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Title: Radiolarian Microfauna in the Northern California Current System: Spatial and Temporal Variability and Implications for Paleoceanographic Reconstructions

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Abstract approved: ______________________________
Nicklas G. Pisias

Radiolaria, as with other plankton, appear to be highly tuned to specific environments and thus provide very sensitive water mass and current indicators. We present radiolarian results of sediment trap and surface sediment data from the Multitracers Study in the eastern North Pacific for the sampling interval 9/87 - 9/89. Three sediment trap moorings positioned on a transect across the northern California Current System at approximately 120, 270, and 630 km respectively from the coast sample a wide variety of oceanographic conditions both spatially and temporally. Multivariate statistical techniques are used to illuminate trends and establish quantitative relationships between the radiolaria and their physical environment.

The largest amount of variability in this data is attributed to the southward-flowing California Current. Species associated with this current are most abundant at the two sites closest to shore, that is within 300 km of the coast. This distance seems to represent the basic division between onshore and offshore environments for this data set. The seasonality of the California Current is clearly reflected by

changes in the composition of the radiolarian trap assemblages; very different species dominate this region in summer vs. winter. In addition to seasonal trends, evidence in both the offshore and onshore environments suggests significant differences between years. This region appears to have been more strongly influenced by cold, Subarctic water during the winter of 1988/89 than during the previous year.

The usefulness of radiolarian as indicators of productivity and paleoproductivity appears to be complex. While statistical relationships exist between radiolarian compositional changes and organic carbon flux, the high variability of carbon flux in this region combined with the effects of dissolution, greatly reduces the predictive value of these relationships based on two years of data.

Finally we examine how the temporal information from the sediment trap is preserved in the sediment record. The sediment trap data provides valuable environmental information about certain radiolarian species which is not available from sediment distributions alone. We identify two species with very similar sediment distributions that exhibit quite different temporal patterns and thus reflect entirely unique environmental conditions.

Further insight is gained about information that is selectively removed or in some cases amplified in the transfer of environmental signals to the sediments. We identify a group of species that have greatly reduced abundances in the sediment record as compared to the sediment trap samples. While these organisms may contain potentially useful environmental information, their overall contribution to the total data set is not large. Removing these species from our analysis increases our ability to describe the sediments in this area and does not seem to alter the fundamental patterns which we observe from the temporal records provided by the sediment traps.

Enhanced preservation in the nearshore sediments is apparent. For example, a trap assemblage strongly linked to the offshore environment exhibits an onshore pattern of increase in the sediments. On the whole, while radiolarian sediment compositions certainly contain preservational effects, we can extract much useful information about the influence of various Pacific water masses in this region over long time periods. Certain radiolarian species and assemblages should thus provide valuable tools for indicating changes in the physical oceanographic regime both in the present and in the past.

Radiolarian Microfauna in the Northern California Current System: Spatial and Temporal Variability and Implications for Paleoceanographic Reconstructions

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INTRODUCTION

The Multitracers Experiment was an interdisciplinary project to develop a set of independent sediment tracers of productivity and paleoproductivity in the northern California Current System. The project was designed as a coupled water column / sediment trap / sediment study to measure directly, and evaluate the long-term importance of those processes most important in the production of carbon and its transfer from the surface to deep waters. This study area was selected because hydrographic and biologic properties vary strongly here on both regional and seasonal scales. Thus, with a small number of long term sediment trap moorings it was possible to sample a wide range of oceanographic conditions. The prime objective of the experiment was to relate seasonal and annual flux variations of microfossils, organic carbon, and geochemical tracers to contemporaneous oceanographic conditions in order to identify those processes that control the particulate flux to modern and ancient sediments. This strategy of ground-truthing an array of sediment components allows us to establish the special utility as well as the limitations of each tracer. The ultimate goal is a set of highly tuned independent proxies that we can use to describe the paleoceanography of this area using the sediment record.

One of the important paleoceanographic proxies in studies of the Pacific Ocean are Polycistine radiolaria. It has been known for some time that distribution patterns of these siliceous microfauna, as with other plankton (e.g. Johnson and Brinton, 1963), reflect the geographical extent of specific currents and water masses (e.g. Casey, 1971; Nigrini, 1971; Renz, 1976; Kling, 1979). Certain species have frequently been used in paleoceanography as indicators of water mass and temperature (e.g. Moore, 1978; Romine, 1985; Schramm, 1985; Pisias et al., 1986; Hays et al., 1989; Morley, 1989). Radiolaria are particularly well suited for this purpose. They have relatively long life spans, on the order of a month or more, are very diverse, and are distributed in all major oceans (e.g. Anderson, 1983). The environmental specificity of these organisms is further illustrated by the distinct depth preferences exhibited by many radiolarian species, some apparently living as deep as 1000m (e.g. Kling, 1979; Dworetzky and Morley, 1987). While there is indication that some radiolaria may respond to increased productivity (e.g. Pisias et al., 1986), this relationship has not been unequivocally established.

In this paper we analyze radiolarian compositional changes in sediment trap and surface sediment samples. We focus here on three things: 1) radiolaria as oceanographic indicators of temperature, water masses, and currents; 2) as indicators of productivity and paleoproductivity; and 3) how the temporal information from the sediment trap is preserved in the sediment record.

This thesis is divided into five main sections. The first section is a brief review of our present understanding of the physical and biological characteristics of the northern California Current System. The second section outlines the experimental design and sampling procedure. The third section is divided into five subsections. First are the factor analysis results. Using these results as guidelines, we then examine the fluctuations of key individual species and their relationships to measured changes in hydrographic conditions during the sampling interval. A general overview of the variability of organic carbon flux for the first two years of data collection is presented next and the relationship between radiolaria and flux of organic carbon to the deep sea is examined in this section using multiple linear regression. Following this we examine the sediment record which provides a measure of how well the observed patterns of radiolarian variability and the accompanying oceanographic interpretations are reflected over long time periods. Finally, we address the problem of differential preservation of some radiolarian species over others. The Discussion section is intended to provide an integrated view of this two-year data set and the Conclusions outline key results.

BACKGROUND AND GENERAL OCEANOGRAPHIC SETTING

I. The Transition Zone

The Multitracers study area is located in a transition zone in the eastern North Pacific (Fig. 1). A transition zone, by definition, is a region of mixing of two or more water types (Sverdrup et al., 1942). Roden (1970) characterized the North Pacific transition zone which lies between 32°N and 42°N and marks the boundary between Subarctic and Subtropical water masses. Along the North American coast, the Coastal Transition Zone lies generally between 100 km and 250 km offshore and separates coastal from oceanic regimes (e.g. Lynn and Simpson, 1987; CTZ Group, 1988; Strub et al., 1990). The transition zone in the eastern North Pacific refers roughly to a triangular-shaped area between about 30°N to 50°N at the coast and extending to about 150°W

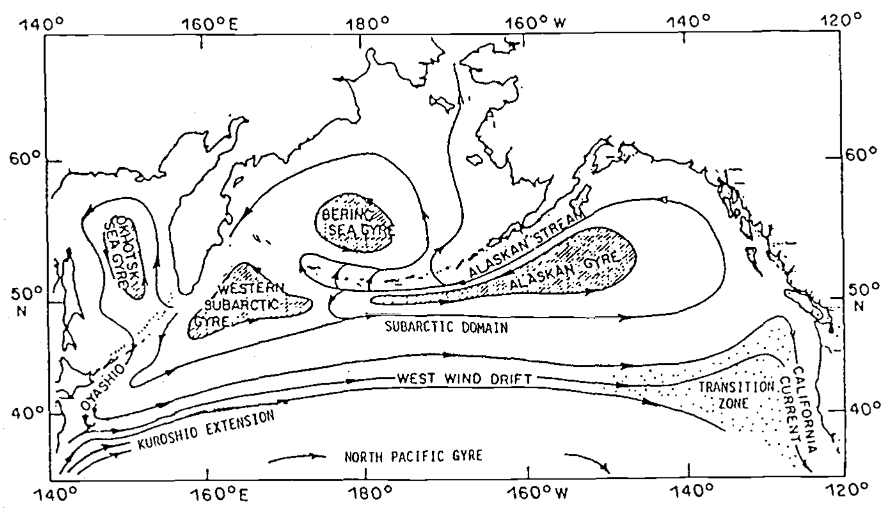


Figure 1. North Pacific surface circulation patterns and upper ocean domains. Illustrated is the transition zone in the east where the West Wind Drift and North Pacific Current diverge at the coast, thus defining the origin of the California Current. (adapted from Hickey, 1989)

(Hickey, 1979) and encompasses both previous definitions. This is a region of high oceanic variability, both spatially and temporally. It is influenced by Subtropical, Subarctic, and Equatorial water masses and coastal runoff and precipitation (e.g. Hickey, 1979) and is characterized by strong horizontal gradients in physio-chemical and biological properties (e.g. McGowen, 1974).

II. Water Masses and Current Regime

Large-scale circulation in the North Pacific is dominated by the anticyclonic North Pacific Gyre, the northernmost boundary of which is the eastward-flowing North Pacific Current. This current diverges at the North American coast into northward-flowing and southward-flowing branches, the latter marking the origin of the California Current (Fig. 1). Interannual variations in the location of the divergence are reported to be as large as seasonal variations (e.g. Hickey, 1979), but generally it occurs at about 45°N during the winter and about 50°N in summer (Pickard & Emery, 1982). Seasonal and nonseasonal fluctuations in the eastern boundary current regime deliver various Pacific water masses into our study area.

The southward-flowing California Current brings Subarctic water, identified by low salinity, relatively low temperature (Tibby, 1941; Bernal and McGowen, 1981) and high oxygen and phosphate, from high latitudes (Pickard & Emery, 1982). Off California the core of the current appears to be dynamically related to intermittent but recurring features, such as mesoscale eddies and energetic meanders, identified as the Coastal Transition Zone (e.g. Ikeda and Emery, 1984; Lynn and Simpson, 1987). Mesoscale surveys of the transition zone off northern

California have revealed the presence of intense southward-flow, known as the coastal jet, during the summer (e.g. Huyer et al., 1990; Kosro et al., 1990) in association with a very strong gradient in physical and biological properties (e.g. Chavez, et al.; Hood et al., 1990). Transport in the jet is about 3.8 Sverdrups (Huyer et al., 1990), over one-third the entire transport of the California Current (Wooster and Reid, 1963). The jet seems to be associated with an active upwelling front, defining the transition from coastal to oceanic regimes (Hood et al., 1990). However, the fresher water carried downstream in this 50-75 km wide surface current is more characteristic of Subarctic rather than upwelled water and probably represents the core of the larger-scale California Current (Huyer et al., 1990; Kosro et al., 1990).

The extent to which the jet occurs north of about 40°N is not known. Strong equatorward-flow has been observed to occur over the shelf off Oregon in association with coastal upwelling in the spring and summer (Mooers et al., 1976; Hickey, 1979; Huyer, 1983; Huyer and Smith, 1985). However, this flow along the upwelling front is effectively confined to a narrow band (25-50 km) near the coast by the Columbia River plume during the spring and early summer; its alongshore continuity is as yet undetermined (Huyer, 1983; Huyer et al., 1990). Off Oregon strongest flow in the California Current is reported by Hickey (1979) to lie 250-350 km offshore and to be best developed in late summer or early fall (see Figs. 2c and 2d). There is speculation that this strong offshore flow may in fact be an expression of the coastal jet later in the upwelling season; that is, as upwelling continues, the jet broadens and begins to migrate offshore, forming the

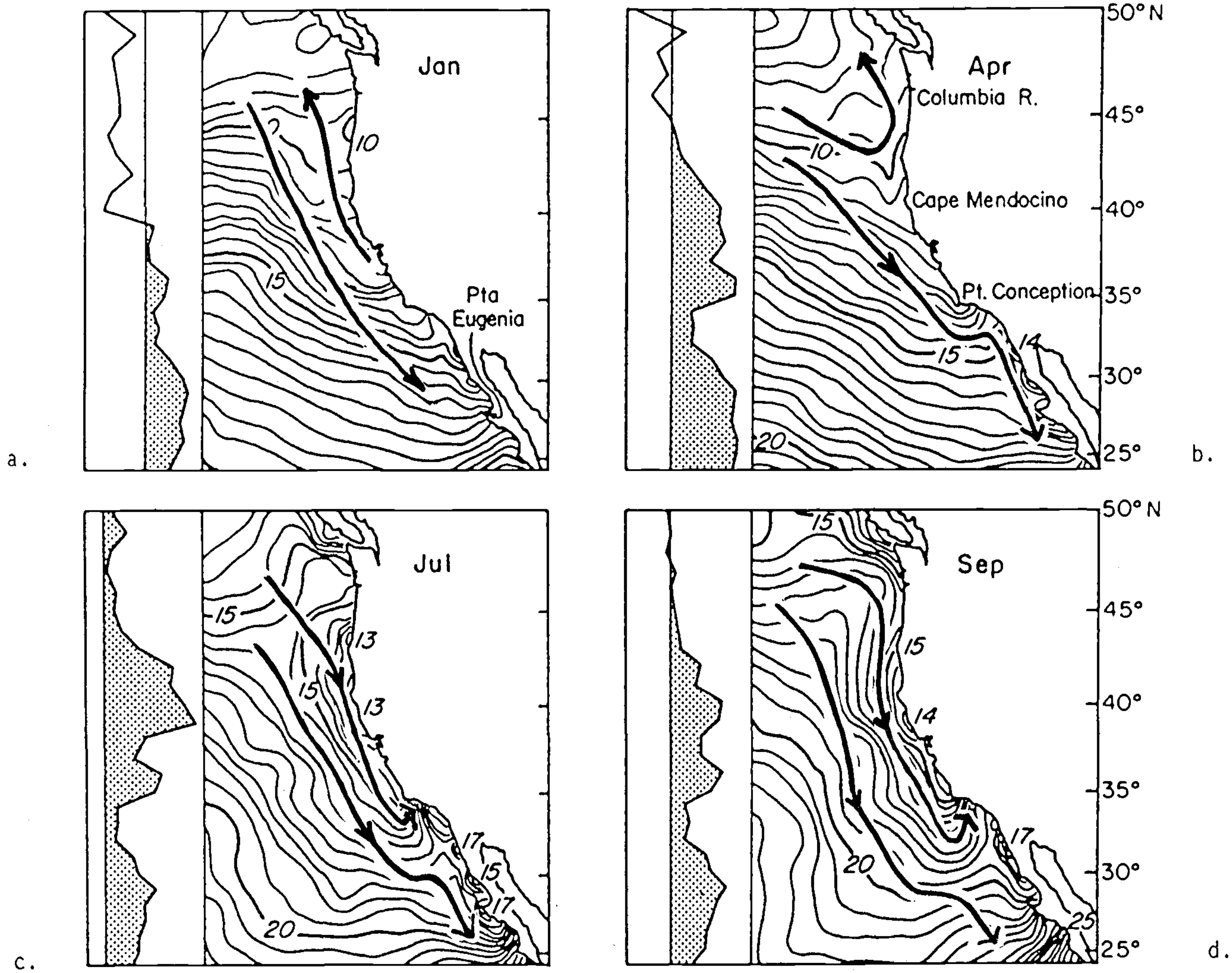


Figure 2. Seasonal surface currents in the California Current System and associated Ekman transport. Shaded area at left represents offshore transport. (adapted from Huyer, 1983 and Hickey, 1979)

mesoscales meanders and eddy features visible in satellite images (Huyer, Smith, pers. comm., 1990). However, it is difficult to establish continuity between these phenomena with the data presently available (Huyer et al., 1990).

Equatorial water enters the California Current System at depth via the poleward-flowing California Undercurrent (e.g. Hickey, 1979; Lynn & Simpson, 1987). This water is relatively warm, salty (Tibby, 1941), high in nutrient concentration, but low in dissolved oxygen (Pickard and Emery, 1982). The extent to which Equatorial water actually reaches the latitude of the Multitracers transect is not known. The distinguishing characteristics of this water mass are diluted as the water makes its way north so that off northern California and southern Oregon the influence of low latitude water is detected primarily by higher relative salinities (Huyer et al., 1989 and 1990). The location of the core of the California Undercurrent appears to vary with latitude and season (e.g. Hickey, 1979; Chelton, 1984 and 1988; Huyer et al., 1989), but it is generally said to exist below the main pycnocline at depths of 200-300m and seaward of the continental shelf (e.g. Hickey, 1979; Lynn & Simpson, 1987; Huyer et al., 1989). Maximum strength of this poleward subsurface current is thought to coincide with maximum equatorward-flow at the surface in the California Current (e.g. Hickey, 1989; Huyer et al., 1989). During fall and winter north of Point Conception the Undercurrent either disappears or shoals, merging with a poleward-flowing, nearshore surface current traditionally known as the Davidson Current (e.g. Hickey, 1979; Chelton, 1984; Huyer et al., 1989). Off Washington and Oregon subsurface northward-flow over the continental shelf, which has consistently been observed during the summer, is usually called the Shelf Undercurrent (e.g. Hickey, 1979; Huyer, 1990) (Fig. 2a). The degree to which the observed poleward-flowing currents in the California Current System are dynamically distinct is unclear and evidence increasingly suggests that they are in fact related (e.g. Hickey, 1979; Lynn & Simpson, 1987; Huyer et al., 1989).

