	5-25	1402	0-100	2
S-51(P2)	V	8°16'N	96°09'W	5-25	1410	0-100	2
S-51(P3)	V	8°16'N	96°09'W	5-25	1415	0-100	2
S-53(P1)	V	5°24'N	94°23'W	5-26	1553	0-100	2
S-53(P3)	V	5°24'N	94°23'W	5-26	1608	0-100	2
S-56	V	5°26'N	92°31'W	5-27	2312	0-100	2
S-57(P1)	V	7°14'N	91°18'W	5-28	1650	0-100	2
S-57(P3)	V	7°14'N	91°18'W	5-28	1712	0-100	2

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
S-60(P1)	V	10°32'N	89°22'W	5-30	1140	0-100	2
S-60(P2)	V	10°32'N	89°22'W	5-30	1146	0-100	2
S-60(P3)	V	10°32'N	89°22'W	5-30	1154	0-100	2
S-62(P1)	V	8°30'N	88°25'W	5-31	0652	0-100	2
S-62(P3)	V	8°30'N	88°25'W	5-31	0705	0-100	2
S-64	V	10°25'N	87°28'W	6-2	1118	0-100	2
S-66(P1)	V	12°16'N	88°17'W	6-3	1312	0-100	2
S-66(P3)	V	12°16'N	88°17'W	6-3	1326	0-100	2
Troll				1955	LST		
0A	M	13°01'N	179°09'E	3-9	0945	0-200	710
1	M	11°58'N	176°08'E	3-10	2154-2210	0-200	855
1A	M	10°57'N	173°26'E	3-10	0843-0901	0-200	591
2	M	9°58'N	170°36'E	3-11	0114-0140	0-200	600
2A	M	8°41'N	167°00'E	3-13	1234-1250	0-200	560
3	M	8°20'N	165°26'E	3-13	2144-2201	0-200	584
3A	M	7°54'N	163°54'E	3-13	0454-0510	0-200	550
4	M	9°23'N	163°36'E	3-14	1414-1431	0-200	569
4A	M	10°48'N	163°20'E	3-14	2304-2320	0-200	546
5	M	12°16'N	163°06'E	3-14	0814-0830	0-200	565
5A	M	13°37'N	162°59'E	3-15	1524-1540	0-200	542
6A	M	13°43'N	162°20'E	3-15	0904-0921	0-200	559
7	M	12°17'N	161°28'E	3-16	1654-1711	0-200	572
7A	M	10°52'N	160°35'E	3-16	0024-0040	0-200	554

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
8	M	9°29'N	159°46'E	3-16	0814-0831	0-200	556
8A	M	8°12'N	159°10'E	3-17	1504-1521	0-200	561
9	M	6°49'N	158°32'E	3-17	2313-2331	0-200	585
9A	M	5°32'N	157°52'E	3-17	0624-0640	0-200	646
10	M	4°00'N	157°00'E	3-18	2154-2210	0-200	636
10A	M	4°55'N	155°54'E	3-18	0554-0610	0-200	643
11	M	5°44'N	154°48'E	3-19	1354-1411	0-200	571
11A	M	6°33'N	153°46'E	3-19	1954-2021	0-200	592
12	M	7°29'N	152°28'E	3-19	0550-0601	0-200	585
12A	M	8°35'N	150°49'E	3-20	1924-1941	0-200	495
13	M	9°31'N	149°46'E	3-20	0254-0311	0-200	545
13A	M	10°28'N	148°36'E	3-20	0954-1011	0-200	545
14	M	11°25'N	147°26'E	3-21	1744-1801	0-200	551
14A	M	12°19'N	145°55'E	3-21	0124-0141	0-200	419
15	M	13°26'N	144°31'E	3-22	1054-1111	0-200	581
15I	M	13°25'N	144°32'E	3-24	1304-1321	0-200	546
15A	M	14°28'N	143°47'E	3-24	1854-1911	0-200	548
16	M	15°34'N	143°01'E	3-24	0144-0201	0-200	560
16A	M	16°43'N	142°11'E	3-24	0804-0821	0-200	546
17	M	17°50'N	141°26'E	3-25	1524-1541	0-200	503
17A	M	18°38'N	140°52'E	3-25	2004-2020	0-200	457
18	M	19°56'N	139°59'E	3-25	0404-0421	0-200	546
18A	M	21°11'N	139°09'E	3-26	1044-1101	0-200	457

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
19	M	22°12'N	138°26'E	3-26	1724-1741	0-200	583
19A	M	21°14'N	137°12'E	3-26	0024-0040	0-200	619
20	M	20°15'N	136°01'E	3-26	0654-0710	0-200	551
20A	M	19°03'N	135°08'E	3-27	1754-1811	0-200	598
21	M	17°59'N	134°24'E	3-27	2354-2411	0-200	596
21A	M	16°58'N	133°24'E	3-27	0454-0511	0-200	619
22	M	15°56'N	132°27'E	3-28	1306-1321	0-200	522
22A	M	14°47'N	131°21'E	3-28	1854-1911	0-200	649
23	M	13°40'N	130°16'E	3-28	0154-0211	0-200	625
23A	M	12°38'N	129°16'E	3-28	0754-0811	0-200	578
24	M	11°40'N	128°19'E	3-29	1414-1431	0-200	601
24A	M	10°19'N	127°21'E	3-29	2204-2221	0-200	671
25	M	9°14'N	126°30'E	3-29	0404-0421	0-200	613
25A	M	10°20'N	126°59'E	3-30	1024-1041	0-200	609
26	M	11°36'N	127°27'E	3-30	1754-1811	0-200	598
27	M	9°01'N	127°42'E	3-30	0454-0511	0-200	653
27A	M	7°37'N	127°56'E	3-31	1114-1131	0-200	635
28	M	6°09'N	128°10'E	3-31	1944-2001	0-200	611
28A	M	4°28'N	128°20'E	3-31	0304-0321	0-200	668
29	M	3°01'N	128°28'E	4-1	1034-1051	0-200	596
30	M	5°58'N	127°22'E	4-1	0114-0131	0-200	567
30A	M	7°28'N	126°48'E	4-1	0924-0941	0-200	612
31	M	8°58'N	126°29'E	4-2	1924-1941	0-200	631

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
31A	M	10°35'N	126°18'E	4-2	0301-0321	0-200	620
32	M	12°00'N	126°03'E	4-3	1054-1111	0-200	620
32A	M	13°37'N	125°10'E	4-3	2004-2021	0-200	657
33	M	15°16'N	124°17'E	4-3	0414-0511	0-200	613
33A	M	16°50'N	123°22'E	4-4	1240-1257	0-200	617
35	M	20°01'N	121°54'E	4-4	0814-0831	0-200	560
35A	M	20°42'N	123°29'E	4-5	1644-1700	0-200	539
36	M	21°30'N	124°44'E	4-5	0144-0201	0-200	585
36A	M	22°17'N	126°12'E	4-6	0904-0921	0-200	591
37	M	22°59'N	127°36'E	4-6	1624-1641	0-200	566
37A	M	24°24'N	127°33'E	4-6	2314-2330	0-200	567
38	M	25°46'N	127°29'E	4-6	0634-0651	0-200	564
38A	M	27°39'N	127°40'E	4-9	1604-1621	0-200	628
39	M	29°34'N	128°14'E	4-9	0214-0234	0-200	579
40	M	31°10'N	128°48'E	4-10	0954-1011	0-200	590
40A	M	30°55'N	130°02'E	4-10	1454-1511	0-200	546
41	M	30°58'N	131°42'E	4-10	2254-2311	0-200	609
41A	M	29°54'N	132°45'E	4-10	0604-0621	0-200	631
42	M	28°19'N	134°02'E	4-11	1444-1501	0-200	598
43	M	27°00'N	135°01'E	4-11	2354-2411	0-200	603
43A	M	28°28'N	135°52'E	4-11	0734-0751	0-200	603
44	M	29°55'N	136°29'E	4-12	1914-1931	0-200	612
45	M	33°05'N	138°09'E	4-13	1304-1320	0-200	571

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
EquaPac - Horizon				1956	LST		
1	M	11°00'N	164°00'E	8-7	2232-2300	0-300	1098
3	M	8°00'N	164°00'E	8-8	0747-0816	0-300	1203
4	M	6°36'N	164°04'E	8-9	0747-0816	0-300	1191
6	M	4°00'N	164°00'E	8-12	0127-0156	0-300	1112
7	M	3°00'N	164°00'E	8-12	1012-1030	0-300	960
9	M	1°02'N	164°00'E	8-13	0621-0648	0-300	1094
11	M	1°00'S	164°00'E	8-13	0107-0134	0-300	948
13	M	3°00'S	163°58'E	8-14	2012-2040	0-300	1073
15	M	5°00'S	164°00'E	8-15	1207-1236	0-300	1004
17	M	7°58'S	164°00'E	8-15	1042-1110	0-300	1322
19	M	10°58'S	164°00'E	8-17	0752-0821	0-300	1030
21	M	9°00'S	162°00'E	8-18	0209-0238	0-300	1334
23	M	7°32'S	159°57'E	8-18	2152-2220	0-300	952
25	M	6°32'S	157°59'E	8-19	1309-1338	0-300	1083
28	M	4°00'S	157°00'E	8-23	2236-2304	0-300	1073
30	M	1°56'S	156°48'E	8-24	1305-1333	0-300	919
32	M	0°03'S	157°00'E	8-24	0502-0530	0-300	1007
34	M	2°00'N	156°59'E	8-25	2238-2306	0-300	1036
36	M	3°54'N	156°00'E	8-26	1357-1425	0-300	1069
38	M	6°30'N	157°00'E	8-27	1057-1125	0-300	1121
40	M	9°27'N	157°08'E	8-28	0626-0654	0-300	1046
41	M	11°05'N	157°00'E	8-28	1822-1850	0-300	1219

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
43	M	11°02'N	158°53'E	8-29	1012-1040	0-300	1370
45	M	11°04'N	161°00'E	8-30	0410-0447	0-300	1208
EquaPac - Stranger				1956	GCT		
1	M	20°43'N	158°28'W	8-21	0426-0439	0-140	443
3	M	18°34'N	160°26'W	8-22	0516-0530	0-140	446
4	M	17°26'N	161°41'W	8-22	1726-1741	0-140	458
6	M	15°14'N	163°56'W	8-23	1556-1610	0-140	429
8	M	13°09'N	165°57'W	8-24	1536-1550	0-140	431
9	M	12°15'N	166°49'W	8-25	0805-0820	0-140	433
11	M	10°00'N	167°00'W	8-26	0026-0040	0-140	439
13	M	8°08'N	166°55'W	8-26	1656-1710	0-140	481
14	M	7°01'N	166°53'W	8-27	0326-0340	0-140	454
15	M	5°59'N	166°40'W	8-27	1115-1130	0-140	414
17	M	4°02'N	166°54'W	8-28	0636-0650	0-140	437
18	M	3°02'N	167°11'W	8-28	1636-1650	0-140	428
19	M	2°02'N	167°10'W	8-29	0216-0230	0-140	437
21	M	0°02'N	166°59'W	8-29	2206-2230	0-140	428
23	M	1°56'S	166°52'W	8-30	1716-1730	0-140	364
24	M	3°00'S	167°02'W	8-31	0136-0150	0-140	332
27	M	6°00'S	167°05'W	9-1	0216-0230	0-140	336
28	M	5°58'S	175°02'W	9-13	0026-0040	0-140	305
30	M	4°01'S	175°00'W	9-13	1616-1630	0-140	349
32	M	2°00'S	175°06'W	9-14	0926-0940	0-140	340