North Pacific Central water lies to the southwest of transect. While this surface water mass is the least saline of the central water masses of the oceans (Pickard and Emery, 1982), it has relatively high temperature and salinity, but low oxygen and nutrient content as it mixes into the California Current System from the west (e.g. Lynn and Simpson, 1987; Pickard and Emery, 1982). North Pacific Central water represents an oligotrophic, oceanic influence in the Multitracers study region.

Upwelled water, found along the coast, is a mixture of Equatorial and Subarctic water masses (e.g. Bernal and McGowen, 1981). It is cold and nutrient rich, but has lower oxygen than Subarctic water and higher salinity than Central or Subarctic water masses (e.g. Lynn and Simpson, 1987; Huyer et al., 1990).

Finally, the Columbia River significantly modifies the composition and density structure of near surface water masses in the northeast Pacific (e.g. Landry et al., 1989). During winter the effluent flows poleward and is primarily confined to the Washington shelf but can extend several hundred miles off the coast of Oregon during the summer when the coastal current is southward and the surface Ekman transport is directed offshore (Hickey, 1989) (Figs. 2a-2d).

III. Processes Affecting Productivity

The coastal environment in the northeast Pacific is generally characterized as highly productive, attributed to a combination of high nutrient and light availability (e.g. Perry et al., 1989). North of about 35°N, persistent north-northwesterly winds develop during the summer when irradiance at the sea surface is high and days are long. These winds drive the coastal current southward and regulate mixing and upwelling processes that enrich surface waters and enhance primary production (e.g. Huyer, 1983; Strub et al., 1987b; Perry et al., 1989; Thomas and Strub, 1989). While planktonic populations in the California Current exhibit a high degree of spatial and temporal variability (e.g. Hayward and McGowen, 1979), in general, highest biomass occurs in the upwelling zone near the coast with an abrupt transition to lower concentrations offshore (e.g. Small and Menzies, 1981; Abbott and Zion, 1985 and 1987; Perry et al., 1989).

It has been suggested that cross-shore infusion of nutrients and plankton biomass from the coastal upwelling zone along cold, upwelling filaments could contribute significantly to offshore production (e.g. Mooers and Robinson, 1984; Abbott and Zion, 1985; Davis 1985). However, strongest advection seems to occur alongshore, due to strong southward-flow in the coastal jet. This characteristic feature of the Coastal Transition Zone is often associated with an upwelling front and appears to actually form a large-scale boundary that inhibits simple exchange between coastal and oceanic environments (e.g. Chavez et al., 1990; Hood et al., 1990). While in the latter part of the upwelling season, this boundary may be less abrupt and migrate seaward, its relationship to coastal upwelling during this time is unclear (Huyer, pers. comm., 1990).

In contrast, low pressure and southerly winds during the winter are associated with the northward-flowing Davidson current and downwelling along the coast (Fig. 2a) (e.g. Hickey, 1979; Huyer et al. 1979; Strub et al., 1987b). However, short term upwelling events are known to occur off Oregon during the winter even when the mean wind stress is not favorable, and can cause a change in the oceanographic regime which persists for several months (Huyer, 1983). Biological measurements in the northeast Pacific during the winter are few but there is some evidence of wintertime increases in production (Roesler and Chelton, 1987; Collier et al., 1989; Sancetta, 1990). Nonetheless, it is generally considered that low light levels and a relatively deep mixed layer effectively limit primary production in this region during the winter (e.g. Landry et al., 1989).

A rapid transition from winter to summer oceanographic regimes, which marks the beginning of the upwelling season in spring (Fig. 2b), occurs in response to large-scale wind forcing (Huyer et al., 1979; Strub et al., 1987a). Thomas and Strub (1989) investigated the sea-surface chlorophyll response to this transition from Coastal Zone Color Scanner (CZCS) satellite images and found high interannual variability in both the timing and location of increased pigment. They report that while increases in chlorophyll pigment coincide with the onset of northerly winds most years, this is not necessarily related to coastal upwelling or the physical transition at the coast. The most dramatic increase, in the five years examined, was observed to have a large spatial distribution and to be concentrated approximately 300 km offshore. They suggest the observed variability in pigment concentration is related to interannual fluctuations in basin-wide wind forcing in conjunction with variability in nutricline and pycnocline depths.

Large-scale and low-frequency fluctuations in flow patterns appear to exert a major influence on the biological characteristics of the California Current (e.g. Bernal, 1981; Bernal and McGowen, 1981; Chelton et al., 1982; Roesler and Chelton, 1987). Roesler and Chelton (1987) examined time series from 32 years of CalCOFI data and determined increases in zooplankton biomass off northern California were largely related to increases in equatorward transport of Subarctic water due to increases in alongshore geostrophic flow. Interannual variability in the intensity of flow in the California Current results in significant deviations from the characteristic seasonal pattern resulting in anomalous cold or warm years with profound effects on biology (e.g. Miller et al., 1983). Recent research efforts substantiate that most, though not all, of the interannual variability in the California Current System is linked to the tropical El Nino-Southern Oscillation phenomena (e.g. Pares-Sierra and O'Brien, 1989). The communication of this phenomenon from its origin in the tropics to its mid-latitude expression is through both oceanic and atmospheric forcing mechanisms (Johnson and O'Brien, 1990). Thus, while upwelling processes can clearly affect an immediate and dramatic biological response near the coast, evidence is strong that understanding large-scale forcing mechanisms is as important when trying to unravel the long-term interactions between physical and biological processes in this eastern boundary current regime.

IV. Export Production

Our focus in this study is on export production because that is what is measured in the traps and is delivered to the sediments. The relationship between carbon fixed in the euphotic zone and carbon exported from this zone is complex. The amount of carbon leaving the system depends on the rate of production and the rate of utilization, which are both affected by the physical dynamics of the system. Legendre and Le Févre (1989) suggest physical discontinuities or "hydrodynamical singularities" in the oceanic environment (such as pycnoclines or fronts) play a major role in determining whether carbon produced is recycled or exported. In highly variable environments, such as coastal and transitional regimes, the dynamic balance between autotrophs and heterotrophs is often unstable and energy transfer to higher trophic levels is low. In such environments, the ratio of export production to total primary production is high and often contains a large proportion of phytoplankton. In less variable systems, such as the open ocean, a higher percentage of nutrients are recycled and export production is low relative to primary production. Of course the variability of a system can change with season; coastal ecosystems may become more stable and develop longer food chains in the latter part of the upwelling season and in wintertime (e.g. DeAngelis et al., 1989), and many places in the open ocean experience spring and/or fall blooms.

Thus, as noted by Berger et al. (1989), export of biogenic material from the surface ocean reflects the physical and biological dynamics of the whole ecosystem rather than just the activity of the primary producers. The complexities of modern systems are important to keep in mind when reconstructing paleoproductivity from organic carbon records in sediments. To this end, the Multitracers project was designed to provide the field data necessary to critically evaluate what information about the system is transferred to and preserved in the geologic record.

MOORING DESIGN AND SAMPLING PROCEDURE

The Multitracers transect consists of three sediment trap moorings across the California Current System at approximately 42°N (Fig. 3). These three sites, referred to as Nearshore, Midway, and Gyre, are approximately 120, 270, and 630 km respectively from the coast. Each mooring has four six-sample-cup traps and a fifth trap with fifteen cups that was recently designed and developed at OSU for high resolution sampling. Traps are located at depths ranging from 500m below the surface to 500m above the bottom. Samples were collected at 2 week to 2 month intervals from 9/87-9/91. The exact sampling interval depends on year, location and water depth. Results presented here are from the first two years of data collection, 9/87-9/89. For the period 9/87-10/88 we have six samples from each site collected at 1000m depth, each representing approximately 2-month intervals. For the period 10/88-9/89 we have thirteen samples from the Midway and Gyre sites and twelve from Nearshore, collected at 1500m, each representing approximately 1-month intervals.

Sediment trap samples were preserved with sodium azide. The samples from each cup were wet-split into fourths; three-fourths of which were dried and analyzed for organic carbon, calcium carbonate, opal, and various trace metals. The remaining fourth was further split for microplankton analysis. Approximately one-sixteenth of a sediment trap sample is used for radiolarian analysis. Preparation and determination of the >63μ fraction followed the technique outlined in Roelofs and Pisias (1986). Seventy-six species were identified in both trap and sediment samples following the taxonomy of Nigrini and Moore

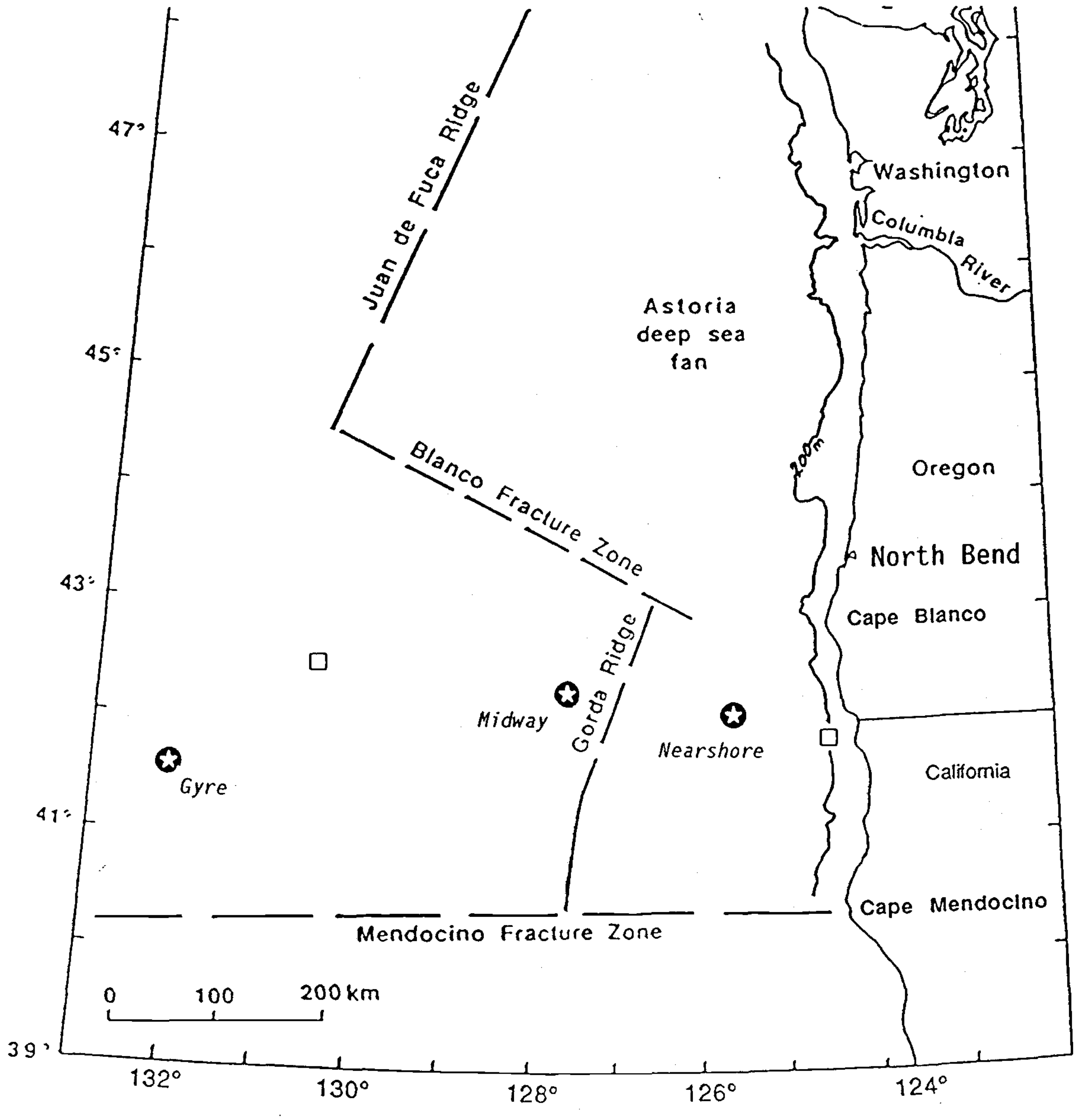


Figure 3. Multitracers transect in the eastern North Pacific. Circled stars locate sediment trap moorings, boxes locate National Data Buoy Center buoys which provide surface hydrographic information for this region.

(1979). In a given sample, the identified species account for between 50% to 75% of the total number of individuals counted and the percent of any particular species rarely exceeds 10%. This helps to minimize the inherent problem that a closed system presents on the interpretation of fluctuations in relative abundance, since no one species ever dominates the entire sample.

We focus on radiolarian composition in this paper rather than fluxes because of the difficulty in determining radiolarian fluxes for these samples with a high degree of confidence. Determination of absolute values relies on a variety of precise measurements from both sample splitting and slide preparation. These sources of error are magnified to a potentially large degree during the final back-calculation to total radiolaria in the sample cup (Roelofs and Pisias, 1986). We are currently quantifying the total error associated with flux calculations so that they can be reported in future with confidence intervals. Since determination of relative abundances does not rely on these measurements they are not subject to the same errors. Accurate quantification of radiolaria trap composition requires that the number of radiolaria counted adequately represent the proportion of the original sample, which we accomplish by counting a minimum of 500 individuals. Compositional values are, therefore, more robust than absolute values and better reflect the spatial and temporal patterns of the region. The species used in this analysis are listed in Table 1. Radiolarian data from both sample years are given in Appendix A.

S1	*Spongurus sp.*
S1A	*Spongurus elliptica*
S3	*Actinomma arcadophorum* & *A. medianum*
S4	*Actinomma* spp.
S7	*Echinomma leptodermum*
S8	*Prunopyle antarctica*
S9	*Amphiropalum ypsilon*
S10	*Echinomma delicatum*
S13	*Polysolenia spinosa*
S14	*Heliodiscus astericus*
S17	*Hexacontium enthacanthum*
S18	*Hymeniastrium euclidis*
S19	*Larcospira quadrangula*
S23	*Didymocyrtis tetrathalamus*
S24	*Lithelius minor*
S29	*Larcopyle butschlii*
S30	*Stylochlamydium asteriscus*
S34	*Polysolenia murrayana*
S36	*Dictyocoryne truncatum*
S36C	*Euchitonia triangulum*
S41	*Spongurus pylomaticus*
S42	*Spongocore puella*
S43	*Spongopyle osculosa*
S44	*Spongotrochus glacialis*
S47	*Stylodictya validispina*
S48	*Porodiscus* sp.
S51	*Stylatractus sp.*
* S52	*Styptosphaera spumacea*
* S53	*Hexapyle* spp.
S54	*Tetrapyle octacantha* & *Octopyle stenozoa*
N1	*Liriospyris reticulata*
N1C	*Zygocircus* spp.
N3	*Anthocyrtidium zanguebaricum*
N4	*Carpocanistrum* spp.
N5	*Lamprocyrtis nigriniae*
N7	*Pterocorys minithorax*
N8	*Carpocanistrum papillosum*
N10	*Eucyrtidium acuminatum*
N11	*Eucyrtidium hexagonatum*
N14	*Tholospyris scaphipes*
N15	*Lamprocyclas junonis*
N18	*Botryostrobus auritus/australis*
N23	*Peripyramis circumtexta*
N24	*Pterocanium* spp.
N25	*Pterocanium praetextum eucolpum*
* N26	*Pterocanium korotnevi*
N28	*Pterocanium trilobum*
N29	*Pterocorys hirundo*
N32	*Phormostichoartus corbula*
N33	*Botryostrobus aquilonaris*
N34	*Stichopilium bicorne*
N35	*Theocalyptra davisiana davisiana*
N35A	*Theocalyptra davisiana cornutoides*
N36	*Theocalyptra bicornis* var.
N38	*Theocalyptra bicornis*
N40	*Pterocorys zancleus*
N42	*Theocorythium trachelium trachelium*
* N44	*Dictyophimus* sp.
* N45	*Helotholus histricosa*
* GN1	*Dictyophimus infabricatus*
* GN2	*Dictyophimus clevii*
* GN3	*Lithomelissa hystrix*
* GN4	*Lithomelissa thoracites*
* GN5	*Lithomelissa* cf. *galeata*
* GN8	*Ceratospyris polygona*
* GN9	*Litharachnium tentorium*
* GN14	*Desmospyris anthocyrtoides*
* GN15	*Lophocorys polyacantha*
* GN16	*Eucecryphalus* sp.
* GN18	*Peridium* spp.
* GN19	*Lithostrobus* cf. *hexagonalis*
* GN21	*Helothus* sp.
* GN22	*Plectacantha* sp.
* GN27	*Dictyoceras acanthicum*
* GN28	*Dictyophimus columbo*
* GN29	*Amphiplecta* cf. *acrostoma*

* species not well preserved in sediments

Table 1. List of radiolarian species identified in this study along with the abbreviations used at OSU.