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
34	M	0°01'N	174°59'W	9-15	0256-0310	0-140	384
36	M	2°04'N	175°02'W	9-15	2010-2120	0-140	361
38	M	4°00'N	174°56'W	9-17	1156-1210	0-140	325
40	M	6°00'N	174°54'W	9-18	0616-0630	0-140	353
46	M	11°57'N	175°03'W	9-20	2116-2130	0-140	364
POFI - 5				1950	LST		
1	M	27°00'N	175°11'W	6-30	0945-1012	0-200	1248.7
2	M	25°00'N	174°10'W	7-1	0258-0325	0-200	1322.7
3	M	22°58'N	173°00'W	7-1	2315-2337	0-200	1343.9
4	M	21°00'N	172°00'W	7-2	0415-0431	0-200	739.5
5	M	19°00'N	171°52'W	7-3	0807-0831	0-200	1254.8
6	M	17°01'N	171°46'W	7-3	1219-1246	0-200	1434.4
7	M	15°00'N	171°54'W	7-4	1649-1710	0-200	888.1
8	M	14°00'N	171°57'W	7-5	0123-0145	0-200	854.8
9	M	13°00'N	172°01'W	7-5	0950-1019	0-200	1327.5
10	M	12°00'N	172°00'W	7-5	1815-1833	0-200	882.8
11	M	11°03'N	172°00'W	7-6	0315-0342	0-200	1333.3
12	M	9°54'N	172°02'W	7-6	1213-1244	0-200	1777.0
13	M	8°54'N	172°00'W	7-6	2012-2036	0-200	1190.2
14	M	7°59'N	171°57'W	7-7	0350-0420	0-200	1623.7
15	M	6°59'N	171°46'W	7-7	1226-1258	0-200	1579.4
16	M	6°02'N	171°56'W	7-7	2130-2201	0-200	1382.2
17	M	5°00'N	172°02'W	7-8	0845-0918	0-200	1821.1

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
18	M	4°00'N	172°03'W	7-8	1659-1729	0-200	1346.2
19	M	3°00'N	172°01'W	7-9	0036-0101	0-200	1063.8
20	M	2°00'N	171°53'W	7-9	0838-0909	0-200	1809.2
21	M	0°54'N	172°12'W	7-9	1746-1815	0-200	1586.0
22	M	0°08'S	172°02'W	7-10	0143-0214	0-200	1943.8
23	M	1°00'S	171°57'W	7-10	0925-0951	0-200	1256.9
24	M	2°00'S	171°55'W	7-10	1740-1809	0-200	1406.4
25	M	2°59'S	171°59'W	7-11	0133-0201	0-200	1309.9
26	M	4°05'S	171°56'W	7-11	1055-1127	0-200	1585.3
27	M	5°04'S	171°58'W	7-11	2110-2141	0-200	1632.8
28	M	4°56'S	158°02'W	7-28	0556-0614	0-200	1384.8
29	M	4°00'S	158°03'W	7-28	1324-1338	0-200	642.8
33	M	0°02'S	157°58'W	7-29	2221-2239	0-200	773.0
35	M	2°00'N	158°07'W	7-30	1532-1553	0-200	851.2
37	M	4°02'N	158°03'W	7-31	0640-0707	0-200	1652.5
39	M	6°00'N	157°57'W	8-1	0144-0214	0-200	1313.7
41	M	8°00'N	157°50'W	8-1	1620-1704	0-200	3361.5
43	M	10°00'N	157°53'W	8-2	0744-0812	0-200	1597.8
45	M	11°59'N	158°04'W	8-2	2343-0008	0-200	1034.5
47	M	14°00'N	157°54'W	8-3	1639-1709	0-200	1305.7
48	M	14°58'N	157°55'W	8-4	0253-0311	0-200	592.8
49	M	17°00'N	158°08'W	8-4	1741-1805	0-200	934.8
50	M	19°02'N	157°59'W	8-5	1006-1031	0-200	1035.0

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
POFI - 8				1951	LST		
2	M	18°47'N	158°01'W	1-15	1449-1504	0-200	625.9
4	M	14°30'N	158°00'W	1-17	0925-0940	0-200	433.1
6	M	12°57'N	157°58'W	1-17	2251-2318	0-200	819.0
8	M	11°00'N	157°53'W	1-18	1633-1658	0-200	1399.9
10	M	9°00'N	157°58'W	1-19	1154-1216	0-200	985.1
12	M	7°08'N	157°58'W	1-20	0615-0645	0-200	1299.2
16	M	3°02'N	157°57'W	1-21	2135-2155	0-200	1018.2
18	M	0°58'N	158°07'W	1-22	1730-1754	0-200	1529.1
20	M	0°55'S	157°54'W	1-23	1208-1233	0-200	1509.4
24	M	5°00'S	158°00'W	1-24	2330-2350	0-200	885.8
26	M	7°00'S	158°01'W	1-25	1548-1616	0-200	1352.6
32	M	6°57'N	154°56'W	1-31	0208-0238	0-200	1521.4
34	M	5°00'N	155°28'W	1-31	1836-1902	0-200	1483.0
42	M	6°50'N	157°33'W	2-3	0612-0639	0-200	1680.3
44	M	5°00'N	158°34'W	2-3	2245-2309	0-200	1245.7
46	M	3°03'N	159°10'W	2-6	0441-0513	0-200	1881.2
52	M	6°59'N	161°12'W	2-7	1025-1049	0-200	1744.5
56	M	2°58'N	162°25'W	2-9	1919-1946	0-200	1819.0
62	M	6°44'N	165°23'W	2-11	1652-1718	0-200	1330.2
72	M	3°05'S	167°50'W	2-15	0323-0353	0-200	1740.7
75	M	5°59'S	168°29'W	2-16	0208-0241	0-200	2424.3
76	M	7°04'S	168°48'W	2-16	0923-0953	0-200	2308.6

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
77	M	14°30'S	171°51'W	2-26	1931-1958	0-200	1876.1
78	M	11°56'S	171°59'W	2-27	1129-1157	0-200	1918.4
80	M	8°00'S	171°56'W	2-28	1821-1846	0-200	1452.5
82	M	5°59'S	172°00'W	3-1	1118-1144	0-200	1399.9
84	M	4°00'S	172°06'W	3-2	0735-0758	0-200	1510.7
86	M	2°00'S	172°02'W	3-3	1612-1641	0-200	1593.0
88	M	0°09'N	171°58'W	3-4	0926-0947	0-200	1066.0
92	M	3°57'N	172°02'W	3-5	1816-1842	0-200	1221.9
94	M	5°55'N	171°50'W	3-6	1105-1130	0-200	1428.2
96	M	7°56'N	171°51'W	3-7	0407-0433	0-200	1498.1
98	M	10°02'N	171°56'W	3-7	2147-2213	0-200	1538.1
100	M	12°00'N	171°52'W	3-8	1417-1443	0-200	1507.0
101	M	13°01'N	171°48'W	3-8	2236-2301	0-200	1720.5
102	M	13°58'N	171°24'W	3-9	0650-0713	0-200	1247.5
103	M	15°00'N	170°52'W	3-9	1557-1619	0-200	1313.9
104	M	16°58'N	169°42'W	3-10	0913-0940	0-200	1993.3
105	M	18°58'N	168°27'W	3-11	0207-0235	0-200	1941.0
106	M	20°59'N	169°07'W	3-11	1913-1940	0-200	1938.5
Capricorn				1952	LST		
28	V	6°02'N	168°31'E	11-27	1000-1002	0-50	1
30	V	5°03'N	168°30'E	11-27	1630-1632	0-50	1
33	V	1°43'N	169°04'E	11-28	1600-1602	0-50	1

Table 1 (cont.)

Cruise, Station	Net	Latitude	Longitude	Date	Time	Sample Depth	Vol. Water
44	V	2°00'S	170°19'E	12-3	1745-1747	0-50	1
				1953			
126	V	10°44'S	133°28'W	1-28	1245-1247	0-50	1
127	V	11°00'S	130°24'W	1-29	0600-0602	0-50	1
136	V	10°54'S	130°28'W	1-29	1335-1337	0-50	1
145	V	14°16'S	120°40'W	2-1	1845-1847	0-50	1
164	V	14°23'S	112°56'W	2-4	1800-1802	0-50	1
169	V	12°02'S	113°25'W	2-6	1000-1002	0-50	1
172	V	10°44'S	114°23'W	2-6	2330-2332	0-50	1
206	V	1°05'S	123°48'W	2-10	2350-2352	0-50	1
207	V	0°10'N	123°29'W	2-11	1500-1502	0-50	1
209	V	3°31'N	123°28'W	2-12	0910-0912	0-50	1

Table 2. Occurrences of planktonic Foraminifera in per cent of total population. X less than 0.5 per cent. Oblique tows, surface to indicated depths. M, V, C refer to meter net, 17 cm. net and Clarke-Bumpus sampler respectively.

CRUISE: TRANSPAC

STATION	1	3		5	6	7	8		9	10		11		12	13	14	15	17	18	
TYPE OF NET	V	C	V	M	M	M	M	C	M	M	C	M	V	C	V	C	V	C	C	V
DEPTH RANGE IN METERS	0-30	0-143	0-50	0-135	0-115	0-170	0-145	0-145	0-170	0-120	0-145	0-170	0-50	0-143	0-50	0-143	0-50	0-145	0-143	0-50
TOTAL SAMPLE POPULATION	37	37	34	16	16	28	46	20	27	23	17	20	8	169	1010	2844	309	208	160	23
POPULATION PER 1000 M^3	59,000	4,940	34,000	36	39	88	92	3,400	52	64	4,000	25	8,000	31,000	1,010,000	388,000	309,000	45,100	5,200	23,000
Candeina nitida																				
Globigerina bulloides	19	26	32					10			6		13	4		3	5	22	10	
conglomerata																				
eggeri	69	6	23	6							12		13	69	85	4	9	2	50	35
hexagona																				
inflata																				
pachyderma		6														1		1	3	
quinqueloba	3	16	42										12	11	4	91	82	44	35	44
sp.																				
Globigerinella aequilateralis																				
sp.																				
Globigerinita glutinata	7		3								6			3		X	1			
Globigerinoides conglobata																				
cf. minuta	2													X	2		3			4
rubra		6									6		58	X						
sacculifera																				
sp.																				
Globorotalia hirsuta																				
menardii																				
scitula																				
truncatulinoides				6				75	4		29		12							
fumida																				
Hastigerina pelagica				6				5	7											
Hastigerinella rhumbleri																				
Orbulina universa		31	76	20	2	60	10	89	100	35	100		12			1	X	14	1	
Pulleniatina obliquiloculata																				
Sphaeroidinella dehiscens																				
unidentified globigerinids	9										6			1	9	X		17	1	17
unidentified globorotaliids																				

STATION	19	20		21	24			27	28	29	31	32	33	36	37	38	42	43	44	45
TYPE OF NET	V	C	V	V	M	C	V	.	C	.	V	C	V	V	V	V	V	V	V	V
DEPTH RANGE IN METERS	0-50	0-143	0-50	0-50	0-180	0-143	0-50	0-50	0-143	0-50	0-50	0-143	0-30	0-50	0-50	0-50	0-50	0-50	0-50	0-50
TOTAL SAMPLE POPULATION	46	248	94	97	104	259	560	340	640	337	284	1290	300	228	114	325	124	166	548	254
POPULATION PER 1000 M^3	46,000	42,900	94,000	97,000	250	50,900	560,000	340,000	104,500	337,000	284,000	256,000	300,000	228,000	114,000	325,000	124,000	166,000	548,000	254,000
Candeina nitida																				
Globigerina bulloides	4	65	39	22	96	66	41	20	69	38	31	46	21	45	36	12	7	1	3	5
conglomerata																				
eggeri	22	1	3	2		9	56	59	16	39	33	16	57	35	23	72	68	69	72	77
hexagona																				
inflata																				
pachyderma						13			6			12								
quinqueloba	68	32	54	68	2	9	19	34	9	18	30	31	12	17	57	12	12	8	3	4
sp.																				
Globigerinella aequilateralis																				
sp.																				
Globigerinita glutinata	2	1		1		3	2	1				1				X			1	1
Globigerinoides conglobata																				
cf. minuta	4		4	7			2	5		5	6		9	3	2	4	12	22	21	13
rubra																				
sacculifera																	1			
sp.																				
Globorotalia hirsuta																				
menardii																				
scitula																				
truncatulinoides																				
fumida																				
Hastigerina pelagica																				
Hastigerinella rhumbleri																				
Orbulina universa																				
Pulleniatina obliquiloculata																				
Sphaeroidinella dehiscens																				
unidentified globigerinids		1			2			1					1							
unidentified globorotaliids																				