DATA ANALYSES

To examine the variability of the radiolarian trap abundances we use Q-mode factor analysis with a VARIMAX rotation (Klovan and Miesch, 1976), a powerful technique for illuminating trends in multivariate data. Since the 1988/89 sample year had eighteen samples and the 1987/88 year had thirty-eight samples, a factor analysis of these fifty-six samples together would over-emphasize the importance of the second year. In order that both years have equal weighting, we entered the two-month samples into the analysis twice, for a total of seventy-four samples. We compared the results to those of an analysis of thirty-six samples, with the second year averaged into two month intervals, and obtained the same set of six linearly independent factors that explain 89% of the total variability of the original data matrix. We report the results of the analysis using the one-month samples because it maintains the most information with the highest temporal resolution.

The importance of each factor on each sample is described by the factor loading matrix (Table 2). A factor loading is the square root of that portion of information in a sample that is described by the factor. For example, a factor loading of 0.6 means that factor explains 36% of the information contained in the sample. The sum of squares of all the factor loadings for a given sample is a measure of how well the factor analysis model explains the sample; a value of 1.0 would indicate the factor model perfectly describes the sample. This is the communality of the sample which is given in the left-hand column of Table 2. The value at the bottom of each column is the sum of squares of the factor loadings for a given factor, divided by the total number of samples. Expressed as a percentage, this represents the portion of the total data set explained by that factor.

The importance of each variable on each factor is described by the factor score matrix. The sum of squares of the factor scores for a given factor equals one. Since this value is dependent on the number of species used, Table 3 lists factor scores which have been scaled by the square root of the number of species. Scaling the factor scores in this way yields standardized values which can be compared to factor scores from other analyses. Only those species with scaled scores > $|1.0|$ are included in Table 3.

Since organisms that occur together in a trap death assemblage may not necessarily coexist in the water column, factors are statistical groupings which may have limited ecological meaning. Nonetheless, the factor analysis defines the most important patterns exhibited by the radiolarian population and subsequently identifies key species that best characterize the variability in these samples.

	sampling interval	trap depth	communality	California Current Factor	Transition Factor	Winter Factor	Subarctic Gyre Factor	Central Gyre Factor	Gulf of CA Factor
Nearshore	9/22/87-10/25/87	1000	0.818	0.667	0.216	0.249	0.091	0.008	0.507
	10/25/87-12/24/87	1000	0.831	0.575	0.266	0.335	0.375	0.287	0.307
	12/24/87-2/22/88	1000	0.967	0.475	0.303	0.650	0.025	0.368	0.301
	2/22/88-4/22/88	1000	0.920	0.326	0.441	0.600	-0.041	0.462	0.208
	4/22/88-6/21/88	1000	0.904	0.706	0.529	0.201	0.064	0.254	0.131
	6/21/88-9/16/88	1000	0.739	0.765	0.112	0.256	0.117	0.123	0.217
	9/16/88-9/30/88	1500	0.908	0.893	0.187	0.137	0.048	0.071	0.224
	9/30/88-10/27/88	1500	0.803	0.853	0.089	0.245	0.063	0.056	0.008
	10/27/88-11/26/88	1500	0.804	0.792	0.072	0.358	0.058	-0.004	-0.202
	11/26/88-12/26/88	1500	0.812	0.771	0.088	0.424	0.107	0.132	-0.033
	12/26/88-1/25/89	1500	0.944	0.694	0.219	0.526	0.332	0.129	0.106
	1/25/89-2/24/89	1500	0.949	0.288	0.075	0.508	0.770	0.089	-0.034
	2/24/89-3/26/89	1500	0.945	0.434	0.251	0.791	0.189	0.144	-0.106
	3/26/89-4/25/89	1500	0.904	0.490	0.454	0.612	0.132	0.253	-0.041
	4/25/89-5/25/89	1500	0.890	0.372	0.372	0.773	0.125	0.038	-0.017
	5/25/89-6/24/89	1500	0.868	0.493	0.622	0.396	0.134	0.167	0.186
	6/24/89-7/24/89	1500	0.957	0.657	0.532	0.418	0.192	0.169	-0.050
	7/24/89-8/23/89	1500	0.811	0.593	0.564	0.292	0.186	0.129	0.074
Midway	9/22/87-10/25/87	1000	0.883	0.706	0.387	0.333	0.174	0.304	-0.015
	10/25/87-12/24/87	1000	0.947	0.716	0.304	0.202	0.201	0.256	0.440
	12/24/87-2/22/88	1000	0.941	0.126	0.235	0.811	0.163	0.429	0.047
	2/22/88-4/22/88	1000	0.935	0.283	0.438	0.717	0.045	0.293	0.247
	4/22/88-6/21/88	1000	0.930	0.775	0.464	0.221	0.145	0.210	0.024
	6/21/88-9/16/88	1000	0.941	0.891	0.228	0.133	0.129	0.245	0.028
	9/16/88-9/30/88	1500	0.798	0.777	0.273	0.034	0.119	0.057	0.317
	9/30/88-10/27/88	1500	0.946	0.870	0.304	0.261	0.091	0.140	0.002
	10/27/88-11/26/88	1500	0.921	0.872	0.201	0.312	0.091	0.119	-0.031
	11/26/88-12/26/88	1500	0.915	0.854	0.090	0.351	0.096	0.213	-0.015
	12/26/88-1/25/89	1500	0.923	0.642	0.155	0.651	0.207	0.104	0.098
	1/25/89-2/24/89	1500	0.926	0.421	0.057	0.632	0.583	0.081	0.012
	2/24/89-3/26/89	1500	0.916	0.370	0.197	0.777	0.321	0.146	0.115
	3/26/89-4/25/89	1500	0.917	0.490	0.369	0.683	0.183	0.191	0.073
	4/25/89-5/25/89	1500	0.927	0.245	0.420	0.811	0.109	0.143	0.019
	5/25/89-6/24/89	1500	0.866	0.508	0.558	0.484	0.108	0.219	0.052
	6/24/89-7/24/89	1500	0.886	0.672	0.490	0.362	0.095	0.149	0.178
	7/24/89-8/23/89	1500	0.891	0.525	0.656	0.362	0.138	0.181	0.051
	8/23/89-9/15/89	1500	0.894	0.653	0.574	0.301	0.090	0.185	0.078
Gyre	9/22/87-10/25/87	1000	0.882	0.458	0.321	0.190	0.264	0.678	-0.062
	10/25/87-12/24/87	1000	0.905	0.574	0.232	0.219	0.222	0.629	0.167
	12/24/87-2/22/88	1000	0.874	0.134	0.417	0.187	0.151	0.774	0.157
	2/22/88-4/22/88	1000	0.880	0.028	0.524	0.367	-0.057	0.680	-0.057
	4/22/88-6/21/88	1000	0.850	0.245	0.703	0.249	-0.015	0.456	-0.160
	6/21/88-9/16/88	1000	0.948	0.804	0.287	0.229	0.183	0.316	-0.185
	9/16/88-9/30/88	1500	0.715	0.479	0.139	0.348	0.113	0.574	0.060
	9/30/88-10/27/88	1500	0.491	0.358	0.150	0.347	0.033	0.464	-0.058
	10/27/88-11/26/88	1500	0.848	0.681	0.393	0.203	0.089	0.342	0.253
	11/26/88-12/26/88	1500	0.859	0.666	0.354	0.204	0.210	0.377	0.250
	12/26/88-1/25/89	1500	0.946	0.330	0.222	0.159	0.840	0.195	0.136
	1/25/89-2/24/89	1500	0.901	0.123	0.075	0.116	0.924	0.114	-0.019
	2/24/89-3/26/89	1500	0.821	0.303	0.661	0.236	0.293	0.303	0.243
	3/26/89-4/25/89	1500	0.872	0.256	0.736	0.259	0.226	0.336	0.185
	4/25/89-5/25/89	1500	0.908	0.194	0.814	0.274	0.060	0.337	0.127
	5/25/89-6/24/89	1500	0.957	0.373	0.832	0.194	0.115	0.240	0.127
	6/24/89-7/24/89	1500	0.942	0.292	0.855	0.266	0.095	0.214	-0.039
	7/24/89-8/23/89	1500	0.922	0.466	0.725	0.288	0.047	0.255	0.173
	8/23/89-9/15/89	1500	0.902	0.489	0.591	0.392	0.226	0.274	0.185
			INFORMATION	32.928	17.559	17.449	5.827	11.459	3.424
			CUM. INF	32.928	50.487	67.935	73.763	85.221	88.645

Table 2. Varimax Factor Loadings for six factor model.

	species	California Current Factor	Transition Factor	Winter Factor	Subarctic Gyre Factor	Central Gyre Factor	Gulf of CA Factor
S1	*Spongurus* sp.	2.326	-0.715	-0.321	-0.211	0.161	0.511
S8	*P. antarctica*	0.291	1.030	-0.144	0.485	0.246	-0.421
S17	*H. enthacanthum*	0.337	1.609	1.081	0.000	-0.654	-0.594
S24	*L. minor*	1.553	1.069	-0.086	0.066	0.073	-0.875
S29	*L. butschlii*	-0.935	4.715	1.202	1.131	0.992	2.263
S43	*S. osculosa*	-0.503	-0.347	0.115	8.172	0.295	0.225
S48	*Porodiscus* sp.	-0.355	-1.264	7.245	0.843	-0.648	-0.741
S54	*T.octacantha/O.stenozoa*	-0.124	-1.098	-0.283	0.442	4.440	0.978
N4	*Carpocanium* spp.	-0.147	1.263	-0.504	0.328	0.463	-0.549
N5	L. nigriniae	1.784	1.034	0.466	0.332	1.555	-1.999
N10	*E. acuminatum*	-0.078	1.409	0.332	0.047	-0.541	0.264
N11	*E. hexagonatum*	-1.424	0.133	0.932	-1.172	5.671	0.105
N14	*T. scaphipes*	0.095	-0.039	0.122	-0.060	-0.180	1.056
N33	*B. aquilonaris*	1.128	0.635	0.426	0.148	-0.685	-1.667
N35	*T. davisiana davisiana*	3.942	-0.744	1.108	-0.174	-0.862	-2.806
N38	*T. bicornis*	1.064	1.906	-0.234	-0.040	0.321	-2.109
N40	*P. zancleus*	-0.661	5.245	0.398	-0.645	0.170	-1.796
N44	*Dictyophimus* sp.	3.579	-0.925	-0.150	0.583	3.452	-1.478
GN2	*D. clevii*	1.771	0.051	1.555	-0.623	-0.690	1.544
GN3	*L. hystrix*	-0.001	-0.375	2.994	-0.989	0.362	1.779
GN4	*L. thoracites*	-0.188	1.117	1.669	-1.009	0.849	0.834
GN5	*L.* cf. *galeata*	0.942	-0.775	0.552	-0.779	0.082	3.248
GN18	*Peridium* spp.	4.683	1.840	-0.633	0.674	-0.474	4.618
GN21	*Helothus* sp.	1.517	-0.001	0.253	-0.099	0.800	-0.659

Table 3. Scaled Varimax Factor Scores for six factor model. Only those species with scaled scores > |1.0| are included.

RESULTS

I. Factor Analysis

The results of the factor analysis are illustrated in Figures 4a-4f. The first factor (Fig. 4a), which we call the California Current factor, accounts for 33% of the information in the total data set, and is predominant at some time at each of the three mooring sites. It is associated with this southward-flowing current because of both the location and timing of its maximum influence; it is most prominent at Midway and Nearshore during the summer and fall, coincident with both the location and timing of maximum equatorward-flow in the California Current (Hickey, 1979; Chelton, 1984). The most important species for this factor are *Peridium* spp. (GN18), *Theocalyptra davisiana* (N35), *Dictyophimus* sp. (N44), and *Spongurus* sp. (S1).

The Winter factor, which accounts for 18% of the sample information, is also most prominent at Midway and Nearshore (Fig. 4b). However, temporally this factor is the converse of the first, exhibiting strongest influence during the winter and early spring, when southward-flow is weak. Species associated with this factor are *Porodiscus* sp. (S48) and *Lithomelissa hystrix* (GN3). The California Current factor and the Winter factor together explain over 50% of the radiolarian variability in the sediment trap samples. The interplay between these two factors appears to reflect the seasonal variations of equatorward-flow in the California Current, the most dominant physical process in the Multitracers study region.

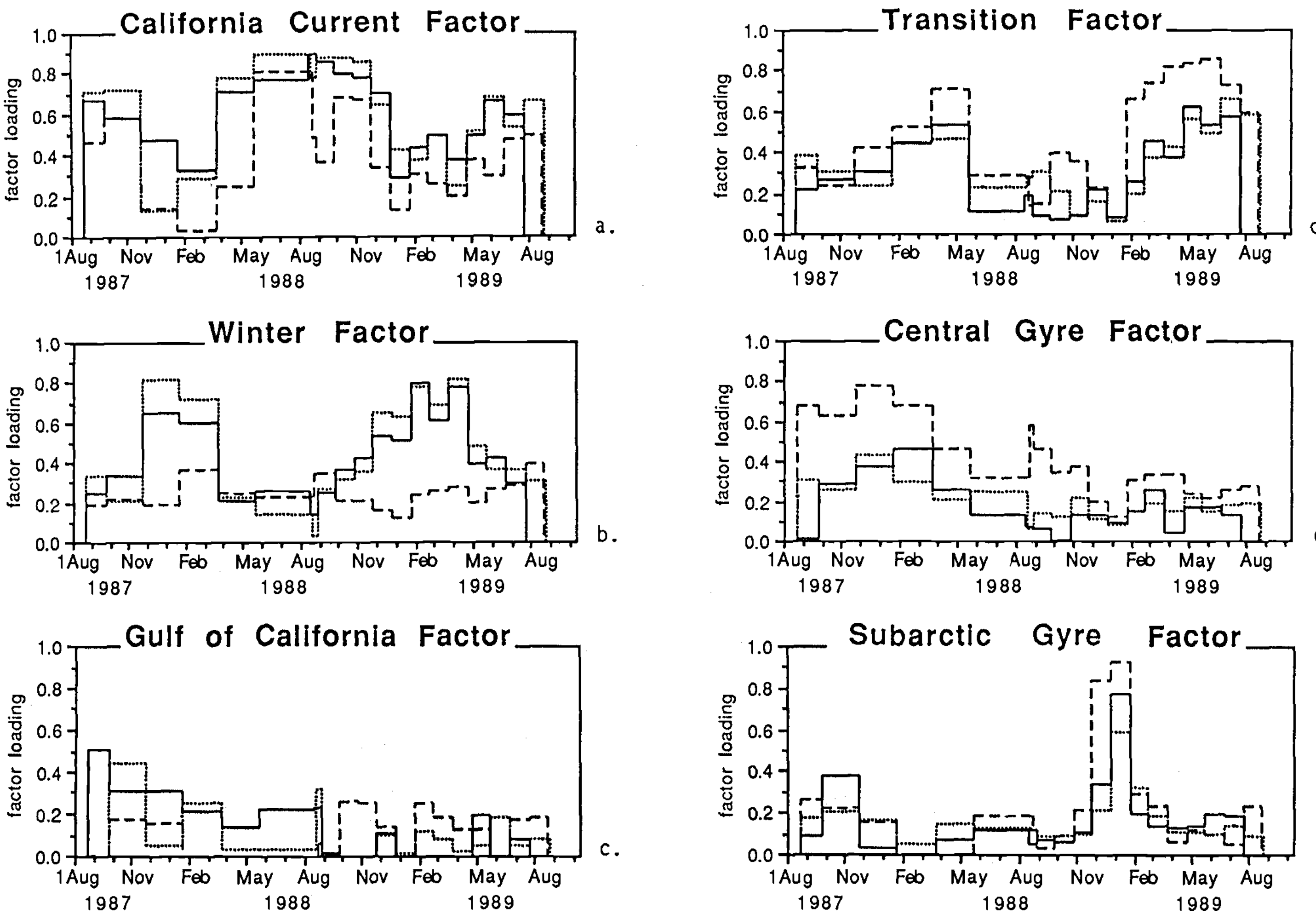


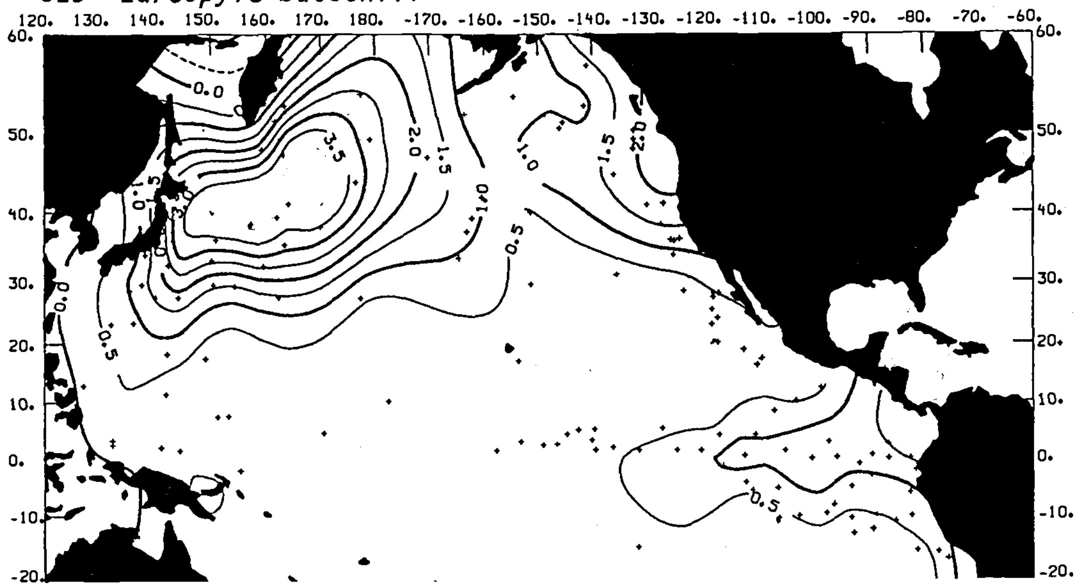
Figure 4. Graphs of factor loadings from six factor model. Sediment trap samples were collected from 9/87 to 9/89. Nearshore = solid, Midway = dotted, Gyre = dashed.

While the Gulf of California factor (Fig. 4c) explains only 3% of the sample information, it has been retained in the factor model because it is important at Nearshore in the late summer/early fall of 1987. Many species in this factor, namely *Peridium* spp. (GN18), *Lithomelissa* cf. *galeata* (GN5), *Dictyophimus clevii* (GN2) and *L. hystrix* (GN3), have not been included in detailed analysis of radiolaria on an oceanwide (Moore, 1978) or regional (Robertson, 1975; Molina-Cruz, 1977; Pisias, 1978) basis. *Peridium* spp. (GN18) and *L. histrix* (GN3) have been found, however, to be significant components of the radiolarian assemblages in sediments from the Gulf of California (Pisias, 1986). This factor seems to be related to a distinctly nearshore process, perhaps coastal upwelling. Alternatively, it may represent the influence of low latitude water brought north via the poleward-flowing California Undercurrent or Davidson Current.

The Transition factor accounts for 17% of the data. It is important at all three sites, but is most prominent at Gyre (Fig. 4d). This factor is so named primarily because species associated with it, *Larcopyle butschlii* (S29) and *Pterocorys zancleus* (N40), are found in highest abundance in sediments beneath the transition zone in the North Pacific (Figs. 5a and 5b). The importance of this factor begins to increase during the late winter, reaches a maximum value in the spring and has low abundances in the summer and fall. The importance of the Transition factor during the spring indicates it may be related to the transition in this region from winter to summer oceanographic regimes, especially in the offshore environment. This factor is significant in the nearshore environment in the spring, but is overshadowed by the California Current factor in summer.

S29 *Larcopyle butschlii*

a.



N40 *Pterocorys zancleus*

b.

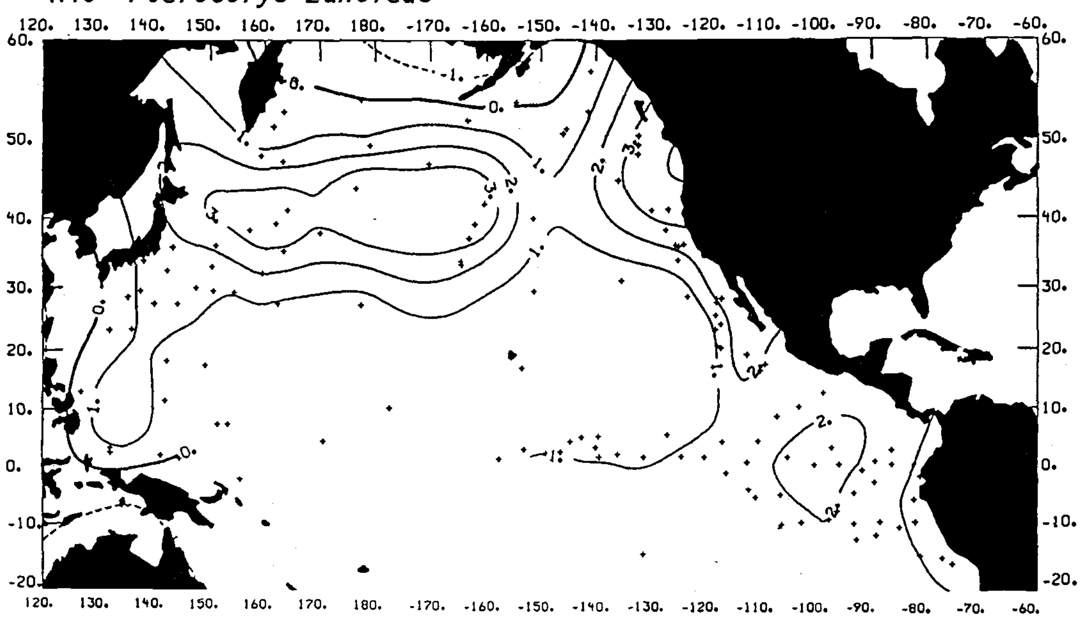


Figure 5. Surface sediment distribution patterns for species important in the Transition factor. Contours are in relative abundance. (data from Pisias, 1990)

The Central Gyre factor, which explains 11% of the data, (Fig. 4e) has a very strong influence in the offshore environment during the fall and winter of the 1987/88 sample year. During the second sample year, however, this factor appears to be notable only in the fall of 1988 with perhaps a minor increase again in the late winter/early spring of 1989. Species important in this factor are *Eucyrtidium hexagonatum* (N11), *Tetrapyle octacantha & Octopyle stenozoa* (S54 - two species which are generally grouped together), and *Dictyophimus* sp. (N44). *T. octacantha & O. stenozoa* (S54) are found in highest abundance in sediments beneath the subtropical ocean (Fig. 6), and have previously been interpreted as indicative of warm, subtropical surface water (Pisias et al., 1986). We believe this factor to represent the influence of an offshore, oligotrophic environment in the Multitracers study region.

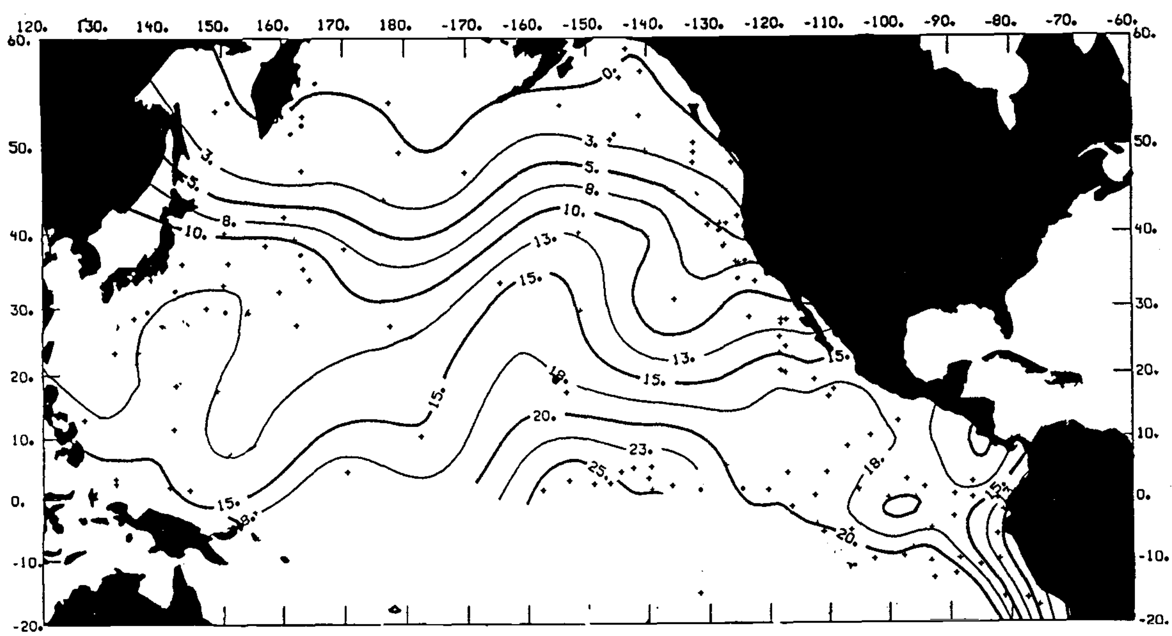


Figure 6. Surface sediment distribution of *T. octacantha & O. stenozoa* (S54), species important in the Central Gyre factor. (data from Pisias, 1990)

During the winter of 1988/89 the Subarctic Gyre factor, which explains 6% of the data, exhibits a pronounced influence at all three sites (Fig. 4f). This factor signals the strong appearance in the Multitracers study area of one species, *Spongopyle osculosa*(S43). This species has high sediment abundances beneath the Subarctic Gyre (Fig. 7), hence the name of the factor.

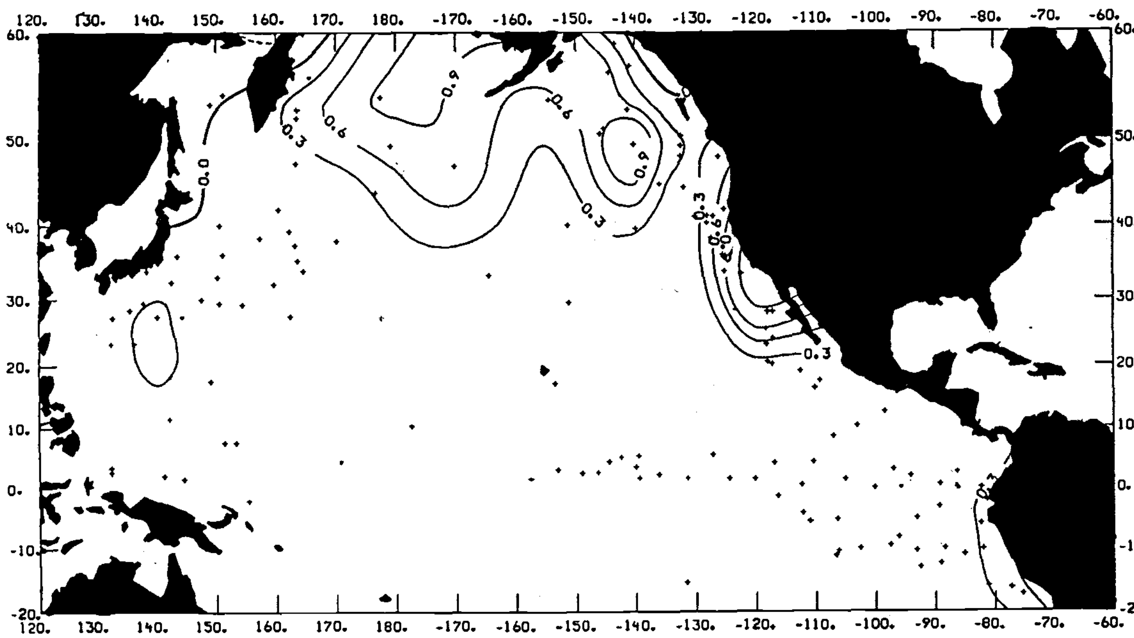


Figure 7. Surface sediment distribution of *S. osculosa* (S43), a species important in the Subarctic Gyre factor. Contours are in relative abundance. (data from Pisias, 1990)

The Central Gyre and Subarctic Gyre factors, which are both important primarily in the offshore region, appear to represent the influence of distinctly different water masses in the Multitracers study region. In the following section we examine this further by looking at the temporal fluctuations of individual species along with hydrographic data from this region.

II. Species Time Variability and Hydrographic Conditions

Using the factor analysis as a guideline, we examined fluctuations of certain individual species of radiolaria from the sediment trap samples. We have generally chosen a representative species from each of the factors. Two species from the California Current factor are presented because they seem to demonstrate different aspects of this current. Also, we focus on those species which exhibit strong positive scores for only one factor and for which an ocean-wide sediment data base is available. For this reason no species from the Gulf of California factor is presented.

The radiolarian sediment trap records are a direct account of biological change associated with time varying hydrographic conditions. Two National Data Buoy Center buoys, located at 41.8°N, 124.4°W and 42.5°N, 130.4°W, monitor these conditions in our study area (Fig. 3). Sea surface temperature records from these buoys, along with a record of wind vectors from the North Bend airport at the Oregon coast, provide a high resolution description of the onshore and offshore physical environment which we use to clarify the radiolarian abundance patterns observed in the traps (Fig. 8).

Since one buoy is on the shelf and the other is located approximately 500 km offshore (Fig. 3), the average temperature difference between them allows a rough comparison of the horizontal gradient across the core of the California Current (Figs. 8a and 8b). The offshore temperatures typify the mid-latitude annual cycle of summer heating and winter cooling. The temperature over the shelf is similar to that in the offshore region during the winter. In summer,

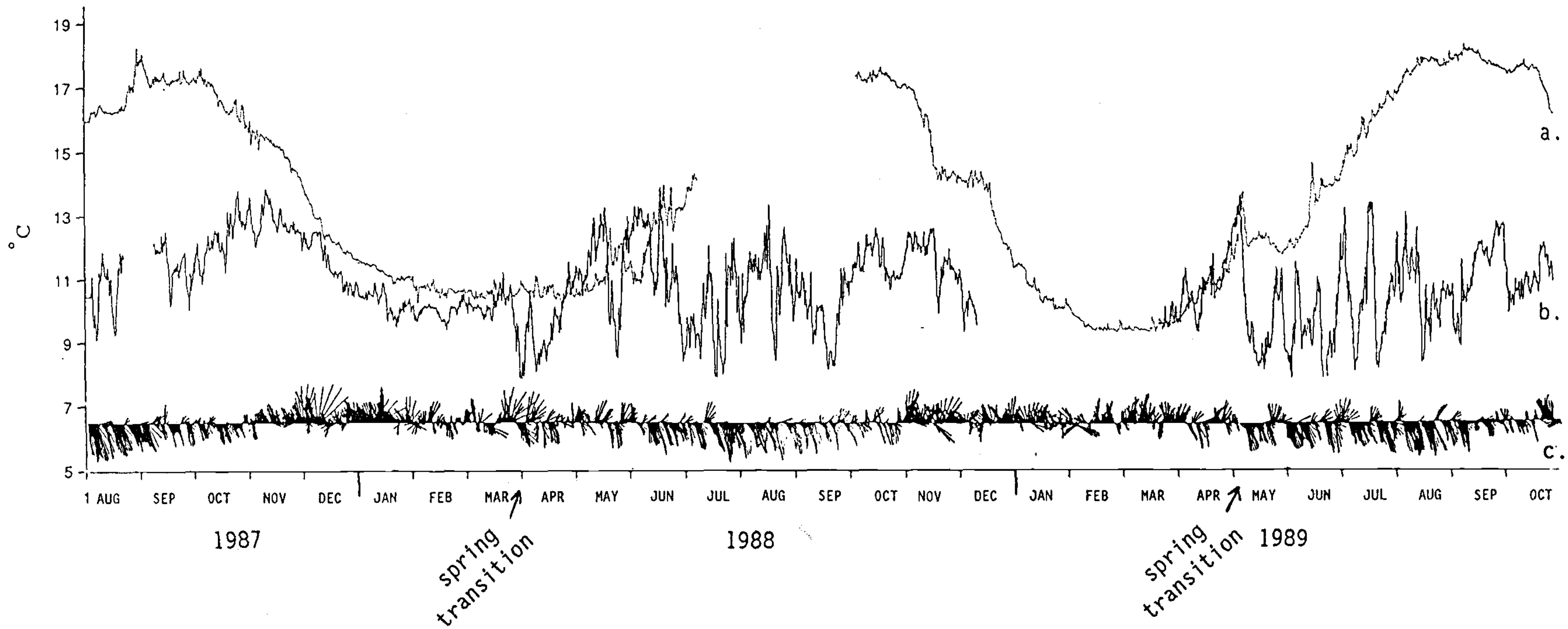


Figure 8. Temperature and wind vector time series from the Multitracers region. a) NDBC buoy located approximately 500 km offshore, b) NDBC buoy located over continental shelf, c) wind vectors from North Bend airport, Oregon coast.

temperatures over the shelf are punctuated by rapid fluctuations associated with mixing and/or upwelling events at the coast and maintain an average value near that during the winter.