STATION	47	48	50		51		52		53	54	55			56			57	58	59
TYPE OF NET	V	C	C	V	C	V	C	V	V	M	M	C	V	M	C	V	V	C	V
DEPTH RANGE IN METERS	0-50	0-143	0-143	0-50	0-143	0-50	0-143	0-50	0-50	0-170	0-169	0-145	0-50	0-135	0-143	0-50	0-50	0-143	0-50
TOTAL SAMPLE POPULATION	99	495	696	335	346	128	31	21	84	252	66	142	130	99	96	55	57	26	17
POPULATION PER 1000 M^3	99,000	78,400	165,000	335,000	66,300	128,000	5,700	21,000	84,000	311	145	25,800	130,000	187	15,700	55,000	57,000	4,560	17,000
Candeina nitida																			
Globigerina bulloides	1	22	13	2	12	3	33	10		2	6	3			18	2		23	
conglomerata																			
eggeri	81	12	2	25	2	19	29	70	42	66	52	36	64	86	66	75	18	20	65
hexagona																			
inflata										1									
pachyderma		30	24		8		6											11	
quinqueloba	1	31	61	51	70	45	6	10	1			11		6	2	9	48	46	12
sp.																			
Globigerinella aequilateralis										1	1	1		2					
sp.																			
Globigerinita glutinata		3	X	1	1		10					1			1				
Globigerinoides conglobata																			
cf. minuta	17		X	41	6	35	3	10									42		17
rubra																			
sacculifera									55	24	33	42	34	6	13	14			
sp.												1							
Globorotalia hirsuta													1						
menardii																			
scitula																			
truncatulinoides										1	5	3							
fumida																			
Hastigerina pelagica										3	2								
Hastigerinella rhumbleri																			
Orbulina universa											1								
Pulleniatina obliquiloculata																			
Sphaeroidinella dehiscens																			
unidentified globigerinids		1			1				2	2		1	1						6
unidentified globorotaliids																			

CRUISE: TRANSPAC

STATION	60	61		62	63		64	65	66	68	69	70		71		72	75		74	76
TYPE OF NET	C	C	V	C	C	V	V	V	V	C	V	M	V	C	V	C	C	V	V	V
DEPTH RANGE IN METERS	0-143	0-145	0-50	0-143	0-145	0-50	0-50	0-50	0-50	0-171	0-50	0-165	0-58	0-61	0-50	0-163	0-143	0-50	0-50	0-50
TOTAL SAMPLE POPULATION	243	578	406	560	257	228	245	241	238	1650	172	252	101	129	68	58	96	59	48	38
POPULATION PER 1000 M^3	48,100	97,100	406,000	104,500	47,200	228,000	245,000	241,000	238,000	326,000	172,000	562	101,000	52,500	68,000	14,100	78,300	59,000	48,000	38,000
Candeina nitida																				
Globigerina bulloides	5	5	X	7	9	1	12	5	4	8	2				6	3	18	17		9
conglomerata																				
eggeri	47	22	9	5	36	46	46	31	6	23		13	55	1	6	5	2	24	46	31
hexagona																				
inflata																				
pachyderma	6	26		26	36					12				5		10	13			
quinqueloba	38	43	35	48	48	36	25	28	39	69	63		2	80	77	73	55	47	10	
sp.												1	1							
Globigerinella aequilateralis												13	1							3
sp.																				
Globigerinita glutinata			20	2		25	X		X			2	4	3						9
Globigerinoides conglobata												1								
cf. minuta		21	23	7	2	1	16	21	26	5	8		6	1	6	2	11	12	2	
rubra	3										2	4	5						40	18
sacculifera												6	2							3
sp.												10	1							6
Globorotalia hirsuta												X								
menardii																				
scitula																				
truncatulinoides																				
fumida																				
Hastigerina pelagica												29								9
Hastigerinella rhumbleri																				
Orbulina universa											1	10								
Pulleniatina obliquiloculata												10	7							6
Sphaeroidinella dehiscens																				
unidentified globigerinids	1	5		1	x		X				1	1	11		5	7	1		2	6
unidentified globorotaliids																				

STATION	78		79		80		81		82		85	84		86	89		92	93		94
TYPE OF NET	C	V	M	C	M	C	M	C	M	C	V	M	C	C	M	V	V	M	V	C
DEPTH RANGE IN METERS	0-143	0-50	0-190	0-51	0-112	0-166	0-127	0-155	0-129	0-153	0-50	0-153	0-127	0-129	0-158	0-50	0-50	0-110	0-50	0-143
TOTAL SAMPLE POPULATION	124	9	169	141	164	89	243	43	147	83	80	67	42	75	578	160	43	270	51	461
POPULATION PER 1000 M^3	22,500	9,000	705	35,200	382	18,200	539	8,100	317	13,800	8,000	145	8,270	12,600	822	160,000	43,000	478	51,000	101,000
Candeina nitida																				
Globigerina bulloides	3		1	4		3	X	2		1				2	1	7	14	2	29	2
conglomerata																				
eggeri	28	45	10	21	4	3	1	16	2	6	2			9	25	47	14	18	6	25
hexagona									1											
inflata																				
pachyderma	15																			
quinqueloba	31			1			X			5								1		
sp.							X			4		1	2	1		1			2	3
Globigerinella aequilateralis			5	4	4	2	7	7	5	6		1		4	2		7	4	6	1
sp.			1		1															
Globigerinita glutinata	1			7		18		19	1	12	26		16	8		9	9		4	2
Globigerinoides conglobata			7		5	2	1		2					1	3			2		X
cf. minuta																				
rubra	3	11	14	39	6	45	3	34	6	44	57	9	60	56	8	10	19	25	12	16
sacculifera	3		9	10	5	12	3	7	13	7	35	3	7	29	17	3	5	9	14	7
sp.			4	2		4			1	5		1	5	4	1	4		4	2	2
Globorotalia hirsuta							X		1									1		
menardii	2																			
scitula																				
truncatulinoides																				
fumida																				
Hastigerina pelagica			5	1	32	4	20	5	11	2	1	6			2	2		1		1
Hastigerinella rhumbleri																				
Orbulina universa			36	1	55	1	60	5	56	1		79		1	11	1		14	2	1
Pulleniatina obliquiloculata	6	11	7	5	9	2	3			1				1	36	13	7	18		37
Sphaeroidinella dehiscens																				X
unidentified globigerinids	8	33	1	6	1	4		5		6	9		10	4		3	25		23	3
unidentified globorotaliids																				

STATION		95	96			98		99	100	101			103		105	106		108	
TYPE OF NET	V	V	M	C	V	M	C	V	C	M	C	V	M	C	M	C	V	M	C
DEPTH RANGE IN METERS	0-50	0-50	0-115	0-143	0-50	0-155	0-123	0-50	0-163	0-165	0-143	0-50	0-175	0-143	0-175	0-163	0-50	0-115	0-164
TOTAL SAMPLE POPULATION	48	81	386	240	28	171	16	16	20	71	17	7	45	23	114	195	90	844	443
POPULATION PER 1000 M^3	48,000	81,000	892	155,000	28,000	406	3,000	16,000	3,480	170	3,390	7,000	97	4,050	315	13,100	90,000	1,720	79,800
Candeina nitida																			
Globigerina bulloides	2	1		3	11		6											X	6
conglomerata																			
eggeri	27	11	11	26	7	3	12	44	30	3	12		4	17	4	24	19	9	18
hexagona	2				4														
inflata																1		3	13
pachyderma																			
quinqueloba																			
sp.		1	1	1	4		6	6	5	7	6	14	3			2	6	1	3
Globigerinella aequilateralis			4	1		5	13		5	11	17		13	10	7	2	1	18	3
sp.			1			4													
Globigerinita glutinata	2	1		3	8		6	12	5		12	14	4	39		25	20		19
Globigerinoides conglobata		1	2	1		1												1	
cf. minuta																			
rubra	13	11	8	13	21	2	6		35		23	49	13	15	1	14	4	2	5
sacculifera	4		11	2	27	6	13	20	10	14	6	28	7	4	1	2	1	5	3
sp.		30	3	2	7	1	6			1							1	2	X
Globorotalia hirsuta			11	1		23				6			7		3			1	
menardii																1			
scitula											6					1	4		1
truncatulinoides																			
fumida																			
Hastigerina pelagica			7	1		23				21			31		33	2		15	1
Hastigerinella rhumbleri																			
Orbulina universa			20	1		23				34			15		30		1	18	
Pulleniatina obliquiloculata	40	12	19	30	11	5	19	6	20		6		3		20	20	10	[illegible]	25
Sphaeroidinella dehiscens																			
unidentified globigerinids	10	32	2	15		4	13	12		1	12			17	1	7	33		5
unidentified globorotaliids																			

Table 3. Occurrences of planktonic Foraminifera
in per cent of total population.
X less than 0.5 per cent. Oblique tows,
surface to indicated depths.
M, V, C refer to meter net, 17 cm. net
and Clarke-Bumpus sampler respectively.

CRUISE	TRANSPAC																																		
STATION	108	110	111	112			113	114		115	116			118		120		122	123	124	125	126	128	130	135		136	137	138	139		141		142	143
TYPE OF NET	V	M	M	M	C	V	M	M	C	M	M	C	V	C	V	C	V	C	M	C	M	C	C	C	M	C	M	C	M	M	C	M	C	M	M
DEPTH RANGE IN METERS	0-50	0-85	0-155	0-135	0-149	0-50	0-50	0-160	0-118	0-165	0-105	0-169	0-50	0-115	0-50	0-145	0-50	0-139	0-130	0-155	0-142	0-155	0-134	0-143	0-151	0-151	0-375	0-144	0-345	0-320	0-139	0-325	0-143	0-300	0-415
TOTAL SAMPLE POPULATION	259	365	86	52	141	32	20	59	109	40	25	32	16	311	128	17	7	6	34	14	61	42	27	41	294	63	101	22	145	271	60	36	16	52	41
POPULATION PER 1000 M^3	259,000	750	2.09	64	23,600	32,000	64	128	20,180	101	60	9,490	16,000	63,000	128,000	3,510	7,000	1,100	65	3,720	155	7,720	5,380	8,650	727	21,200	128	5,080	186	303	6,780	56	2,330	41	54
Candeina nitida																																			
Globigerina bulloides	4				2	6	10	2	6					1	1																				
conglomerata																																	6		
eggeri	30	0	2	16	34	35	35	9	19	8	4	6	9	4	15	6										3		5		X			12		5
hexagona	X																																		
inflata	10	26	6	24	23	35	12	5	5	2		3	15	73	53	2	14				2														
pachyderma																																			
quinqueloba									1	3					2													5			3				
sp.	X	1	2			3		10	1	5	16						29	17				2	4	10	3	6	6	5	4	1	2				2
Globigerinella aequilateralis		8	6								12				1	17					5	2	4		5	2	3		3	4			3	6	28
sp.																																			
Globigerinita glutinata	19			3	1	3			2				6	1	6	6	14			14		24	15	22		22	1	53	1		27		6		
Globigerinoides conglobata		1	2																		2		4		5		9		8	3					
cf. minuta	1																																		
rubra	5	7	5	3	6		5	3	35	2		3		7	9	6	29				2	14	18	19	3	31	4	13	3	7	45	6	31		2
sacculifera	1	4	4	6		5		3	1				6	X	1			17	6	7	7	12	7	25	56	27	41	5	20	57	12				
sp.	2								1			3											4		19	3	6								
Globorotalia hirsuta																																			
menardii																2		17	3	65	3	29	22	10			1	5	10	8	4	17	13	22	25
scitula					3																														
truncatulinoides	5		1	3	20	6	10	5	27	60	56	79	37	8	9	6		32	6															6	2
tumida																													4	5					
Hastigerina pelagica		7	58	3			5	3		17	12								82	7	70	5			15		14		40	13		58		16	8
Hastigerinella rhumbleri																																			
Orbulina universa		25	13	16			5	2											3		10			2	15		15		8	10		22		47	30
Pulleniatina obliquiloculata	10	5	9	3			15	5		3				2																					
Sphaeroidinella dehiscens																																			
unidentified globigerinids	11	8		3	11	9			2			6	19	4	3	35	14	17		7		12	22	12	2	6		9			7		19	3	
unidentified globorotaliids																																			