The spring transition from winter to summer physical regimes at the coast can be seen both in the onset of the first major cold temperature spike and in the change in magnitude and direction of the wind vectors at the North Bend airport. Figures 8b and 8c show this to occur in late March of 1988 and early May of 1989.

The buoy records for 1988/89 are consistent with the general circulation patterns shown in Figure 2 which depict a seasonal change in this region from a high onshore/offshore thermal gradient in the summer, when temperatures at the coast are cold and offshore temperatures are warm, to a low gradient in the winter, when both onshore and offshore temperatures are cold. While the coldest temperatures at the coast occur in spring and summer in association with maximum upwelling, the strongest gradient occurs in late summer/early fall when the offshore temperatures are highest. This coincides with the time of maximum strength of southward-flow in the California Current (Hickey, 1979).

The general seasonality of this region, apparent in the wind and temperature patterns described above, are reflected in the abundance patterns of the three species shown in Figures 9a-9c. Each of these species is an important component respectively of the California Current factor, the Winter factor, and the Transition factor, the three most important factors. The apparent seasonal fluctuation patterns for these species are consistent for both sample years and generally agree with the oceanographic interpretations made for the factors.

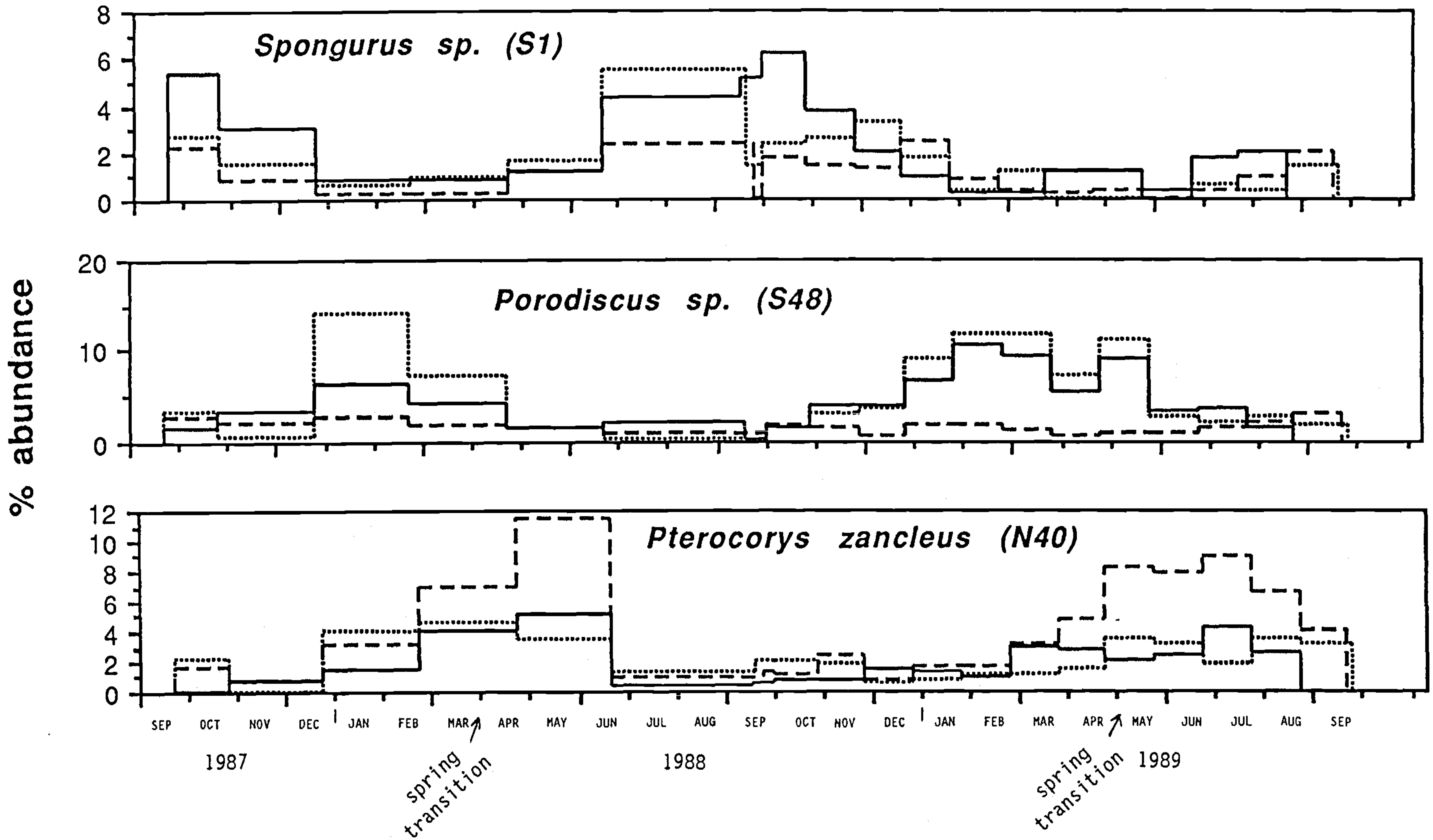


Figure 9. Temporal fluctuations from the sediment traps of three species exhibiting seasonal variability. a) *Spongurus* sp. (S1), from California Current factor, b) *Porodiscus* sp. (S48), from Winter factor, and c) *P. zancleus* (N40), from Transition factor. Nearshore = solid, Midway = dotted, Gyre = dashed.

Spongurus sp. (S1), an important species in the California Current factor (Fig. 9a), reaches maximum abundance at Nearshore in the late summer/early fall and decreases with the onset of wintertime conditions. The highest relative abundance of this species thus occurs when the onshore/offshore thermal gradient is highest and the wind field in the North Pacific induces coastal upwelling and increased southern transport. The sediment distribution of this species further supports its association with Subarctic water and the eastern boundary current (Fig. 10).

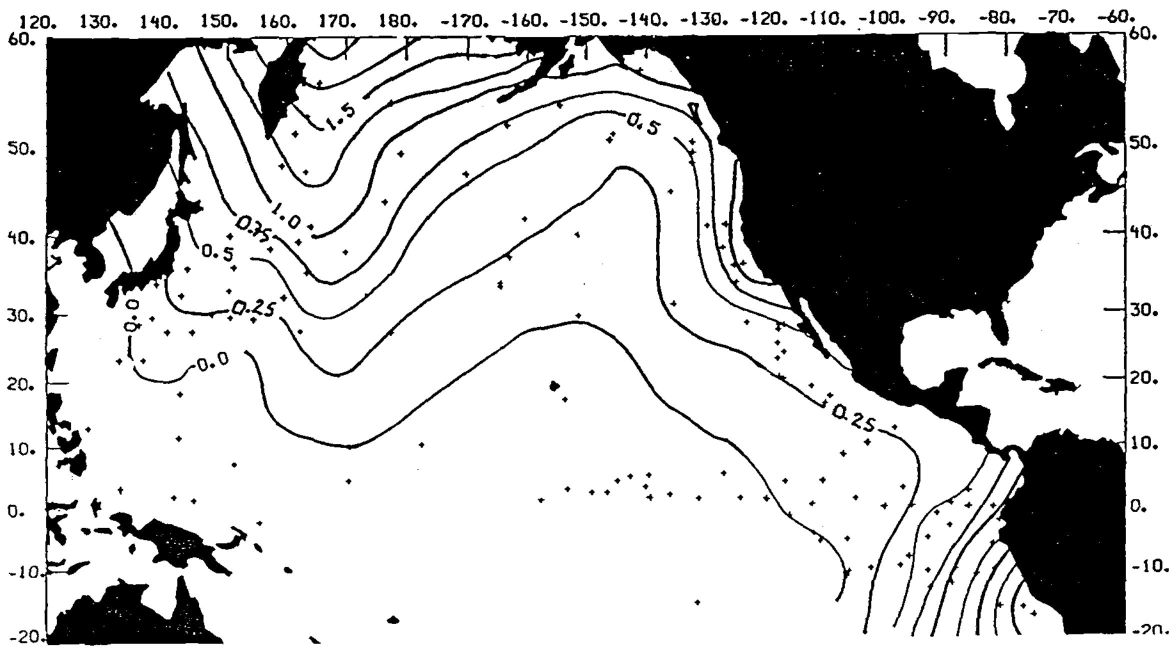


Figure 10. Surface sediment distribution of *Sponguras* sp. (S1), a species important in the California Current factor. Contours are in relative abundance. (data from Pisias, 1990)

As *Spongurus* sp. (S1) declines, *Porodiscus* sp. (S48), an important species in the Winter factor begins to increase in relative abundance (Fig. 9b). This species reaches its highest trap abundance at Midway, when surface temperatures are similarly cold in both coastal and oceanic regions (Figs. 2a, 8a, and 8b). The sediment distribution of *Porodiscus* sp. suggests its source also to be very cold, northern water (Fig. 11). While *Spongurus* sp. and *Porodiscus* sp. have very similar sediment distribution patterns, their temporal patterns in the sediment traps make it clear they represent very different oceanographic environments (Figs. 9a and 9b).

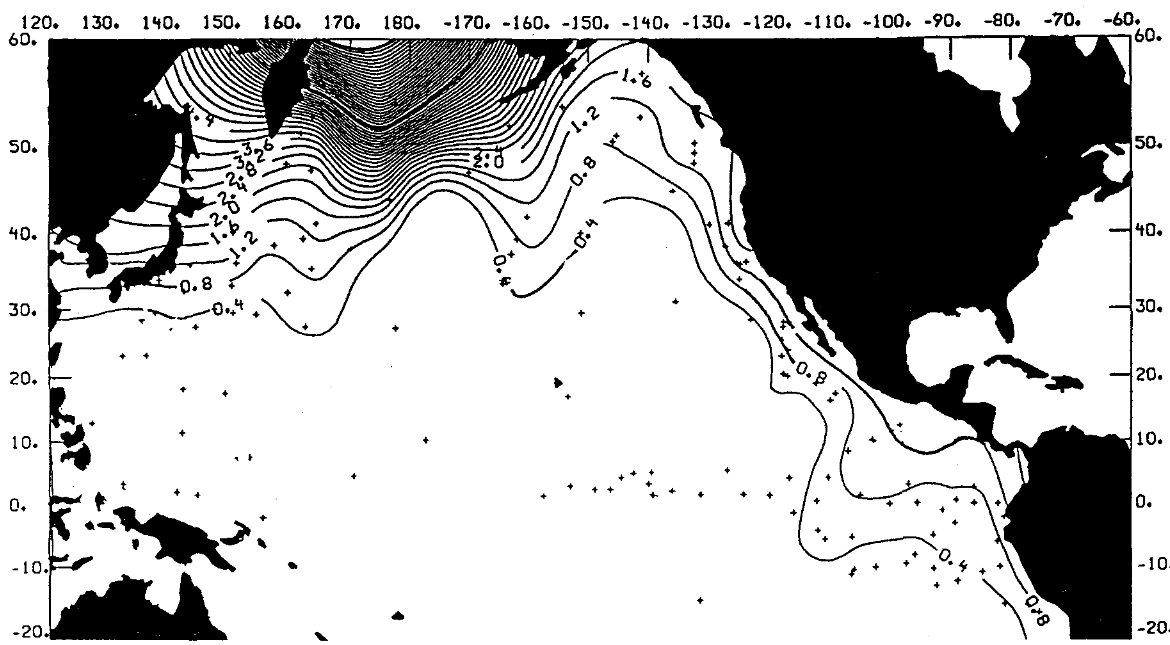


Figure 11. Surface sediment distribution of *Porodiscus* sp. (S48), a species important in the Winter factor. Contours are in relative abundance. (data from Pisias, 1990)

P. zancleus (N40), an important species in the Transition factor, shows its strongest influence at Gyre (Fig. 9c). It increases and reaches its highest relative abundances in spring or early summer as offshore temperatures increase (Fig. 8a). The high abundances of *P. zancleus* beneath the transition zone in the North Pacific (Fig. 5b) indicates the increase in abundance of this species in the spring may represent large-scale advection of water from the transition zone eastward as the West Wind Drift intensifies.

In addition to seasonal trends, significant differences between years are apparent in individual species fluctuations. For example, one group of species previously mentioned as important in the Central Gyre factor, *T. octacantha & O. stenozoa* (S54) reflect the pattern exhibited by this factor (Fig. 12a). They show high abundances at the Gyre site during the 1987/88 fall and winter, but are much less prominent the following year. Apparently, the warm surface water environment that these organisms prefer had a strong offshore influence during 1987/88 but was less pronounced during 1988/89.

Conversely, *S. osculosa* (S43), the main species of the Subarctic Gyre factor, was not particularly abundant in the 1987/88 sample year, but increased dramatically during the winter of 1988/89 (Fig. 12b). Since this species shows high abundances in surface sediments beneath cold, Subarctic waters in the North Pacific (Fig. 7), our trap data suggest a pronounced influence of these waters in the offshore region of the Multitracers study area during our second sample year. Comparison of the offshore temperatures between the two years supports this interpretation; the 1987/88 winter was about 1.5°C warmer than the winter of 1988/89 (Fig. 5a).

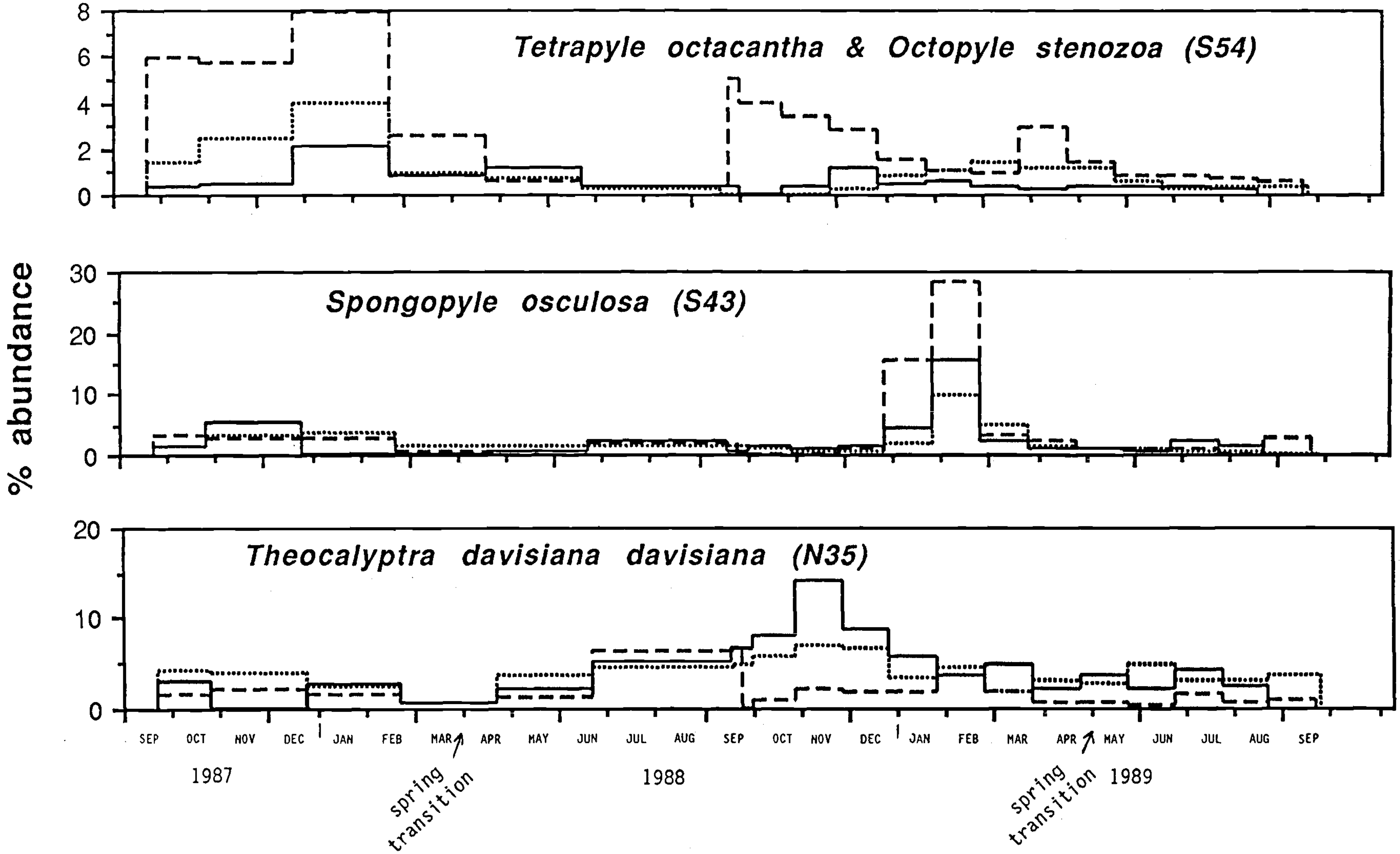


Figure 12. Temporal fluctuations from the sediment traps showing nonseasonal variability in both onshore and offshore regions. Nearshore = solid, Midway = dotted, Gyre = dashed.