CRUISE	CHINOOK														
STATION	#1	1	2		4	5	6	10	11	12		13	14	15	16
TYPE OF NET	V	M	M	V	V	V	V	V	V	M	V	V	M	V	V
DEPTH RANGE IN METERS	0-50	0-130	0-91	0-50	0-50	0-50	0-50	0-50	0-50	0-100	0-50	0-50	0-94	0-50	0-50
TOTAL SAMPLE POPULATION	16	107	148	6	5	39	75	66	137	26	35	4	224	12	9
POPULATION PER 1000 M^3			267	6,000	5,000	39,000	75,000	66,000	137,000	50	35,000	4,000	391	12,000	9,000
Candeina nitida															
Globigerina bulloides															
conglomerata	12		1	17		11	4	24	2	22	31	15	3	42	22
eggeri						5	7	6	7		15		1		
hexagona															
inflata															
pachyderma															
quinqueloba							56	68	79	63				25	11
sp.															
Globigerinella aequilateralis											8				
sp.															
Globigerinita glutinata	12								1	3					11
Globigerinoides conglobata			1										3		
cf. minuta										9		25			11
rubra	18	11	27	35	10	18		2							
sacculifera	40	12	28	17						3			15		11
sp.		2	1			3	1								
Globorotalia hirsuta															
menardii															
scitula															
truncatulinoides															
tumida															
Hastigerina pelagica	6	67	36										66	8	
Hastigerinella rhumbleri															
Orbulina universa		8	7			18	1				46		12		
Pulleniatina obliquiloculata															
Sphaeroidinella dehiscens															
unidentified globigerinids	12			35		45	1		1					25	20
unidentified globorotaliids															

CRUISE	NORPAC								
STATION	6	7	8	15	16	17	18	19	20
TYPE OF NET	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-97	0-152	0-126	0-107	0-106	0-119	0-132	0-88	0-131
TOTAL SAMPLE POPULATION	78	1	26	2	0	10	154	226	142
POPULATION PER 1000 M^3	161	1.7	53	1.0	0	2.4	405	480	364
Candeina nitida									
Globigerina bulloides									
conglomerata							1		
eggeri	3						42	19	10
hexagona									
inflata									
pachyderma									
quinqueloba									
sp.									
Globigerinella aequilateralis									
sp.									
Globigerinita glutinata									
Globigerinoides conglobata									
cf. minuta									
rubra									
sacculifera									
sp.									
Globorotalia hirsuta									
menardii									
scitula									
truncatulinoides	5					20			1
tumida									
Hastigerina pelagica									
Hastigerinella rhumbleri									
Orbulina universa	92	100	100	100		80	41	45	86
Pulleniatina obliquiloculata									
Sphaeroidinella dehiscens									
unidentified globigerinids							16	16	5
unidentified globorotaliids									

CRUISE	NORPAC																													
STATION	22	23	23.5	24	24.42	26	27	28	29	30	31	32	33	34	35	36	37	38	40	41	42	42.5	43	43.25	44	45	46	47	48	49
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-129	0-112	0-123	0-92	0-119	0-125	0-133	0-104	0-130	0-135		0-104	0-134	0-119	0-122	0-99	0-87	0-128	0-142	0-141	0-143	0-121	0-150	0-112	0-130	0-136	0-128	0-142	0-134	0-127
TOTAL SAMPLE POPULATION	206	298	256	204	142	7	6	1	22	18	111	2	0	0	2	2	167	4	10	11	75	25	10	2	4	5	20	11	97	27
POPULATION PER 1000 M^3	516	719	490	459	284	12	15	2	52	204	295	32	0	0	5		401	9	83	23	179	48	27	5	9	15	92	27	230	65
Candeina nitida																														
Globigerina bulloides						29	33														3		60			20			1	
conglomerata																														
eggeri	37	37	86	96	89	29	50		9	5							2			46	79	60	40			20	40	45	58	4
hexagona																														
inflata										3												4								
pachyderma																														
quinqueloba																														
sp.												7								9										
Globigerinella aequilateralis											1							25												
sp.																														
Globigerinita glutinata	1																													
Globigerinoides conglobata																														
cf. minuta																														
rubra			2								1						5				3									
sacculifera																					1	16								
sp.																													2	
Globorotalia hirsuta																														
menardii																														
scitula						3											1													
truncatulinoides												1							11			4								7
tumida																														
Hastigerina pelagica									9													4								36
Hastigerinella rhumbleri																														
Orbulina universa		9	9	4	5	29	17	100	82	92	95	36			100	100	92	75	90	36	14	12		18	28	60	60	55	46	59
Pulleniatina obliquiloculata																														
Sphaeroidinella dehiscens																														
unidentified globigerinids	2	3	3		5															9										
unidentified globorotaliids																														

CRUISE	NORPAC (cont.)																												
STATION	52	53	54	55	56	57	57.5	58	59	60	61	65	66	67	68	71	72	73	76	77	78	79	80	81.5	82	87	88	91	93
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-152	0-142	0-139	0-129	0-131	0-133	0-138	0-134	0-138	0-115	0-129	0-146	0-109	0-155	0-132	0-135	0-135	0-131	0-139	0-137	0-137	0-134	0-137	0-144	0-135	0-140	0-134	0-135	0-141
TOTAL SAMPLE POPULATION	80	60	184	34	6	29	17	12	22	10	19	85	142	85	61	61	209	65	116	88	109	62	145	231	354	235	67	109	13
POPULATION PER 1000 M^3	190	155	438	81	12	65	31	25	50	24	47	201	285	226	138	142	510	148	325	222	271	156	364	555	840	575	168	275	34
Candeina nitida									5		5	13							2		4	5	3	8	2			4	
Globigerina bulloides	23	10	5										10			8	5	6								32			38
conglomerata																													
eggeri	25	13	25	3	17		6			60	43	36	11	5		13	4	6		2						22			38
hexagona												2																	
inflata											5			1															
pachyderma																													
quinqueloba	2											2		4															
sp.													1										1		1	3	6	2	8
Globigerinella aequilateralis									5						3		7			3			4	4	12		4	2	
sp.																													
Globigerinita glutinata																						1			1				
Globigerinoides conglobata																		12			2		1						
cf. minuta																													
rubra		3	1	6		3	6	17	18				8	6	3		9		2	2	4	18	23	1	5		4		
sacculifera				6			6		14													5	12	31	34				
sp.				3																					4				
Globorotalia hirsuta																		2										2	
menardii																													
scitula																													
truncatulinoides			1			14	12	17	9		10	2			5		1			15	2	5	1	1	X			3	
tumida																													
Hastigerina pelagica					33	65	58	58	45	20	32	1		2	46		2		46	19	28	34	42	38	26	X		47	
Hastigerinella rhumbleri																													
Orbulina universa	45	74	68	82	50	17	6	8	5	20	5	44	70	80	43	79	75	74	49	56	17	36	10	16	18	39	76	34	16
Pulleniatina obliquiloculata																													
Sphaeroidinella dehiscens																													
unidentified globigerinids	5						6							2					5	3		5	1	1	1	1	18	4	
unidentified globorotaliids																													

Table 4. Occurrences of planktonic Foraminifera in per cent of total populations. X less than 0.5 per cent. Oblique tows, surface to indicated depths. M, V, C refer to meter net, 17 cm. net and Clarke-Bumpus sampler respectively.

CRUISE	NORPAC																			
STATION	96	98	100	102	104	105	105S	106	106B	108	109	110	111	112	113	114	118	119	120	122
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-137	0-135	0-138	0-140	0-135	0-142	0-159	0-149	0-157	0-126	0-131	0-130	0-140	0-135	0-155	0-119	0-142	0-135	0-136	0-130
TOTAL SAMPLE POPULATION	10	35	42	54	12	153	157	95	250	58	18	55	5	25	19	24	10	11	6	5
POPULATION PER 1000 M³	32	58	105	155	32	360	306	264	581	144	46	89	14	59	44	61	145	35	15	11
Candeina nitida				2		3		1	2											
Globigerina bulloides					8					19		6					9			
conglomerata																				
eggeri	0	4								48	45	38	40	16	16		49	94	64	
hexagona																				
inflata																3				
pachyderma																				
quinqueloba																				
sp.								1	X			3	48	4						
Globigerinella aequilateralis		8					3	4	3	5	22	5		4	5		5		17	40
sp.																				
Globigerinita glutinata			5																	
Globigerinoides conglobata								3												
cf. minuta																				
rubra	10		14	11	8	7	1	11	2	21	22	45		32			6			
sacculifera				2	50	23	41	36	26											
sp.			5			1	1	4	1											
Globorotalia hirsuta																				
menardii		4							X						5	7				
scitula																				
truncatulinoides	10	4	5	2					1					4	5					
tumida																				
Hastigerina pelagica	70	76	68	88	18	53	41	17	48	7			20	40	64	62				21
Hastigerinella rhumbleri																				
Orbulina universa		4	2		8	5	12	23	16	9	11				5	28	20	6	17	20
Pulleniatina obliquiloculata																				
Sphaeroidinella dehiscens																				
unidentified globigerinids					8	1						3					11			20
unidentified globorotaliids																				

CRUISE	NORPAC																
STATION	123	124	125	127	128	130S	131	135	135	132	137	142	143	144	145	146	149
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-135	0-136	0-127	0-132	0-135	0-140	0-134	0-136	0-131	0-125	0-127	0-135	0-141	0-159	0-159	0-139	0-155
TOTAL SAMPLE POPULATION	2	190	225	141	208	26	141	146	37	6	8	4	22	3	11	12	56
POPULATION PER 1000 M³	4	344	488	306	456	71	284	235	114	12	19	9	46	7	22	28	128
Candeina nitida			1					1									
Globigerina bulloides								1	8				46	33			
conglomerata																	
eggeri									56	17		25	36				
hexagona										17				35			
inflata																	
pachyderma																	
quinqueloba																	
sp.																	
Globigerinella aequilateralis					1				10	32	12						
sp.																	
Globigerinita glutinata																	
Globigerinoides conglobata							1	2							46	17	4
cf. minuta																	
rubra	50	2	5	1	1	8	1	2		17				35	9	35	
sacculifera				4	2	8	7	19							9	25	
sp.								1							9	17	2
Globorotalia hirsuta																	
menardii								1									
scitula																	
truncatulinoides			1														
tumida																	
Hastigerina pelagica		47	9	53	91	54	20	47			36	25			9		50
Hastigerinella rhumbleri																	
Orbulina universa	50	1	2	11	4	30	11	22	15	17	12				9		44
Pulleniatina obliquiloculata									3								
Sphaeroidinella dehiscens																	
unidentified globigerinids				1								50	18		9	8	
unidentified globorotaliids																	