Evidence exists for stronger influence of cold, northern water in this area during 1988/89 in the nearshore environment as well. *T. davisiana davisiana* (N35), an important species in the California Current factor is much more abundant during the late fall/early winter of 1988 than in 1987 (Fig 12c). This species, which has previously been linked to very cold, deep water (Morley and Hays, 1983), exhibits very high abundances in sediments beneath the Sea of Okhotsk as well as in sediments beneath both Pacific eastern boundary currents (Fig. 13).

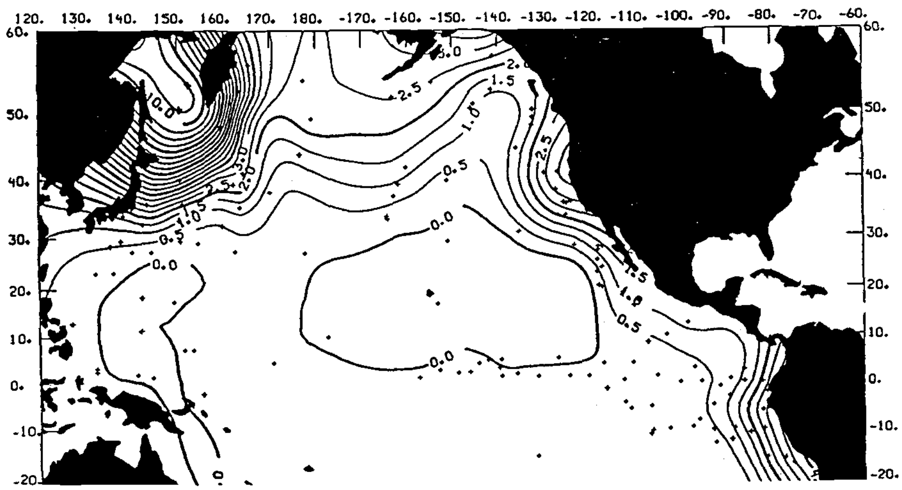


Figure 13. Surface sediment distributions of *T. davisiana davisiana* (N35), a species important in the California Current factor. Contours are in relative abundance. (data from Pisias, 1990)

Temporal fluctuations of individual species in the sediment traps show both seasonal and nonseasonal variability. This is in accordance with the understanding that circulation in the California Current System exhibits strong temporal variability, both seasonally and interannually. In a transitional region such as the eastern North Pacific, where many different water masses are mixed, radiolaria provide a unique tracer of these water masses and the currents that carry them.

III. Carbon Flux and Radiolarian Data

An important goal of this project is to identify processes important in the transfer of carbon from the surface to the deep ocean. In general, organic carbon flux decreases by about a factor of 4 from Nearshore to Gyre (Lyle et al., 1989 and 1990). Figures 14a-c display temporal variations ranging from a factor of 3 at Nearshore to more than a factor of 15 at Gyre. While Midway and Gyre demonstrate roughly similar seasonal patterns for both years, fluctuations at Nearshore show distinctive differences from year one to year two. In 1987/88 the highest flux at Nearshore began in the winter and extended into the spring. High fluxes were also observed at Midway during the 1987/88 winter, though to a lesser extent. Organic carbon fluxes for the 1988/89 year have more than one maxima at all three sites; high fluxes occur in the fall/early winter, spring and again in late summer.

From a comparison of radiolarian compositional changes to organic carbon flux we can examine the relationship between these microfauna and export production using multiple linear regression. Two independent analyses were run, one using the fluctuations of 35 individual species and one using the loadings of the 6 factors as independent variables. Organic carbon variations were used as the dependent variable in both cases. Species which exhibit a maximum value of 2.0% or more at some time during the first two years of trap data were included in the first analysis. Using an equal-tails test with 54 degrees of freedom and a 5.0% significance level, a correlation coefficient > 0.3 indicates a significant correlation between an individual species or factor and organic carbon. Based on this test, 7 species and 2 factors exhibit a significant correlation to organic carbon (Tables 4 and 5).

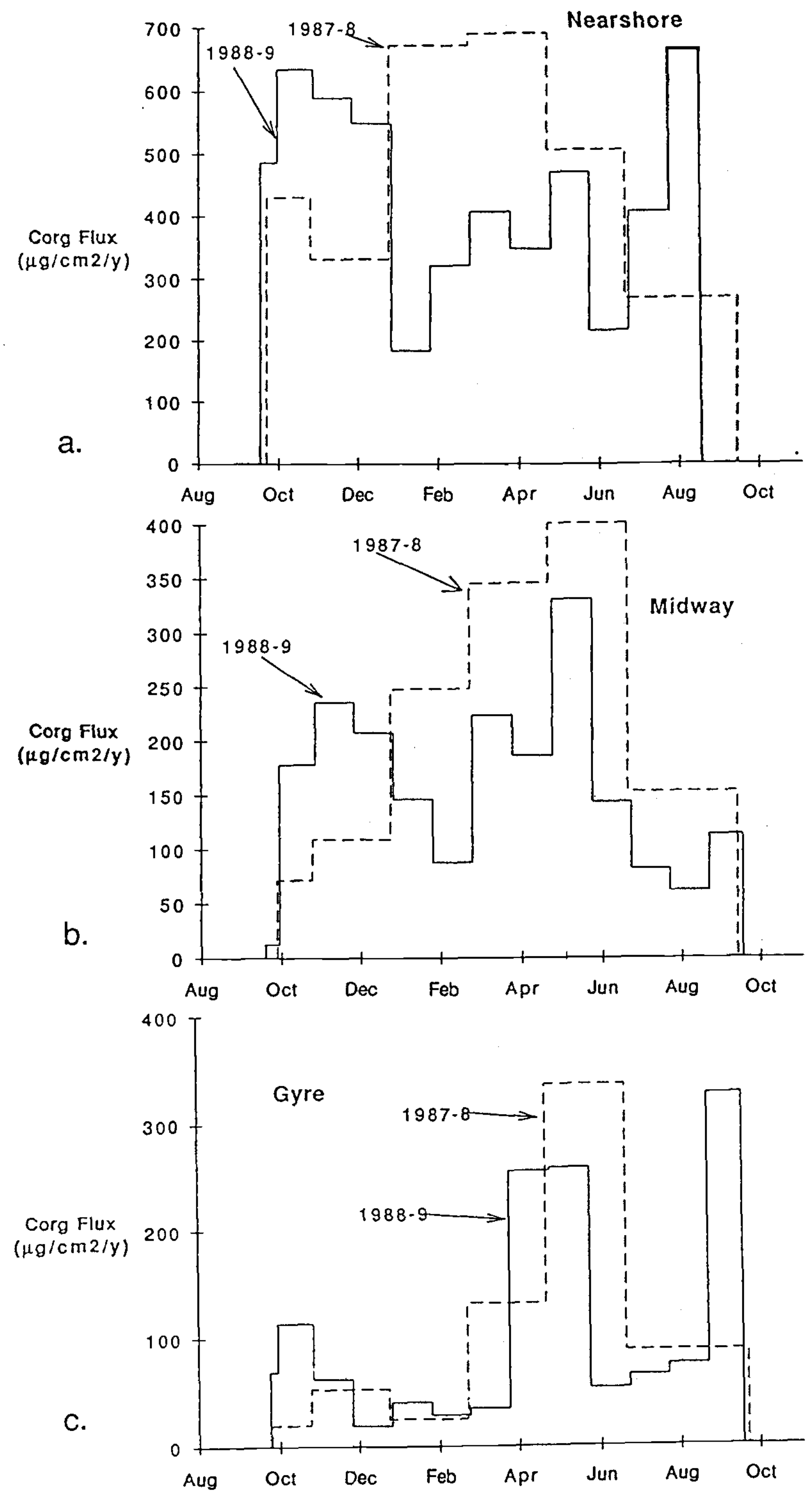


Figure 14. Organic carbon flux from the first two years of sediment trap samples. (from Lyle et al., 1990)

S1 = **0.32**	S43 = -0.21	N10 = -0.11	**N35 = 0.31**	GN4 = 0.25
S8 = -0.18	S44 = 0.12	N11 = -0.11	N38 = 0.01	GN5 = 0.18
S13 = -0.28	S47 = 0.14	N14 = 0.16	N40 = -0.03	GN9 = -0.10
S17 = -0.05	S48 = 0.19	N15 = 0.15	N44 = -0.10	GN18 = -0.06
S24 = -0.03	**S54 = -0.35**	N18 = -0.08	N45 = 0.03	GN21 = 0.10
S29 = -0.19	N4 = -0.28	**N24 = -0.35**	**GN2 = 0.61**	GN22 = -0.10
S30 = -0.24	N5 = -0.06	**N33 = 0.37**	**GN3 = 0.33**	GN27 = -0.23

Table 4. Correlation matrix of 35 species to organic carbon. See Table 1 for species abbreviation guide. Values in bold are significant (54 degrees of freedom; $\alpha = 0.05$).

California Current factor	= 0.16
Transition factor	= -0.13
Winter factor	= **0.33**
Subarctic Gyre factor	= 0.29
Central Gyre factor	= **-0.31**
Gulf of California factor	= -0.04

Table 5. Correlation matrix of 6 factors to organic carbon flux. Values in bold are significant (54 degress of freedom; $\alpha = 0.05$).

Of the 7 species in Table 4 which have a significant relationship to organic carbon, five have a positive and two have a negative correlation. *D. clevii* (GN2) has a correlation coefficient of 0.61, the strongest positive correlation with organic carbon. This species, important in the Gulf of California factor, strongly prefers the nearshore environment and was most abundant during the late fall/early winter of 1988. Other species with positive correlations are *T. davisiana davisiana* (N35, r=0.31), *Spongurus* sp. (S1, r=0.32), *L. hystrix* (GN3, r=0.33), and *Botryostrobus aquilonaris* (N33, r=0.37). Three of these, *T. davisiana davisiana, B. aquilonaris*, and *Spongurus* sp. are important species in the California Current factor and *L. hystrix* is important in the Winter factor (Table 3). *Pterocanium sp.* (N24) and *T. octacantha & O. stenozoa* (S54) show significant negative correlations to organic carbon; both have an r=-0.35. *T. octacantha & O. stenozoa* have been previously mentioned as indicative of warm, subtropical surface water. The following regression equation based on species has r=0.75.

$$Corg = 51(GN2) + 34(GN3) + 57(N33) - 76(N24) + 77(GN27) + 26 \quad \text{(eq. 1)}$$

with a standard error of estimate = +/- 130.

From the correlation of individual species to organic carbon (Table 4), one might expect that the California Current, Gulf of California, and Winter factors all to have a positive relationship to organic carbon and the Central Gyre factor to have a negative correlation. However, Table 6 shows the only significant relationships between any of the factors and organic carbon are with the Winter factor (r=0.33) and the Central Gyre factor (r=-0.31). Using factors, these two years of data suggest the wintertime to be the most important time of year for export of carbon to the sediments. The regression equation based on factors, with r=0.42, is not as strong as that with species.

$$Corg = 164W.F. - 128C.C. - 474S.G. - 432C.G. - 205T.F. + 518 \quad (eq. 2)$$

standard error of estimate = +/- 170.

W.F. = Winter factor; C.C. = California Current factor;
S.G. = Subarctic Gyre factor; C.G. = Central Gyre factor;
T.F. = Transition factor.

Clearly there exist statistical relationships between radiolarian abundances and flux of organic carbon for these two samples years. This appears to be stronger and more indicative of true physical relationships using individual species than using trap assemblages. Equation 1 represents the additive effects of several individual species, each of which are important at different times of the year. This implies more than one time of year, thus, more than one process is related to export flux. Equation 2 suggests that only one time of year, wintertime, is indicative of high flux. Referring back to Figure 14, it is clear this is not the case. Therefore, the relationship between factors and organic carbon flux does not appear to be causal. The relatively high standard error of estimate for both of these equations indicates temporal variations, especially at Midway and Gyre would be difficult to discriminate, while the overall difference between onshore and offshore environments may be more readily discernable. While equation 1 may represent a more causal relationship than equation 2, the effects of dissolution (see section on differential preservation) greatly reduce the predictive value of this relationship in the sediments.

IV. Trap Factor Sediment Patterns

Sediment studies combined with flux studies offer the opportunity to evaluate which processes currently operating in the system are important over long time periods. Surface sediment samples represent a long-term average of both preservational and input processes in this region. If a trap assemblage is well represented in the sediments this suggests a) processes associated with it in the water column are important as input, meaning they represent enhanced export production, b) these organisms are perhaps more robust than others and thus selectively preserved, or c) the water mass or current which represents the environment preferred by these organisms has a strong influence in this region over time. All of these effects are woven together in the sediment sample. The relationship between radiolaria and export production (a) was discussed in the previous section and differential preservation (b) will be examined in the following section. Here we address (c), how well the radiolarian trap assemblages, identified by the factor analysis of two years of sediment trap data, are reflected in the longer time intervals represented by the surface sediments. The time averaging depends on rates of sedimentation and bioturbation and ranges from hundreds of years at Nearshore to thousands at Gyre.

Sediment distribution maps of the trap factors (Figs. 15-17) are constructed by applying the factor scores (Table 3) to surface sediment samples in which the same species set has been identified. Appendix B lists cores used and radiolarian data. Note that this is not equivalent to doing a factor analysis of surface sediment samples, but is a technique for evaluating how the trap factors are reflected in the

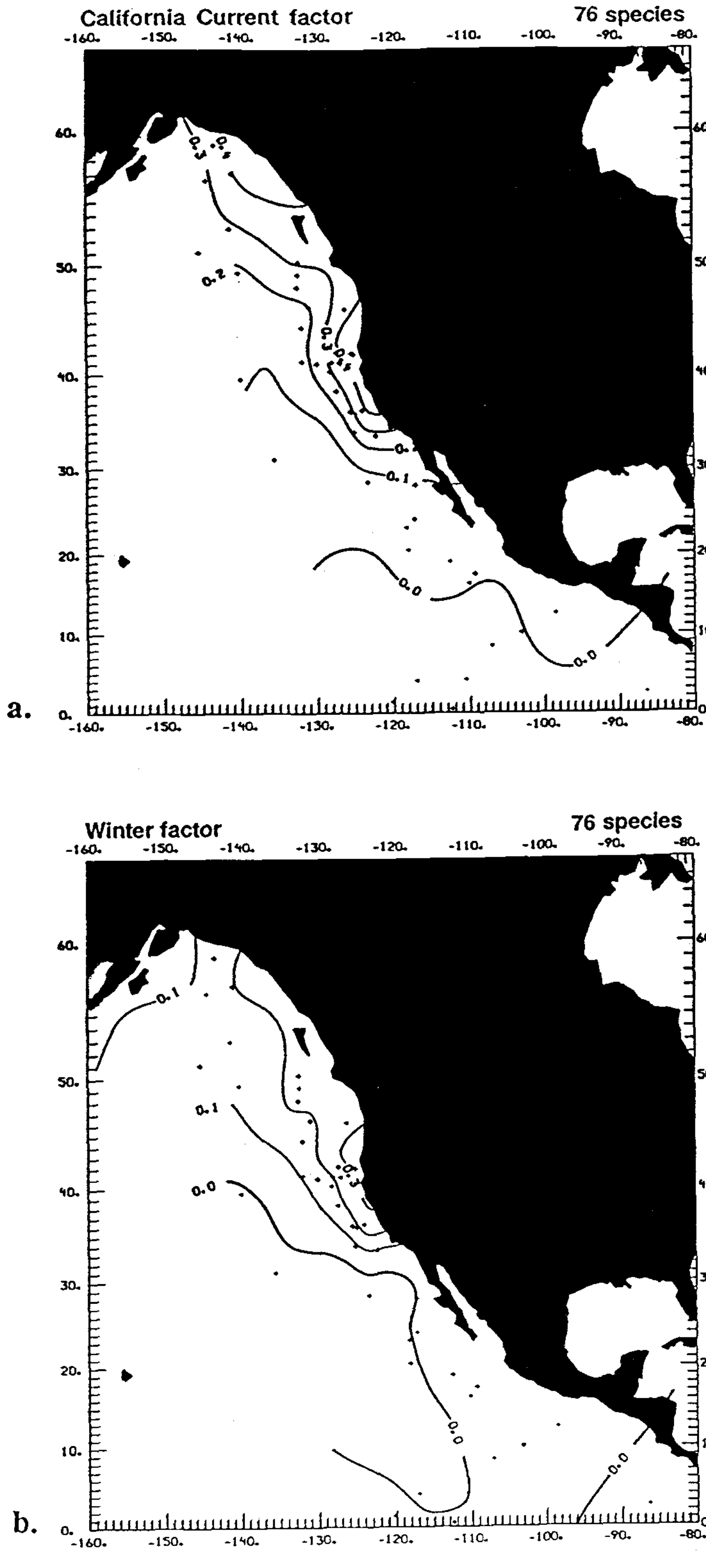


Figure 15. Representation of sediment trap factors in the surface sediments beneath the California Current System. a) California Current factor, b) Winter factor.

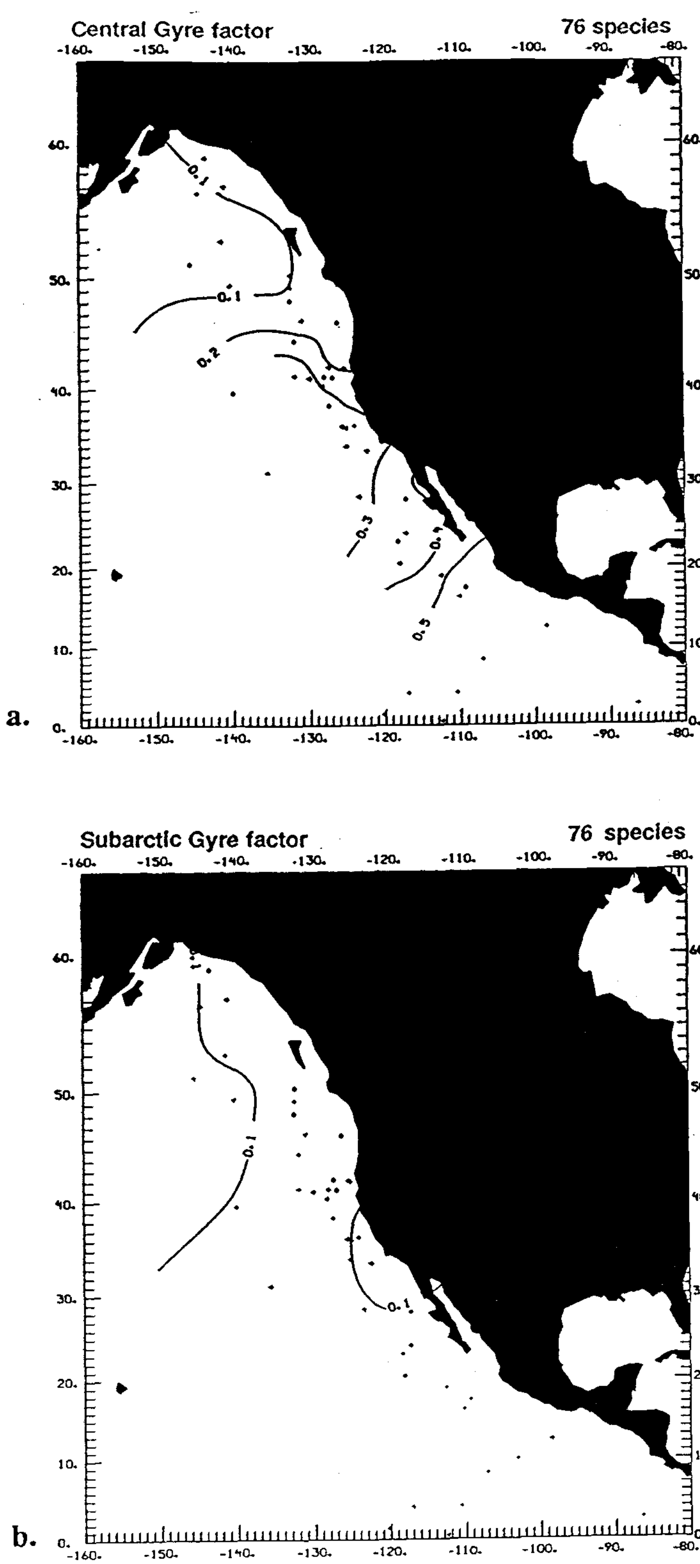
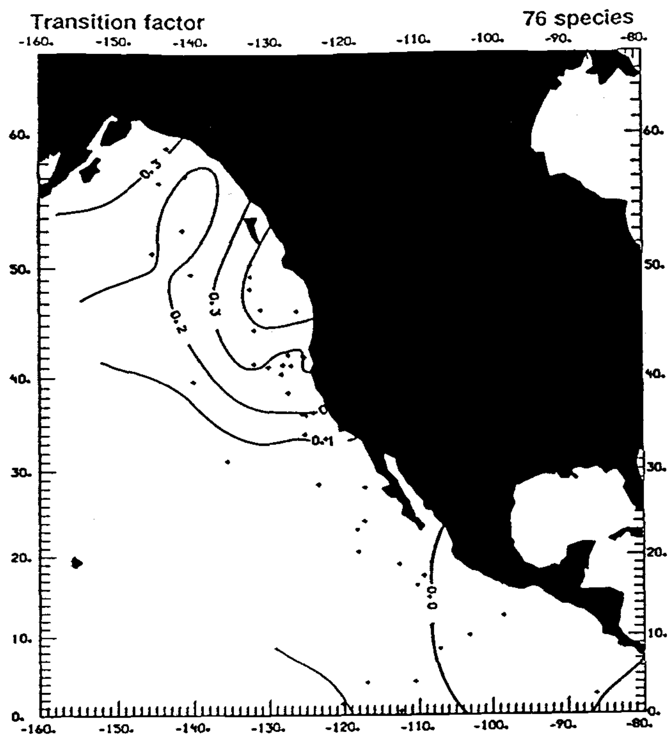
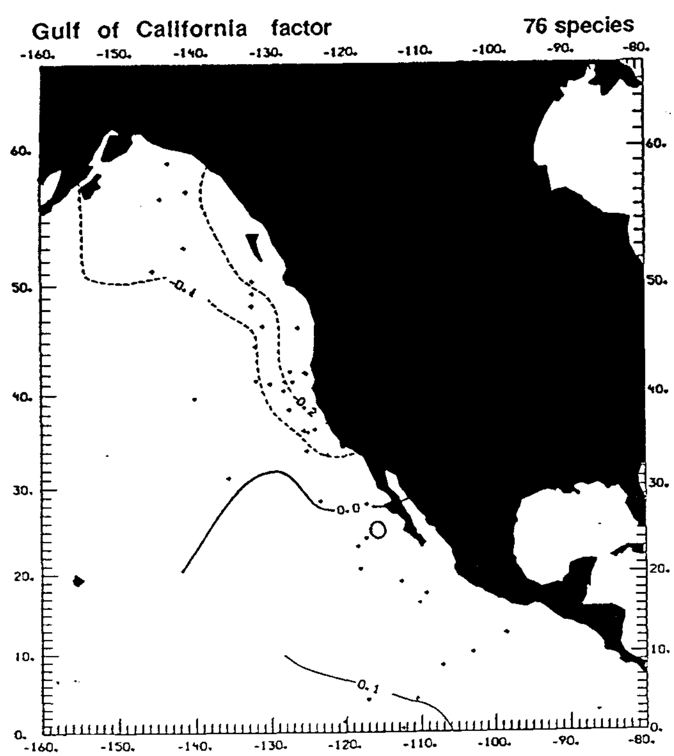


Figure 16. Representation of sediment trap factors in the surface sediments beneath the California Current System. a) Central Gyre factor, b) Subarctic Gyre factor.



a.



b.

Figure 17. Representation of sediment trap factors in the surface sediments beneath the California Current System. a) Transition factor, b) Gulf of California factor.

sediments. The values are, however, exactly analogous to factor loadings. The sediment distribution patterns generally support our interpretations about aspects of the physical oceanographic regime that appear to be reflected by the trap factors.

The California Current factor (Fig. 15a) shows a distinct sediment pattern of increased importance both onshore and to the north of the Multitracers study area in the Gulf of Alaska. This distribution pattern supports the association of this factor with the southward-flowing Subarctic water of the eastern boundary current. Since up to 20% of the information in the sediments can be explained by this factor, the California Current appears, not surprisingly, to have a major influence on both the physical and biological character of this region when averaged over long time periods.

The pattern exhibited by the Winter factor (Fig. 15b) is similar to the that of California Current factor in demonstrating an onshore trend. This is not surprising since both of these factors were important primarily at the Nearshore and Midway sites. The Winter factor does not, however, appear to be particularly important in sediments in the Gulf of Alaska, thus it does not indicate a Subarctic source. The maximum amount of information in the sediments that is explained by this factor is approximately 10%. While oceanographic conditions that occur during the wintertime represent an important component of the sediment input in this region, their long term influence does not appear to be as great as conditions that occur during the summer.

The Central Gyre factor (Fig. 16a) displays an expected sediment distribution increasing offshore and to the south, where production is low. It is better represented along the Multitracers transect than the Subarctic Gyre factor (Fig. 16b), however, suggesting the offshore influence of Subtropical water has been more important along the Multitracers transect over time than the colder offshore water that was present during the 1988/89 winter.

The Transition factor appears also to be well represented in the sediments (Fig. 17a). It exhibits its highest sediment abuundances at around 50°N, which supports the interpretation that this trap assemblage is linked to the North Pacific transition zone water. Interestingly, even though the trap samples indicate this factor is more related to offshore waters, the sediment pattern shows an overall onshore trend. This suggests either a) the transitional water has had a stronger influence in the coastal environment in the past, b) organisms associated with this factor have a preference for the nearshore environment most years so that these two years were both anomalous in this regard, or c) the preservation of this factor is somehow enhanced. In order for the transition zone waters to exert a much stronger influence in the nearshore environment (a) the circulation in this region would have to have been drastically different in the recent past. There is no other evidence that this was the case. Option (b) also does not seem very reasonable since it really implies a very recent ecological shift in this group of species, which is highly improbable. Therefore we suggest enhanced preservation (c) to be the most plausible mechanism for the onshore trend of the Transition factor in the sediments.

Sediment distribution of the Gulf of California factor is dominated by negative contours and seems to demonstrate an inverse relationship with the California Current factor (Fig. 17b). This is because some of the species that have negative scores for this factor have positive scores on the California Current factor (Table 3). The sediment patterns are dominated by the negative values because these species are better preserved in the sediments than those contributing a positive effect. This does not mean that the species contributing positively to this factor exhibit an inverse sediment distribution to the California Current factor.

As was mentioned previously, many of the species that contribute to the Gulf of California factor have not been well documented because they rarely found in sediments. Since dissolution seems to have a major effect in the sediment representation of this factor, we cannot extract information about its geographic distribution or its long-term influence in this region from the sediments. Whatever physical or environmental signal this factor indicates is apparently not well preserved.

V. Differential Preservation

The reflection of trap assemblages in the sediments not only helps illuminate which processes are most important in this region over long time periods but also how accurately sediments record the oceanographic variability observed in this region. When interpreting the paleoceanography of this area from the preserved sediment record some information is invariably lost. While the trap factors exhibit reasonable distribution patterns and most are relatively well represented in the surface sediments, they can not account for all of the variability in the sediments. Figure 18 is a map of the communality of these factors in the surface sediments showing how well the factor analysis describes the sediment samples in this region. This map demonstrates that the composition of the radiolarian sediment assemblages is different than our trap assemblages, even within sediment samples taken at each trap location, since the maximum amount of information in the sediments that the factors can account for is about 55%.

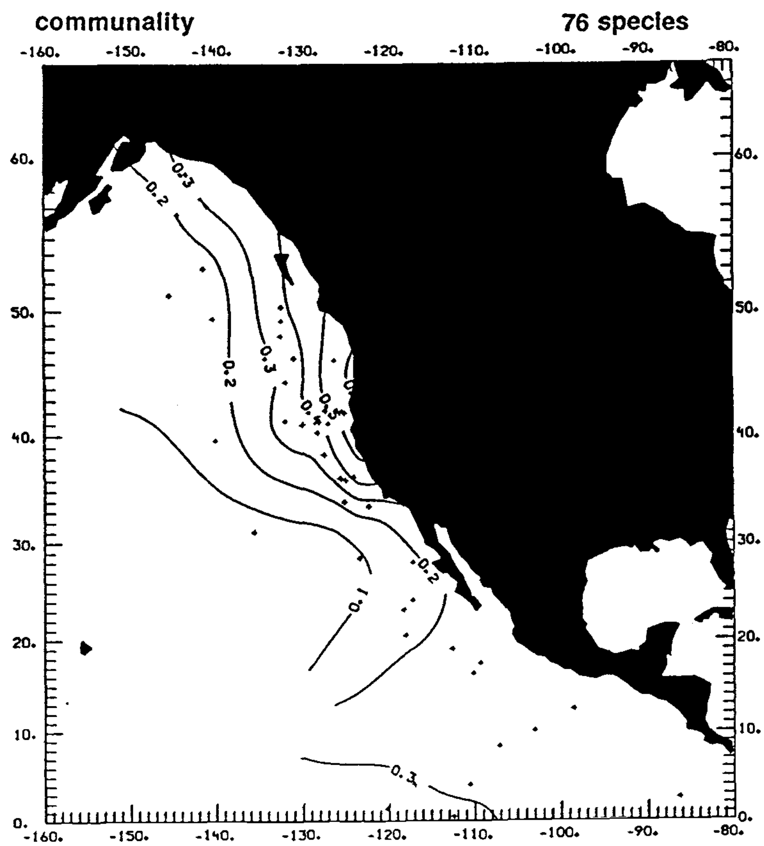


Figure 18. Communality map showing how well the six factor model describes the surface sediments beneath the California Current System. Sediment cores beneath the mooring sites are connected by lines. In the vicinity of the Multitracers transect the factor analysis can account for up to 55% of the information in the sediments.

While this difference may be due, in part, to the fact that the trap assemblages represent only two years of data collected in a region of high interannual variability, silica dissolution is another important phenomenon which must be considered. Since not all radiolarian species are equally susceptible to dissolution, this process can lead to the preferential preservation in the sediments of some species over others (e.g. Robertson, 1975).

In our data set we have identified a group of species that have greatly reduced relative abundances in the sediment samples compared to the trap samples. These include all of the so called GN species plus *Dictyophimus* sp. (N44) (Table 1). It should be noted that this is a functional rather than a taxonomic group. GN simply stands for Gulf Nassellarian; this group of species was found to be important in Gulf of California sediments, a high preservation environment (Pisias, 1986). Interestingly, most of the species in this group seem to be particularly important in the nearshore environment and several exhibit relatively high correlations to export production (Table 4).