CRUISE	NORPAC															G. CALIF.						
STATION	151	152	152S	153	154	154S	155	155S	156	157	157A	157B	160	161	162	1	2	5	6	9	11	12
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-134	0-35	0-149	0-139	0-138	0-139	0-135	0-133	0-155	0-133	0-155	0-159	0-131	0-42	0-139	0-68	0-66	0-69	0-66	0-68	0-68	0-69
TOTAL SAMPLE POPULATION	205	174	210	249	217	416	165	136	94	125	100	92	7	50	5	133	286	1284	597	228	174	218
POPULATION PER 1000 M³	465	408	455	600	590	740	376	248	245	286	155	220	18	121	20	510	1,050	4,500	1,350	780	610	790
Candeina nitida										1		1										
Globigerina bulloides													14	2								
conglomerata			1		1	5		1														
eggeri													14			1	X				1	
hexagona				X			1															
inflata																						
pachyderma																						
quinqueloba																						
sp.													14	4		5	X				2	
Globigerinella aequilateralis				3			1			2	4	2		2		69	10	16	19	38	8	2
sp.																						
Globigerinita glutinata																		X	2		8	5
Globigerinoides conglobata					1	1	3	4			2	1			12	2	X		1	4		2
cf. minuta																						
rubra					1		2	3	2		2	1	38	64	38	8	15	57	24	11	54	72
sacculifera	1	1	1	5	5	26	15	12	22	10	16	21	14	26	25	6	8	42	39	41	18	11
sp.				X	1		1	1		1		1			25	1	1	2	8	3	4	
Globorotalia hirsuta																						
menardii		1		1	1	X	1			1		2	14			1	X	X	4	1	4	2
scitula																						
truncatulinoides																						
tumida						1	1		1													
Hastigerina pelagica	83	94	90	61	65	57	47	60	58	46	36	4						X	1			
Hastigerinella rhumbleri																						
Orbulina universa	10	4	8	30	5	31	29	19	45	46	46	61		4		5		x	1			
Pulleniatina obliquiloculata																						
Sphaeroidinella dehiscens																						
unidentified globigerinids						1			2							2		X	1	3	1	1
unidentified globorotaliids																						

CRUISE	GULF OF CALIFORNIA																				
STATION	13	15	16	17	19	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-69	0-69	0-66	0-67	0-69	0-70	0-67	0-70	0-68		0-67	0-70	0-72	0-69	0-68	0-70	0-69	0-68	0-69	0-70	0-71
TOTAL SAMPLE POPULATION	56	236	46	190	178	234	212	124	1140	56	926	1110	600	2004	1960	1548	146	382	66	384	886
POPULATION PER 1000 M³	170	750	130	590	580	800	680	40	5,950		3240	3470	2,000	6400	6400	4230	460	1250	230	1250	2720
Candeina nitida																					
Globigerina bulloides				1							X	1		1						17	1
conglomerata																					
eggeri						1											3			1	
hexagona																					
inflata																					
pachyderma																					
quinqueloba																					
sp.																					
Globigerinella aequilateralis				2			3	6	X			1	2	3	4	2	8	4	21	19	17
sp.																					
Globigerinita glutinata	4	25		6	15	12	29	19	16	19	57	17	28	30	51	36	22	21	24	6	35
Globigerinoides conglobata				1			1		1			1			1		1	1	6	2	1
cf. minuta																					
rubra	79	62	70	46	46	69	57	50	66	58	36	50	51	36	17	37	37	36	12	15	11
sacculifera	11	5	26	37	34	18	12	14	13	19	4	12	12	10	23	18	25	29	9	22	17
sp.		1		2							X		2	2		1	1		4		
Globorotalia hirsuta																					
menardii	8	5		2	4		2	10	4	4	3	5	5	18	24	6	4	8	24	16	18
scitula																					
truncatulinoides																					
tumida																					
Hastigerina pelagica																					
Hastigerinella rhumbleri																					
Orbulina universa				2		1			X		1							X			X
Pulleniatina obliquiloculata											1										X
Sphaeroidinella dehiscens																					
unidentified globigerinids		2	4	1					X	X	1						4	1		2	X
unidentified globorotaliids																					

CRUISE	B-41													
STATION	15316	15019	14728	14524	14459	14453	13816	13735	13221	13034	12159	12154	11550	11530
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-158	0-114	0-157	0-63	0-91			0-55	0-55	0-55	0-70	0-42	0-63	0-29
TOTAL SAMPLE POPULATION	56	6	10	84	100	8	16	112	600	62	98	52	33	40
POPULATION PER 1000 M³	75	14	17	350	270	67	210	500	3550	420	360	370	110	246
Candeina nitida														
Globigerina bulloides				5	10	25	13	20	38	55	59	28	18	38
conglomerata														
eggeri					6		13	9	8	13	12	19	27	10
hexagona														
inflata														
pachyderma														
quinqueloba														
sp.														
Globigerinella aequilateralis	56			14	2							4	3	
sp.														
Globigerinita glutinata														
Globigerinoides conglobata														
cf. minuta														
rubra	17		21	5	6	25	13	18	7	6	12	19	27	28
sacculifera	17	67	40	44	11	25	48	5	3	2				
sp.												2		
Globorotalia hirsuta														
menardii														
scitula														
truncatulinoides														
tumida														
Hastigerina pelagica														
Hastigerinella rhumbleri														
Orbulina universa	1		46	8	54	25	13	32	13	23	31	25	9	15
Pulleniatina obliquiloculata														
Sphaeroidinella dehiscens														
unidentified globigerinids		35			12			16	30	2	6	2	15	10
unidentified globorotaliids														

CRUISE	SHELLBACK																							
STATION	1	5	6	7	8	9	10	10	11	12	12	13	15	15	17	20	20	21	22	23	25	26	27	28
TYPE OF NET	V	M	M	M	M	M	M	V	M	M	V	M	M	V	V	M	V	V	V	V	V	V	V	V
DEPTH RANGE IN METERS	0-100	0-281	0-277	0-266	0-269	0-256	0-319	0-100	0-475	0-320	0-100	0-261	0-301	0-100	0-100	0-277	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100
TOTAL SAMPLE POPULATION	120	12	9	13	14	35	38	65	177	90	47	66	147	17	24	548	157	61	53	46	85	322	112	170
POPULATION PER 1000 M³	60,000	13	9	15	14	38	44	33,000	163	99	24,000	53	215	8,000	12,000	508	71,000	30,000	26,000	23,000	42,000	161,000	56,000	85,000
Candeina nitida																								
Globigerina bulloides	12										2											1	1	X
conglomerata																								
eggeri	28		11		2	6		1	1	1	9	2	2		4	X	1				2	18	8	21
hexagona									1				2			3					1	2		
inflata	1																							
pachyderma																								
quinqueloba	4																							
sp.	1	25			7								1		4			2	4	4			2	3
Globigerinella aequilateralis			34		4	3	5	1			4		18	6	17	2						2		4
sp.				8														3						
Globigerinita glutinata						6		13		1	21		3	47	28	2	30	41	41	44	53	25	42	51
Globigerinoides conglobata								1					3			2	1						1	
cf. minuta																								
rubra	16	59	11		7			13	1	1	13	3	4	12	13	13	35	24	16	15	22	12	6	X
sacculifera							3	35		1	15	5	25	6	13	41	21	14	8	11	8	21	13	11
sp.											2	2	1			2	1		2	16	2	7	5	X
Globorotalia hirsuta			11					8						6		X								
menardii				8				18			19	2	23		8	31	1	2	13	2		1	4	11
scitula																								
truncatulinoides				15	7																			
tumida				8																				
Hastigerina pelagica		8	22	8	44	79	89		95	95		81	7			X								
Hastigerinella rhumbleri																								
Orbulina universa	6		11	30		6	3		3	3	2	2	18			3								1
Pulleniatina obliquiloculata																						10	4	4
Sphaeroidinella dehiscens																								
unidentified globigerinids	21	8		23				18			13	3	1	23	12	1	9	14	16	8	12	9	14	11
unidentified globorotaliids																	1							

Table 5. Occurrences of planktonic Foraminifera in per cent of total population. X less than 0.5 per cent. Oblique tows, surface to indicated depths. M, V, C refer to meter net, 17 cm. net and Clarke-Bumpus sampler respectively.

CRUISE	SHELLBACK																													
STATION	22	30		32	35		37	39	41	44	46	47		51		56	57	58	59	60	61		65	66	69	70	75	76		78
TYPE OF NET	V	M	V	V	M	V	V	M	V	V	V	M	V	M	V	V	M	V	V	V	M	V	M	V	V	V	V	M	V	V
DEPTH RANGE IN METERS	0-100	0-312	0-100	0-100	0-290	0-100	0-100	0-177	0-100	0-100	0-100	0-226	0-100	0-308	0-100	0-100	0-179	0-100	0-100	0-100	0-219	0-100	0-214	0-100	0-100	0-100	0-100	0-321	0-100	0-100
TOTAL SAMPLE POPULATION	235	2159	266	376	420	262	251	158	105	163	176	558	182	1175	104	148	5156	90	117	118	1598	83	358	27	7	4	30	804	44	218
POPULATION PER 1000 M^3	115,000	2570	152,000	131,000	393	151,000	136,000	121	53,000	81,000	99,000	316	91,000	1041	52,000	75,000	8607	45,000	58,000	59,000	1351	13,000	325	14,000	4000	2000	15,000	1050	22,000	109,000
Candeina nitida																	X													
Globigerina bulloides		X	2	11		7	9	1		5	14	1	1		1		X							7	14					
conglomerata								1			1	2	1	1			4			1	1									
eggeri	23	3	11	16	1	14	16	9	13	15	17	16	32	4	12	5	X		3		X	4								
hexagona		1		X	5			3				1					1				X							2		
inflata																														
pachyderma																														
quinqueloba				1																										
sp.	X		4	2	5	1	1	6	6	3	5	10	2		2	1		1	1	3			1					1	11	
Globigerinella aequilateralis	5	1	1	3		2	1	1			1	2		1	1	2	2	1	1		1	4	4	4				1		1
sp.		X										2		1			X				X							X		X
Globigerinita glutinata	16	X	22	19	1	2	9	1	19	26	17	2	13	X	16	20		26	33	18	X	9	1	34	44		75		5	
Globigerinoides conglobata	X	X			6							7		16			6			1	5		3	7						
cf. minuta																														
rubra	5	3	6	8	2	11	19	5	9	15	11	4	14	15	23	38	7	19	5	11	4	13	4	11			3	1	16	X
sacculifera	22	29	21	21	45	28	57	63	45	15	12	20	16	27	25	22	60	23	30	36	73	44	47	15	14	25		12	27	4
sp.	1	1	1	1	8	2	2	3		1		2	2	6		4	1		1	3	2	13		7	14	25	3	1		X
Globorotalia hirsuta		X	2		1	1		1									1													
menardii	17	53	7		5	3	2	1	3	10	X		3	2	10	11	4	17	12	14	7	9	4	4			3	38	16	21
scitula																														
truncatulinoides																														
tumida					2			3				3		X																
Hastigerina pelagica		1			2							1		3			8			1	2							35	2	6
Hastigerinella rhumbleri		X			1									X														X		X
Orbulina universa	X	3		X	2							14	1	26	4		6				4		57					8		6
Pulleniatina obliquiloculata	2	3	5	5	8	3	X	1		3	9	15	4	1							X									
Sphaeroidinella dehiscens														X																
unidentified globigerinids	8	X	18	14	1	7	4	1	7	9	11		18		8	4		14	4	9	X	4		11	14		16		23	
unidentified globorotaliids						X					2		1						1	2										

CRUISE	SHELLBACK																												
STATION	79	80	81	84	100	105	108	111	114	119	122	126	129	133	136	138	139	141	142	145		149	154	155	158	159	160		161
TYPE OF NET	V	M	V	M	M	M	M	M	M	M	M	M	M	M	M	V	M	V	M	M	V	M	V	M	V	V	M	V	V
DEPTH RANGE IN METERS	0-100	0-351	0-100	0-205	0-308	0-318	0-286	0-314	0-314	0-314	0-312	0-302	0-311	0-280	0-323	0-100	0-297	0-100	0-321	0-252	0-100	0-176	0-100	0-311	0-100	0-100	0-326	0-100	0-100
TOTAL SAMPLE POPULATION	60	2114	41	96	670	196	80	365	272	161	311	62	118	137	206	84	152	27	129	261	31	240	851	977	99	107	300	451	277
POPULATION PER 1000 M^3	30,000	2441	80,000	91	806	256	98	420	312	204	377	58	149	139	229	42,000	165	14,000	148	208	16,000	212	426,000	1,019	50,000	54,000	318	226,000	139,000
Candeina nitida			2																										
Globigerina bulloides			2	1	3	11	3	10	33	32	8	23	60	75	32	44	1	52	5	15	49	24	15	24	4	7	1	3	18
conglomerata																													
eggeri	28	4	12	22	14	16	32	27	18	32	11	3	28	17	6	7	4	11	5	10	3	29	75	19	21	10	22	25	9
hexagona					4				11		X				1				12	3		8		1					
inflata																													
pachyderma																													
quinqueloba									1				2	2	1	1							1						
sp.		6		5	1	1	5	3	1	2					1	1	8		9	3	13	3	1	4		1	5	X	1
Globigerinella aequilateralis	7	11		6	1	2			1			10			2		4		11	6	3	1	X	8	2	1	5	X	X
sp.		X																											
Globigerinita glutinata	28	1	25	2	1	3			8				3		3	1	3	7	1	2	3	6	3	1	15	18	4	52	49
Globigerinoides conglobata		2																											
cf. minuta																													
rubra		4	5	4	7	5						3	2		5	5	1	7	2	2	6		1	8	2	22	7	9	9
sacculifera	15	34	5	14	8	2	3	1	1			3	2		1			4	1	1	3			2	13	22	18	8	9
sp.	2	1			1														1	1			X			2	4	X	
Globorotalia hirsuta									1	1	1												1	1	25		11	3	3
menardii	28	14	17	40	1	1			1			6	2	1		6	1				3	1	1	X	4		4	2	3
scitula								1																					
truncatulinoides		1																											
tumida		1			1										1		3		8	6									
Hastigerina pelagica		4		1	48	44	47	57	19	28	79	49	2	5	17		17		12			24	X	12			3		
Hastigerinella rhumbleri		X				1																		2					
Orbulina universa		5		2	16	10	10	1	4	2	1		6		22	1	51		20	15		6	X	5			15	X	
Pulleniatina obliquiloculata		2		3	1	1			1	1					9	2	1		11	2		3		1			1	X	X
Sphaeroidinella dehiscens		1																									1		
unidentified globigerinids	18		32		1	1										33	5	19			17		1	2	8	11	1	6	9
unidentified globorotaliids																							1			1			

CRUISE	SHELLBACK																																	
STATION	162	164	166		168	170	171	175		176	178	179		181	186	187	191	192	193	196	198	199	200		201	202	203		205	206	207	211	214	217
TYPE OF NET	M	V	M	V	V	M	V	M	V	V	V	M	V	M	V	M	V	V	V	V	V	V	M	V	V	V	M	V	V	V	M	M	M	M
DEPTH RANGE IN METERS	0-282	0-100	0-283	0-100	0-100	0-305	0-100	0-290	0-100	0-100	0-100	0-318	0-100	0-299	0-100	0-296	0-100	0-100	0-100	0-100	0-100	0-100	0-297	0-100	0-100	0-100	0-306	0-100	0-100	0-100	0-301	0-303	0-306	0-328
TOTAL SAMPLE POPULATION	150	74	378	90	171	393	95	745	200	127	128	352	34	294	187	290	188	141	67	198	178	209	1502	69	156	43	1654	96	30	21	364	147	94	13
POPULATION PER 1000 M^3	150	36,000	340	45,000	86,000	427	48,000	760	100,000	64,000	64,000	366	17,000	300	94,000	288	94,000	70,000	34,000	99,000	89,000	104,000	1,883	35,000	78,000	22,000	1,898	48,000	15,000	11,000	415	628	112	16
Candeina nitida																																		
Globigerina bulloides	7	9	8	9	34	6	25	3	9	2	5	7	6	20	1	1	2	2	3	6	9	2		3	8	5	X	6	14				6	
conglomerata								1																										
eggeri	4	8	8	12	11	15	24	10	10	6	38	28	26	17	55	24	13	6	4	7	6	9	1	14	6	2		2			1			
hexagona	X		1			5	3	1	X			2		1	1	3							1				1							
inflata																																		
pachyderma																																		
quinqueloba					2				1		2						1			2														
sp.	1		3	2	1	3	1	4			1	2		5	1			1		3	5	5	X	4	7		X	5		10				
Globigerinella aequilateralis	4		28	2	1	7	1			1		2		1		2	1					X	2	1	3		1	1			3	7	32	8
sp.																							X											
Globigerinita glutinata	2	34	6	35	28	3	23	4	35	4	14	4	9		12	1	24	33	24	27	29	17	X	20	15	9	1	32	30	57	2	1	4	23
Globigerinoides conglobata	1		1					1				1						1					X		1		X				X			
cf. minuta																																		
rubra	2	9	5	11	11	3	4	11	13	3	14	8	3	1	2	7	14	18	11	17	26	8	1	7	15	23	2	22	28		4	1	6	
sacculifera	37	4	12	6	1	1		13	1	2	5	20	3	1	7	13	18	28	41	36	16	22	49	11	19	11	5	12			1	6	21	46
sp.		1						14					3			1	3	2	2	1	4	1	X		1		X		5		1		2	
Globorotalia hirsuta	11	25	14	13	8	2	7	16				18		2									X				1							
menardii	8	1	8	1		2	1	6	19	8	4	4	26		15	7	8	5	6	5	2	17	42	21	18	21	68	15	13	18	57	36	19	23
scitula									X						1														3					
truncatulinoides											1																							
tumida								2			3					3																		
Hastigerina pelagica	18		11			48		2			1			48		1						X	1				27				7	1		
Hastigerinella rhumbleri																							X				X							
Orbulina universa	12		3			4		12	X		1	10		4		26							1				2				24	48	8	
Pulleniatina obliquiloculata						X		1	X			1				2				X		6	1	4	1		X							
Sphaeroidinella dehiscens	1							1								2							x				X							
unidentified globigerinids		9		9	3		12		9	32	14		21		5	1	24	12	9		3	7	1	15	6	29		5	7	23				
unidentified globorotaliids							1				1																							

CRUISE	SHUTTLE																								
STATION	3	6	9	15	29-1	29-2	29-3	41	·1	48-2	·3	·1	51-2	·3	53 ·1	·5	56	57 ·1	·3	·1	60-2	·3	62 ·1	·2	64
TYPE OF NET	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
DEPTH RANGE IN METERS	0-50	0-100	0-100	0-100	0-100	0-100	0-400	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100
TOTAL SAMPLE POPULATION	11	20	72	21	31	75	91	26	39	54	43	40	47	22	76	39	32	37	40	38	151	102	22	27	19
POPULATION PER 1000 M^3	11,000	10,000	36,000	10,500	15,500	37,500	11,000	13,000	20,000	27,000	21,000	20,000	23,500	11,000	38,000	15,000	16,000	18,000	20,000	44,000	75,500	51,000	11,000	13,500	10,000
Candeina nitida																3									
Globigerina bulloides			1		3	12	1	4	5		2	15	2	5		3	3	8	7	21	37	29	5	11	16
conglomerata																									
eggeri						3	1						6	9	4		9			28	28	40	7	13	16
hexagona																				1	1			4	
inflata																									
pachyderma																									
quinqueloba																									
sp.			1	43		1	1		5					5		7					1		5		5
Globigerinella aequilateralis	9		3					4				7	8					5						4	
sp.																									
Globigerinita glutinata	37	35	11		3	12	6	8	13	18	11	5	12	14	21	7	20	13	23	3	7	12	53	32	16
Globigerinoides conglobata	9		6	6		1					3														
cf. minuta																									
rubra		11	6	10	51	34	37	16	45	41	61	12	23	9	27	38	22	13	28	9	4	6	10	4	26
sacculifera	27	11	55	22	21	10	51	20	14	16	9	7	4	29	25	21	3	3	7		1	3			
sp.	9	11	15	9	3	1	6	9		3			2			5		3	5						
Globorotalia hirsuta						1						3	2		1		3	6		2	1	1	5	4	16
menardii	9				3	12	6	27	10	12	5	10	27	13	11	7	22	9	16	4	5	3	5	11	5
scitula																									
truncatulinoides																									
tumida																									
Hastigerina pelagica					3							10	4	19					5						
Hastigerinella rhumbleri																									
Orbulina universa				5	3	1		4		4															
Pulleniatina obliquiloculata																									
Sphaeroidinella dehiscens																									
unidentified globigerinids		30	2	5	10	12	5	4	8	6	7	33	10	5	11	9	18	38	9	40	15	6	10	12	
unidentified globorotaliids																									

Table 6. Occurrences of planktonic Foraminifera in per cent of total population. X less than 0.5 per cent. Oblique tows, surface to indicated depths. M, V, C refer to meter net, 17 cm. net and Clarke-Bumpus sampler respectively.

CRUISE	S.		TROLL																								
STATION	[illegible]	[illegible]	0a	1	1a	2	2a	3	3a	4	4a	5	5a	6a	7	7a	8	8a	9	9a	10	10a	11	11a	12	12a	13
TYPE OF NET	V	V	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-100	0-100	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	20	9	101	58	904	454	2276	716	530	1338	1968	1642	1106	872	354	436	1944	487	266	416	100	146	140	136	114	170	376
POPULATION PER 1000 M^3	12,000	4,500	150	105	1520	390	4050	1580	990	2330	3600	3905	2020	1560	350	440	3500	420	350	650	157	225	280	230	196	340	690
Candeina nitida																		X									
Globigerina bulloides	15	11					X														2						
conglomerata			2		1		X	X	X	1										1		6	1	2			
eggeri	40	22												X							1	1					
hexagona										X										1							
inflata																											
pachyderma																											
quinqueloba																							1	1			
sp.	10																X										
Globigerinella aequilateralis			2	4	2		X	1	1		1	X	1	2	1	1	2	1	2	4	2	6		2	5	6	4
sp.				2	1		X	1		X	1		1	1	1	1	X	x	2	2	4		2	2	2	1	8
Globigerinita glutinata	28	22																									
Globigerinoides conglobata			4	4	5		1	2	6	1	3	1	X	3	4	1	2	5	7	7	4	6	6	3	5	5	2
cf. minuta																											
rubra		45	12	1	1		6	1	3	X	X	1	1	2	2	1	X	2	5	2	6	6	2	2	2	1	14
sacculifera			49	65	81	91	95	85	76	90	93	94	88	84	91	86	98	95	62	59	42	30	33	59	58	[illegible]	54
sp.			2					X					1	X		1			4	6	2	10	2		5	4	2
Globorotalia hirsuta	5																										
menardii	5							3	8	2	1	X	1	1			X	1	7	13	16	20	32	13	12	9	4
scitula																											
truncatulinoides																											
tumida			2	4	1		3	1	1																		1
Hastigerina pelagica			10		3	X	1	X			x	X	1		2	1					2	8	3	2	2	1	1
Hastigerinella rhumbleri																											
Orbulina universa			17	14	4	1	2	5	4	2	11	4	7	8	9	9	7	4	10	3	4	3	6	15	9	11	11
Pulleniatina obliquiloculata					X	X			X										1	3	15	1	5	2		1	
Sphaeroidinella dehiscens							X	X	1	2						1			2	1				2		1	1
unidentified globigerinids	5		2	2		X			X	2	X	1								1		4	4				
unidentified globorotaliids																											

CRUISE	TROLL																															
STATION	13a	14	14a	15	151	15a	16	16a	17	17a	18	18a	19	19a	20	20a	21	21a	22	22a	23	23a	24	24a	25	25a	26	27	27a	28	28a	29
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	278	208	178	208	170	126	206	368	202	262	78	52	64	24	30	50	50	94	94	66	100	156	364	272	96	600	216	248	188	58	66	56
POPULATION PER 1000 M^3	510	380	435	560	310	1330	368	670	410	572	143	110	110	45	54	84	50	164	162	92	160	270	310	280	157	985	360	590	298	95	93	94
Candeina nitida			1					2													2											
Globigerina bulloides																										X						
conglomerata																																
eggeri																							2	1				1		3		
hexagona																																
inflata																																
pachyderma																																
quinqueloba																																
sp.																															6	4
Globigerinella aequilateralis	4	5	3	5	2	2	4	3	1	4	5	8	6	7	7	A		4	5	3	4	9	3	4		1	2	2	1	3	5	21
sp.	6	7	3	4	1		1														2						1				[illegible]	
Globigerinita glutinata										1														2								
Globigerinoides conglobata	2		2	9	5	6	13	8	8	14	8		3						2		2			3	8	3	3	2				
cf. minuta																																
rubra	3	2	1			2		2	2				3					2	12	13	10	17	9	4	2	2	1	2	2			
sacculifera	54	48	60	55	66	64	34	39	40	31	51	15	13	7	27	12		15	36	30	16	28	56	60	42	77	61	48	69	38	31	8
sp.	1		1	1			4	4	4								7	2	12	13	8	9		7	2	2	4	2	3			
Globorotalia hirsuta																											1	1		X	3	
menardii	11	3	6			2					3											5	2	7	11	3	2	2	7	28		7
scitula																																
truncatulinoides													3																			
tumida																															9	
Hastigerina pelagica	2	2	2	1	1	5	11	5	13	16	10	23	47	57	53	32	40	34	14	10	20	5	10		11	X	10	10		4	8	46
Hastigerinella rhumbleri	1																															
Orbulina universa	13	11	18	24	23	21	30	28	31	34	23	54	25	28	13	52	53	42	9	30	38	24	14	10	19	12	16	25	14	17	12	4
Pulleniatina obliquiloculata							1																								3	
Sphaeroidinella dehiscens	3		1		1		2	X														1	1	2	6			3	2			
unidentified globigerinids		3	1		1		1															1				1		4	1	10		
unidentified globorotaliids																																

CRUISE	TROLL																									
STATION	30	30a	31	31a	32	32a	33	33a	35	35a	36	36a	37	37a	38	38a	39	40	40a	41	41a	42	43	43a	44	45
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	42	44	69	90	94	104	68	56	76	46	54	92	82	94	82	68	90	104	14	44	83	78	74	110	58	20
POPULATION PER 1000 M^3	69	72	101	145	150	155	110	91	136	85	58	160	150	170	145	110	150	180	25	72	130	150	123	180	95	35
Candeina nitida																	9			10				2	4	20
Globigerina bulloides	5																									
conglomerata																										
eggeri									5	4						9	4	4		12	2					10
hexagona																				2						
inflata																										
pachyderma																										
quinqueloba																										
sp.																										
Globigerinella aequilateralis		5		7		2		4	8			2		6	3		11	4	14	8		5	5	7		
sp.																				4	2					
Globigerinita glutinata												2	2	2				4				2				
Globigerinoides conglobata			3																	1						
cf. minuta																										
rubra		10							3			2	10	15	2	6	20	17		19	5	5	3	14	7	
sacculifera	19	4		9	82	12	12		11	13	6	22	20	15	7	9	9	7		10	10	2	3	7	4	10
sp.			3										5	4			2	1		3						
Globorotalia hirsuta																										
menardii		12	1	7	6	2	3	4		4	6					3	2	2			12	5	3	2		
scitula																										
truncatulinoides																										
tumida																						3				
Hastigerina pelagica	5	22	22	7	15	5	9	64	34	22	45	50	34	45	47	42	3	37	72	15	49	54	78	27	52	60
Hastigerinella rhumbleri																										
Orbulina universa	53	23	42	40	31	71	76	28	2	52	19	20	27	17	39	20	7	9	14	6	15	18	8	33	31	
Pulleniatina obliquiloculata									10			2			2	11	9	11		7	5	2		2		
Sphaeroidinella dehiscens				2																						
unidentified globigerinids	5								8	4	6		2				3	6		1		2		6	4	
unidentified globorotaliids																										

CRUISE	EQUAPAC-H																								E.PAC-S								
STATION	1	3	4	6	7	9	11	13	15	17	19	21	23	25	28	30	32	34	36	38	40	41	43	45	1	3	4	6	8	9	11	13	14
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-300	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140
TOTAL SAMPLE POPULATION	275	81	358	269	642	2232	1850	998	1714	1440	418	476	342	576	342	882	5726	3336	1142	456	350	394	546	364	1795	1050	1030	782	605	288	592	270	209
POPULATION PER 1000 M^3	249	67	300	242	670	2,040	1,950	930	1,708	1,090	416	357	360	347	318	960	3720	3,220	1,070	389	335	326	599	301	4320	2350	2,250	1,822	1404	665	994	592	461
Candeina nitida				X																					X	5	7	5	1				1
Globigerina bulloides																X																	1
conglomerata	X					X				X			2	1	6	7	5	7	3	1	3	1					X	X	1	10	33	10	4
eggeri								1								1	X							1					1		1	1	1
hexagona																																	
inflata																																	
pachyderma																																	
quinqueloba																																	
sp.																																	
Globigerinella aequilateralis	4	7	7	6	4	10	4	8	22	25	13	13	9	5	4	5	1	1	3	2	3	5	7	8	14	5	5	4	8	3	3	2	8
sp.	1		1				1	3	3	X	1	1	2			1	X		X	2	2	8	12	8	8	1	4	3	4	4	4	2	7
Globigerinita glutinata		1	1			X	1									1									X								
Globigerinoides conglobata	5	11	15	9	7	8	7	5	2	2	5	3	5	7	7	1	3	1	x	4	4	1	5	7	3	12	14	7	3		1		
cf. minuta																																	
rubra	6		1	2	1	7	8	7	1	X	1	1	1	2	1	2	X	X	X	5	5	8	5	3	20	20	6	17	2	1	7	6	3
sacculifera	67	43	42	58	75	40	31	29	48	56	34	49	42	65	24	31	7	8	18	17	31	28	44	29	21	34	22	29	49	27	5	27	68
sp.	2		1	1	2	12	15	2	1	1	3	3	1	4	1	1	X	X	1	1	2	4	1	1	12	2	8	9	6	3	7	3	2
Globorotalia hirsuta				X												X																	
menardii				3	3	2	10	13	3	2	5	7	4	1	1	1	3	22	51	46	27	8	3	3	1	2	1	5		1	6	1	1
scitula																																	
truncatulinoides															20	32	68	46	9	8	7	4	1	2			1	1	1				
tumida																																	
Hastigerina pelagica		5	18	12	2	X	1	4	4	4	8	6	24	6	4	2	1	1	1	7	2	9	2	5	7	3	9	5	22	40	25	40	7
Hastigerinella rhumbleri																																	
Orbulina universa	9	33	13	7	6	X	X	1	3	3	9	3	5	3	5	3	X	2	6	6	9	24	20	35	5	16	23	14	11	10	6	6	3
Pulleniatina obliquiloculata					7	20	30	12	5	19	14	4	4	24	12	10	10	6		1	5	2	1	1				X	X		2	1	4
Sphaeroidinella dehiscens			X	X	3	3	1	1	1	11	1	1	2	4	1	2	2	3		1		1											
unidentified globigerinids		1	X	X																					X			X	1	1		2	1
unidentified globorotaliids																																	

Table 7. Occurrences of planktonic Foraminifera in per cent of total population. X less than 0.5 per cent. Oblique tows, surface to indicated depths. M, V, C refer to meter net, 17 cm. net and Clarke-Bumpus sampler respectively.

CRUISE	EQUAPAC – S															
STATION	15	17	18	19	21	23	24	27	28	30	32	34	36	38	40	46
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140	0-140
TOTAL SAMPLE POPULATION	139	1292	606	5592	4272	2200	2445	5985	2971	5478	2059	1256	1454	2504	412	239
POPULATION PER 1000 M^3	556	2790	1415	7760	9890	6050	7590	1510	975	18,500	6040	3220	3970	7720	1165	627
Candeina nitida																
Globigerina bulloides																1
conglomerata	8	23	22	19	3	7	3	7	1	-	21	15	25	2	3	8
eggeri	1	X		X	X		X	2	X	X	X	1	X	X	1	
hexagona																
inflata																
pachyderma																
quinqueloba																
sp.																
Globigerinella aequilateralis	8	19	21	9	13	2	2	6	5	12	5	24	1	3	3	8
sp.	10	X	5	1	2	2	1	1	X	X	1	4	X	X	2	6
Globigerinita glutinata	1			X	X		X	1					X			
Globigerinoides conglobata		1	X	1	X	1	2	3	3	4	5	1	X	X		
cf. minuta																
rubra	4	2	3	2	2	23	1	1	7	X	X	1		4	1	1
sacculifera	24	28	21	19	15	28	32	20	72	36	30	27	28	34	44	21
sp.	4	1	2	2	1	7	6	4	5	5	3	1	X	6	1	
Globorotalia hirsuta																
menardii	2	X	1	1	1	X	X		1	11	8	5	4	21	6	
scitula																
truncatulinoides																
tumida					X	X										2
Hastigerina pelagica	4	X	1	X	1	X				X		1	1	X	2	18
Hastigerinella rhumbleri																
Orbulina universa	7	1	4	1	X	X	3	1	X	X	X	X	X	4	9	25
Pulleniatina obliquiloculata	5	26	28	35	45	33	40	55	5	33	16	19	58	25	9	5
Sphaeroidinella dehiscens		X			X	X				X		1	X		1	
unidentified globigerinids	1	X		X												
unidentified globorotaliids																

CRUISE	POFI – 5																			
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	916	424	452	1192	5936	4896	13045	10714	14286	1214	4596	156	128	126	6056	112	226	616	786	672
POPULATION PER 1000 M^3	735	320	321	1495	3370	3570	24,900	125,000	122,500	1370	55,000	84	101	78	3850	81	124	510	738	371
Candeina nitida		8	5	9	2	X	X	X	X				2							
Globigerina bulloides				X	X					X						2			X	
conglomerata	1			X	X	X	X	X	X		X	3	5	32		2		1	2	7
eggeri				X		X					X	1		2			1	3	5	5
hexagona																2	4			X
inflata																				
pachyderma																				
quinqueloba																				
sp.																				
Globigerinella aequilateralis	3	3	4	X		X	X	X	X	X	4	4	3		X	4		2	2	5
sp.	1	2		1	X	X	1	3	6	1	11	1	49	14	49	43	26	9	8	19
Globigerinita glutinata	X																4		X	4
Globigerinoides conglobata	4	26	30	58	1	X	X	X	X	1		1		2	X				1	1
cf. minuta																				
rubra	2	1	1	1	X		X			X									1	
sacculifera	40	24	12	22	92	96	97	44	93	96		768	12	19	X	28	34	65	57	27
sp.	19	5	1																	
Globorotalia hirsuta																				
menardii		11	3	1	X	X							2						X	1
scitula				X				X												
truncatulinoides																				
tumida			2	X						X										1
Hastigerina pelagica	24	2	2	X	X	X	X	X		X					X	4	2	5	1	1
Hastigerinella rhumbleri																				
Orbulina universa	5	17	28	6	4	3	1	2	X	1	8	8	19	10	1	11	21	4	5	5
Pulleniatina obliquiloculata	1	1	1		X				X	X	X	1	6	15	X	4	4	9	19	23
Sphaeroidinella dehiscens			1									1		5			1			
unidentified globigerinids					X		X				X		2				3	1	X	
unidentified globorotaliids							X													

CRUISE	POFI – 5																			
STATION	21	22	23	24	25	26	27	28	29	33	35	37	39	41	43	45	47	48	49	50
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	532	232	2834	162	146	80	28	76	1760	274	5763	560	5898	2356	492	1558	4842	1584	812	562
POPULATION PER 1000 M^3	335	119	2250	115	112	50	17	55	2140	355	10,300	945	4490	702	308	1310	3700	2340	970	350
Candeina nitida		1	X		1			6		2										
Globigerina bulloides			X						1											
conglomerata	4	1	X	17			23	16	34	15	32	42	70	59	6	5	1	1		
eggeri	3	5	1	10	4		14			1	1									
hexagona					1															
inflata																				
pachyderma																				
quinqueloba																				
sp.																				
Globigerinella aequilateralis	10	14	5	7	4	5		3		4	X	2	X	3	10	3	X	1	1	3
sp.	7	3	4	12	8	21	21			2		1	1	8	2	X	1		26	
Globigerinita glutinata	1	1	X	2	1															
Globigerinoides conglobata	3		4	1	1	25		8	9	12	18	6	1				1	4		3
cf. minuta																				
rubra	1	1	X	1	3	5	7		2	2										
sacculifera	12	16	27	15	57	36	14	5	40	32	43	30	8	6	38	77	85	100	48	49
sp.																				3
Globorotalia hirsuta																				
menardii				1			7						1	X				1		3
scitula																				
truncatulinoides																				
tumida				1				10	7	6	1	2	1	2		X	X			
Hastigerina pelagica	1		X	1	1						X									
Hastigerinella rhumbleri																				
Orbulina universa	5	2	X	2	8		16				1	1	1	15	30	14	13	11	24	39
Pulleniatina obliquiloculata	51	55	57	30	11		14	23	7	24	3	16	16	6	X	X	X	1	X	3
Sphaeroidinella dehiscens	2	1	1	1				3		X	1		1	X				X		
unidentified globigerinids			X							1					4			2		
unidentified globorotaliids			X																	

CRUISE	POFI – 8																			
STATION	2	4	6	8	10	12	16	18	24	26	28	32	34	42	44	46	52	56	62	72
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	46	2354	4610	2580	981	994	84	124	1853	1500	42	190	24	20	6	48	190	183	524	1080
POPULATION PER 1000 M^3	491	5440	5700	1843	990	764	79	81	700	1470	31	126	16	12	5	21	109	101	394	620
Candeina nitida																				
Globigerina bulloides														10	33		2			
conglomerata		X				1	15	10	10	12	10	15	8	20		10				
eggeri		X						10			5					18	4			4
hexagona		X			X	1		6	1		5								1	7
inflata																				
pachyderma																				
quinqueloba																				
sp.																				
Globigerinella aequilateralis		X	X	X	2	1	5		2	2	5	2	8				13	3	6	13
sp.			X		7				3			52	7	40				4	2	1
Globigerinita glutinata	4	X	X	X	X							1	1					7	4	
Globigerinoides conglobata		2			X	X		3	1	2	49						4		2	
cf. minuta																				
rubra	4	10	1	21	33	6		19	1	2	14	1	8				8	16	8	4
sacculifera	35	56	43	53	30	44	5	29	57	69	29	8	17	20	33		23	30	34	22
sp.	13	9	47	26	26	46	20	2	4	2	5					18	8		5	2
Globorotalia hirsuta			X		X	X														
menardii		X																2	2	2
scitula																				
truncatulinoides		1							1											
tumida	4	1		X	1	X		3	13	4	10									3
Hastigerina pelagica	4	X			X		5	2				1	8	10					3	1
Hastigerinella rhumbleri																				
Orbulina universa	35	1	4	X	2	1							25				2		3	1
Pulleniatina obliquiloculata		X			4	5	35	16	1	2		19	8		34	50	34	27	19	39
Sphaeroidinella dehiscens					X														5	
unidentified globigerinids	4	X	X	X	X	X	15		1		14					20		10	3	2
unidentified globorotaliids																				

CRUISE	POFI – 8																			
STATION	75	76	77	78	80	82	84	86	88	92	94	96	98	100	101	102	103	104	105	106
TYPE OF NET	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH RANGE IN METERS	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200	0-200
TOTAL SAMPLE POPULATION	80	56	120	704	38	8	110	66	802	322	1104	330	330	418	100	34	30	50	48	102
POPULATION PER 1000 M^3	33	24	64	367	26	6	73	41	753	262	775	220	215	277	58	27	23	35	35	53
Candeina nitida				1										1			7			
Globigerina bulloides											X							4		
conglomerata							4			5										
eggeri																				
hexagona		11																4		
inflata																				
pachyderma																				
quinqueloba																				
sp.																				
Globigerinella aequilateralis	5	14	2	3	10				30	16	4	2	4	3	2		7	12	3	2
sp.				5		25	6	12	32	6	2	2						4		
Globigerinita glutinata									X	2	2		1							
Globigerinoides conglobata	5	7	8	3				3		1					10					2
cf. minuta																				
rubra	12	7	3	2	16		16	12	4	8	22	4		2	12	12		4	3	
sacculifera	32	34	35	77	48	50	32	51	4	4	36	85	85	84	52	47	20	20	56	2
sp.	12						2	9	1	2	4	2	2	1	10	6		8		
Globorotalia hirsuta														1		6				
menardii		4							1	1								4		
scitula																				
truncatulinoides																				
tumida																				8
Hastigerina pelagica				1				9	1	1		1	1		10	18	53	12	6	58
Hastigerinella rhumbleri																				
Orbulina universa	22	14	53	8	6	25	2						7	53	4	6	7		32	26
Pulleniatina obliquiloculata		7					36		35	56	3	4	1	2		6		38		
Sphaeroidinella dehiscens																				
unidentified globigerinids	2						2	3	2	1	1			1			7			2
unidentified globorotaliids																				

CRUISE	CAPRICORN													
STATION	29	30	33	94	126	127	136	145	164	169	172	206	207	209
TYPE OF NET	V	V	V	V	V	V	V	V	V	V	V	V	V	V
DEPTH RANGE IN METERS	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50	0-50
TOTAL SAMPLE POPULATION	115	19	24	24	46	54	86	9	20	11	32	23	50	76
POPULATION PER 1000 M^3	115,000	19,000	24,000	24,000	46,000	54,000	86,000	9,000	20,000	11,000	32,000	23,000	50,000	76,000
Candeina nitida														
Globigerina bulloides				4										
conglomerata														
eggeri	2			8	2	1	1			10	3		8	7
hexagona														
inflata														
pachyderma														
quinqueloba														
sp.			9										4	1
Globigerinella aequilateralis	2	5	4				1					9	2	
sp.														
Globigerinita glutinata	10	21	33	41	38	13	1	67	30	36	47	18	16	16
Globigerinoides conglobata	1						2						2	
cf. minuta														
rubra	24	11	33	17	26	35	23	22	15		6	4	6	12
sacculifera	50	47	17	25	13	41	59	11	45	36	28	39	4	8
sp.	10	16	4		17	11	13					4		13
Globorotalia hirsuta														
menardii	1											26		4
scitula														
truncatulinoides														
tumida														
Hastigerina pelagica									3					
Hastigerinella rhumbleri														
Orbulina universa														
Pulleniatina obliquiloculata	1												4	3
Sphaeroidinella dehiscens														
unidentified globigerinids				4	4				5	15	15		54	26
unidentified globorotaliids														

Table 8. Occurrence of planktonic Foraminifera at different depths in per cent of total population. Horizontal closing tows, at indicated depths. C refers to Clarke-Bumpus sampler.

LOCATION	31°57'N. 120°28'W.						32°23'N. 119°01'W.						32°35'N. 118°11'W.					32°38'N. 118°06'W.								32°49'N. 117°21'W.				
STATION	A						B						C					D								E				
TYPE OF NET	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
DEPTH RANGE IN METERS	1	10	25	50	100	200	2	10	25	50	100	200	1	10	50	100	200	1	10	25	50	100	300	500	1,000	1	10	25	50	70
TOTAL SAMPLE POPULATION	45	71	22	48	3	3	272	86	141	63	17	5	155	169	26	4	6	32	42	60	7	19	3	3	3	3	51	30	28	7
POPULATION PER 1000 M^3	5700	6220	2150	5070	530	530	34300	15100	28000	10480	3130	600	43080	27460	4400	860	990	7020	13110	22740	1660	4400	1170	900	560	580	6400	4070	328	1100
Candeina nitida																														
Globigerina bulloides																														
conglomerata																														
eggeri																														
hexagona																														
inflata																														
pachyderma																														
quinqueloba																														
sp.																														
Globigerinella aequilateralis																														
sp.																														
Globigerinita glutinata																														
Globigerinoides conglobata																														
cf. minuta																														
rubra																														
sacculifera																														
sp.																														
Globorotalia hirsuta																														
menardii																														
scitula																														
truncatulinoides																														
tumida																														
Hastigerina pelagica																														
Hastigerinella rhumbleri																														
Orbulina universa	13	7	27	19	67	100	8	7	6	19	18	20	4	4				9	7	5	14	5					2	7		
Pulleniatina obliquiloculata																														
Sphaeroidinella dehiscens																														
unidentified globigerinids	87	93	73	81	33		92	93	94	81	82	80	96	96	100	100	100	91	93	95	86	95	100	100	100	100	98	93	100	100
unidentified globorotaliids																														

LOCATION	LAT. 33°02'N. LONG. 118°23'W.																														
STATION	A					B											C				D										
TYPE OF NET	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
DEPTH RANGE IN METERS	0	0	10	50	100	5	10	25	40	60	60	80	100	150	200	400	0-5	10	25	40	5	10	25	40	60	80	100	150	200	300	400
TOTAL SAMPLE POPULATION	39	122	222	132	74	103	130	96	139	204	158	218	104	59	38	49	102	179	106	90	41	166	67	162	181	145	50	56	57	29	116
POPULATION PER 1000 M^3	36,000	53,000	89,000	72,000	53,000	40,000	124,000	107,000	87,000	85,000	93,000	64,000	28,000	18,000	13,000	21,000	79,000	200,000	101,000	65,000	22,000	123,000	67,000	108,000	87,000	79,000	50,000	11,000	10,000	10,000	16,000
Candeina nitida																															
Globigerina bulloides																															
conglomerata	13	20	20	16	27	32	23	12	22	30	22	23	18	7	5	10	17	22	23	22	22	25	16	20	22	22	18	21	12	7	17
eggeri																															
hexagona	36	29	47	54	54	34	37	46	49	39	54	51	55	79	60	48	37	50	49	57	27	48	45	45	42	43	32	46	44	62	57
inflata																															
pachyderma				1						1				1		12			1												
quinqueloba														2	3															4	2
sp.																2															
Globigerinella aequilateralis																															
sp.			1			1	1	2	1	1		2	4				1	1	4	1	2	2	2	2	1	2	8	2	3		2
Globigerinita glutinata																													2		1
Globigerinoides conglobata									3	3	3	6		1	5	2	3	3	3	7	10	3	6	3	10	10	10	5	7	4	
cf. minuta																															
rubra																															
sacculifera	20	20	18	6	5	9	14	20	16	14	11	5	2	2	8	4	20	12	9	4	20	11	13	15	10	6	10	11	12	3	6
sp.																															
Globorotalia hirsuta	5	3	2	3		3	1	3			1	1					1	1	1		12	1		1	2	1					
menardii																															
scitula										1		1			3			1							1		2		2		
truncatulinoides													3																		3
tumida													1																		
Hastigerina pelagica																															
Hastigerinella rhumbleri																4														3	2
Orbulina universa																															1
Pulleniatina obliquiloculata		2	2	1	3	5	3	3	1	1	5	1	3	3	11	4	4	3	3		2	3	3	4	2	1	4	4			3
Sphaeroidinella dehiscens																															
unidentified globigerinids	25	26	10	19	11	16	21	14	8	10	4	10	14	5	5	14	17	7	7	9	5	7	15	10	11	15	16	11	18	17	6
unidentified globorotaliids																															

TABLE 9

Comparison of average concentration of Foraminifera and night/day ratios at different depths. Data from Hida and King (1955) and King and Demond (1953).

Cruise	Depth	Time	Number Samples	Av. no. Foramin. per M^3	Ratio N/D
POFI-16	Surface	Night	11	41.0	0.86
POFI-16	Surface	Day	13	47.4	
POFI-5	Surface	Night	18	3.9	0.89
POFI-5	Surface	Day	18	4.4	
POFI-2	Surface	Night	4	2.4	0.44
POFI-2	Surface	Day	4	5.4	
POFI-8	0-200 m.	Night	20	1.07	0.84
POFI-8	0-200 m.	Day	20	1.28	
POFI-2	0-200 m.	Night	6	0.5	0.29
POFI-2	0-200 m.	Day	6	1.7	
POFI-16	Intermed.	Night	7	7.3	0.34
POFI-16	Intermed.	Day	9	21.5	
POFI-16	Deep	Night	6	3.7	1.2
POFI-16	Deep	Day	10	3.1	

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