To investigate the role dissolution may play on how well our factor model describes the sediments in this region we performed another factor analysis without these species. Table 6 gives the factor loadings and Table 7 gives the factor scores from this analysis. We applied the factor loadings from the reduced species model to the sediments in the California Current region in the same manner as before.

	sampling interval	trap depth	communality	Transition Factor	California Current Factor	Winter Factor	Subarctic Gyre Factor	Central Gyre Factor
Nearshore	9/22/87-10/25/87	1000	0.635	0.234	0.641	0.155	0.360	0.123
	10/25/87-12/24/87	1000	0.876	0.399	0.212	0.368	0.711	0.177
	12/24/87-2/22/88	1000	0.923	0.369	0.281	0.703	0.091	0.452
	2/22/88-4/22/88	1000	0.928	0.562	0.136	0.562	0.014	0.527
	4/22/88-6/21/88	1000	0.867	0.738	0.470	0.178	0.044	0.260
	6/21/88-9/16/88	1000	0.916	0.184	0.859	0.215	0.280	0.138
	9/16/88-9/30/88	1500	0.900	0.144	0.923	0.029	0.097	0.130
	9/30/88-10/27/88	1500	0.872	0.053	0.916	0.139	0.079	0.061
	10/27/88-11/26/88	1500	0.871	0.028	0.890	0.277	-0.001	0.021
	11/26/88-12/26/88	1500	0.839	0.059	0.789	0.430	0.084	0.147
	12/26/88-1/25/89	1500	0.926	0.217	0.548	0.665	0.357	0.089
	1/25/89-2/24/89	1500	0.841	0.009	0.247	0.573	0.670	0.057
	2/24/89-3/26/89	1500	0.943	0.325	0.462	0.760	0.181	0.117
	3/26/89-4/25/89	1500	0.890	0.539	0.446	0.557	0.177	0.241
	4/25/89-5/25/89	1500	0.911	0.451	0.410	0.715	0.161	0.048
	5/25/89-6/24/89	1500	0.865	0.749	0.308	0.317	0.292	0.154
	6/24/89-7/24/89	1500	0.949	0.614	0.591	0.396	0.216	0.137
	7/24/89-8/23/89	1500	0.897	0.672	0.521	0.204	0.302	0.203
Midway	9/22/87-10/25/87	1000	0.890	0.534	0.596	0.334	0.271	0.253
	10/25/87-12/24/87	1000	0.835	0.393	0.489	0.146	0.518	0.391
	12/24/87-2/22/88	1000	0.958	0.229	0.121	0.814	0.124	0.461
	2/22/88-4/22/88	1000	0.941	0.525	0.156	0.705	0.130	0.357
	4/22/88-6/21/88	1000	0.876	0.583	0.649	0.246	0.135	0.189
	6/21/88-9/16/88	1000	0.904	0.258	0.876	0.056	0.171	0.194
	9/16/88-9/30/88	1500	0.760	0.265	0.812	0.033	0.083	0.152
	9/30/88-10/27/88	1500	0.931	0.349	0.862	0.225	0.062	0.109
	10/27/88-11/26/88	1500	0.881	0.216	0.848	0.333	0.033	0.066
	11/26/88-12/26/88	1500	0.930	0.116	0.847	0.430	0.060	0.103
	12/26/88-1/25/89	1500	0.946	0.163	0.477	0.808	0.187	0.060
	1/25/89-2/24/89	1500	0.911	-0.007	0.324	0.743	0.498	0.076
	2/24/89-3/26/89	1500	0.921	0.189	0.287	0.811	0.357	0.131
	3/26/89-4/25/89	1500	0.931	0.427	0.366	0.734	0.231	0.148
	4/25/89-5/25/89	1500	0.944	0.500	0.269	0.755	0.153	0.166
	5/25/89-6/24/89	1500	0.891	0.687	0.441	0.366	0.223	0.204
	6/24/89-7/24/89	1500	0.791	0.636	0.465	0.345	0.188	0.130
	7/24/89-8/23/89	1500	0.888	0.723	0.406	0.324	0.218	0.217
	8/23/89-9/15/89	1500	0.878	0.673	0.534	0.250	0.161	0.228
Gyre	9/22/87-10/25/87	1000	0.859	0.340	0.395	0.154	0.324	0.677
	10/25/87-12/24/87	1000	0.907	0.243	0.359	0.183	0.318	0.764
	12/24/87-2/22/88	1000	0.919	0.354	0.037	0.184	0.171	0.854
	2/22/88-4/22/88	1000	0.868	0.518	0.042	0.285	-0.062	0.716
	4/22/88-6/21/88	1000	0.833	0.697	0.230	0.201	-0.101	0.494
	6/21/88-9/16/88	1000	0.884	0.309	0.801	0.232	0.122	0.281
	9/16/88-9/30/88	1500	0.748	0.168	0.195	0.542	0.074	0.619
	9/30/88-10/27/88	1500	0.394	0.277	0.306	0.259	0.149	0.366
	10/27/88-11/26/88	1500	0.772	0.448	0.475	0.215	0.099	0.538
	11/26/88-12/26/88	1500	0.779	0.372	0.479	0.209	0.340	0.501
	12/26/88-1/25/89	1500	0.836	0.107	0.202	0.183	0.844	0.195
	1/25/89-2/24/89	1500	0.741	-0.027	0.162	0.148	0.821	0.132
	2/24/89-3/26/89	1500	0.808	0.648	0.138	0.233	0.392	0.401
	3/26/89-4/25/89	1500	0.862	0.730	0.148	0.165	0.339	0.407
	4/25/89-5/25/89	1500	0.884	0.831	0.071	0.176	0.106	0.383
	5/25/89-6/24/89	1500	0.953	0.902	0.134	0.167	0.141	0.272
	6/24/89-7/24/89	1500	0.925	0.869	0.224	0.221	0.093	0.251
	7/24/89-8/23/89	1500	0.928	0.830	0.214	0.296	0.047	0.320
	8/23/89-9/15/89	1500	0.871	0.649	0.331	0.369	0.316	0.323
			INFORMATION	22.397	25.195	17.234	8.572	13.690
			CUM. INF	22.397	47.592	64.825	73.397	87.087

Table 6. Varimax Factor Loadings for five factor reduced species model.

	species	Transition Factor	California Current Factor	Winter Factor	Subarctic Gyre Factor	Central Gyre Factor
S1	*Spongurus* sp.	-0.408	3.056	-0.862	0.873	0.299
S8	*P. antarctica*	0.653	0.629	-0.270	0.280	0.478
S17	*H. enthacanthum*	1.639	0.542	0.676	0.302	-0.639
S24	*L. minor*	1.331	1.838	-0.387	0.502	-0.026
S29	*L. butschlii*	4.374	-0.804	0.658	2.702	1.079
S43	*S. osculosa*	-1.019	0.027	0.411	6.186	0.379
S48	*Porodiscus* sp.	-0.602	0.129	6.962	-0.103	-0.627
S54	*T.octacantha/O.stenozoa*	-1.144	0.087	-0.173	0.655	4.277
N4	*Carpocanium* spp.	0.791	-0.022	-0.389	-0.042	0.557
N5	L. nigriniae	0.947	2.378	0.165	0.223	1.712
N10	*E. acuminatum*	1.197	0.086	0.210	0.115	-0.313
N11	*E. hexagonatum*	-0.432	-0.738	1.028	-1.613	5.219
N14	*T. scaphipes*	0.016	0.193	-0.032	0.482	-0.080
N33	*B. aquilonaris*	0.621	1.464	0.324	-0.384	-0.602
N35	*T. davisiana davisiana*	-0.809	5.250	0.555	-0.623	-0.048
N38	*T. bicornis*	1.822	1.313	-0.395	-0.367	0.256
N40	*P. zancleus*	4.242	-0.240	0.381	-1.572	0.469

Table 7. Scaled Varimax Factor Scores for five factor reduced species model. Only values > |1| are included.

The map of communality for this analysis (Fig. 19) demonstrates we have increased our ability to describe the sediments in this region considerably. This is especially noticeable for cores in the immediate vicinity of the Multitracers moorings where the factor model from the reduced species list can account for up to 85% of the sediment variability.

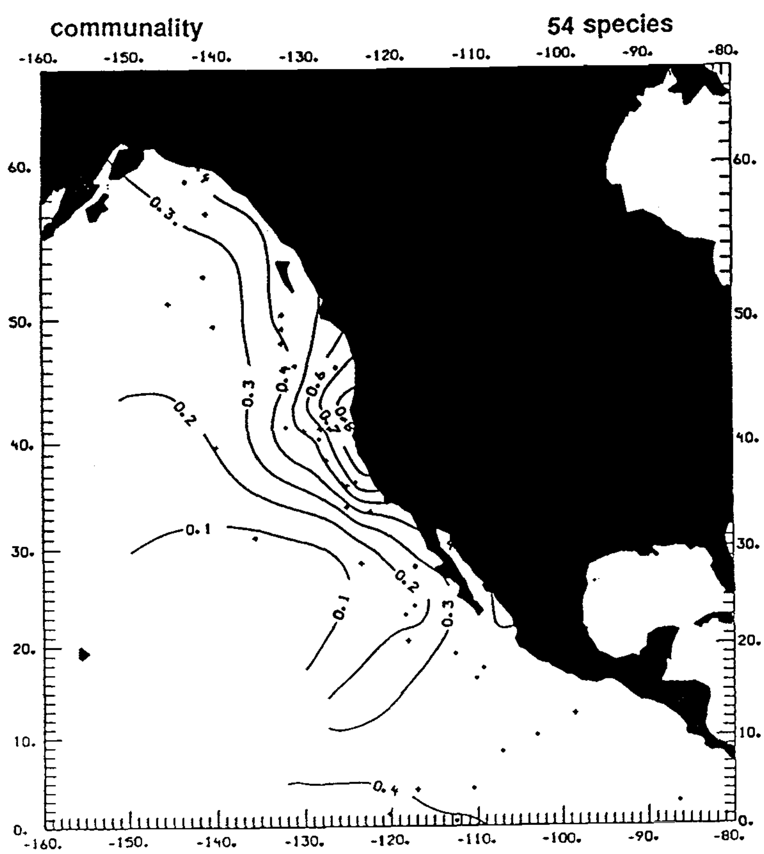


Figure 19. Communality map showing how well the five factor model describes the surface sediments beneath the California Current System. Sediment cores beneath the mooring sites are connected by lines. In the vicinity of the Multitracers transect the factor analysis can account for up to 85% of the information in the sediments.

Factor distribution maps for the analysis using fifty-four species show very similar patterns to those using seventy-six species (Figs. 20-22). In most cases, the relative weighting of the factors in the sediments is stronger with the GN species removed than when they are included in the analysis (Figs. 20 and 21). Two exceptions to this are notable. First, the Gulf of California factor completely disappears, resulting in a five-factor rather than a six-factor model. Second, the importance of the Winter factor in the sediments is substantially reduced (compare Figs. 15b and 22). Both of these factors originally contained significant information about the variability of the GN species, at least some of which is obviously preserved in the sediment record. Though this group of species may contain useful environmental information about this system, they do not represent a very large proportion of the total trap variability. The Gulf of California factor accounts for only 3% of the information, and while the Winter factor accounts for 18%, the signature of this factor remains even with the removal of important species. Thus, removing the GN species does not seem to have altered the fundamental trends and patterns of radiolarian variability that we observe from the factor analysis.

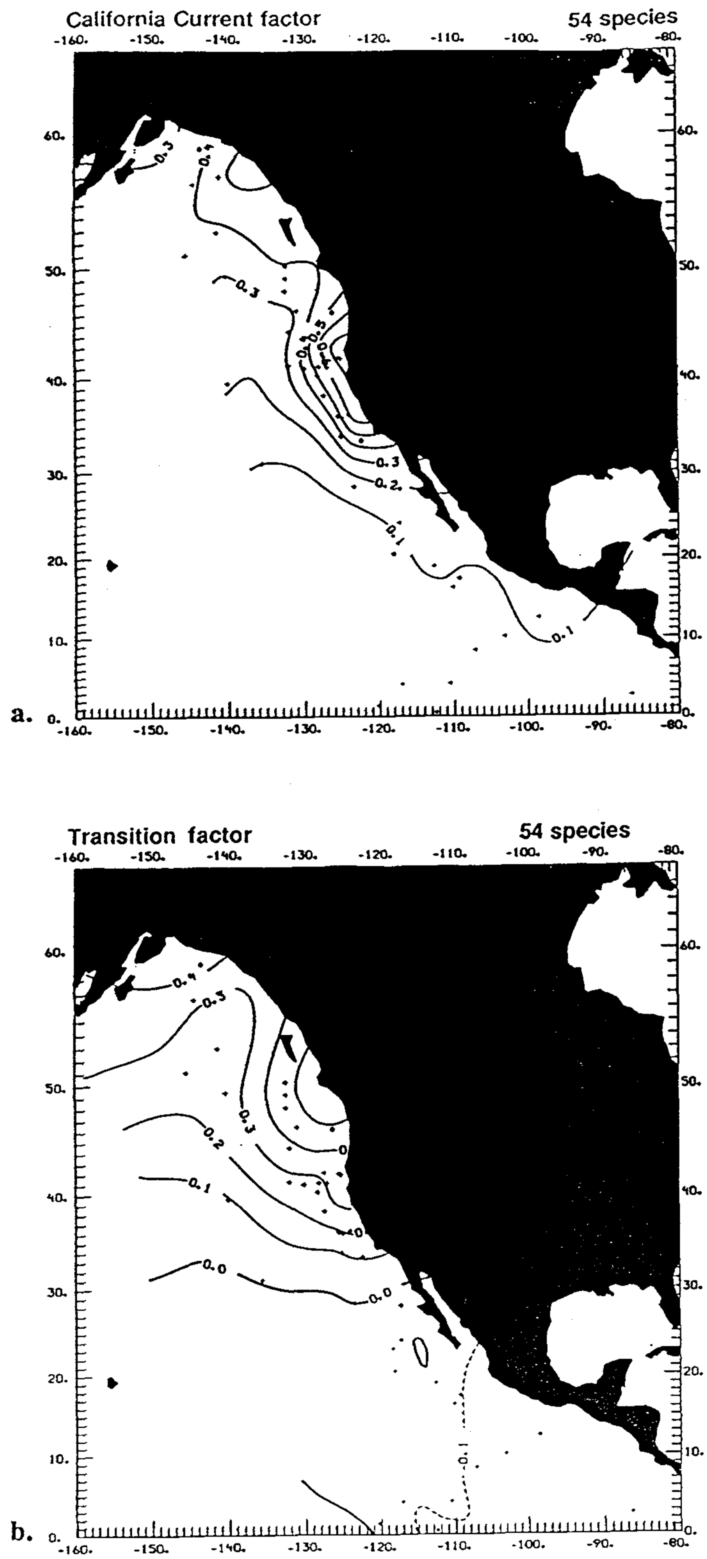
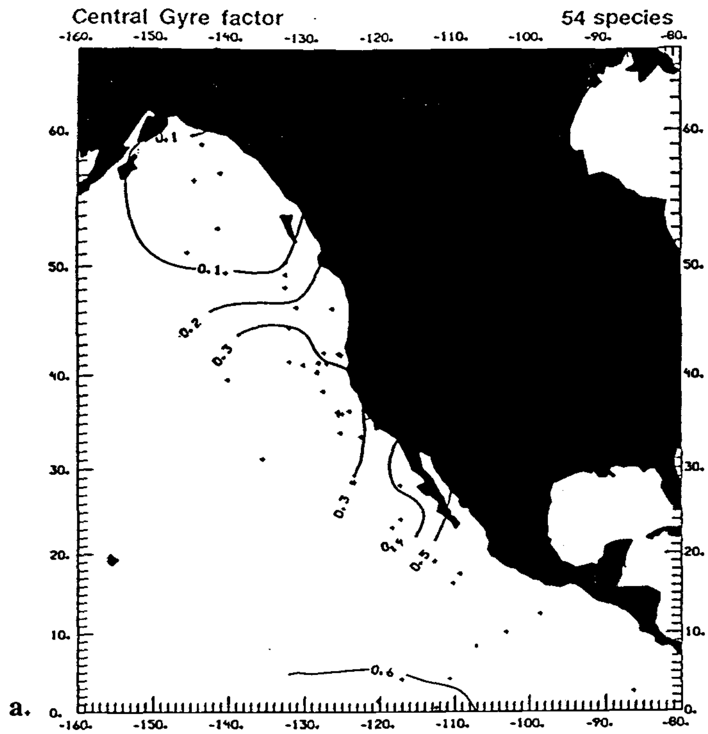


Figure 20. Representation of sediment trap factors from reduced species model in the surface sediments beneath the California Current System. a) California Current factor, b) Transition factor.



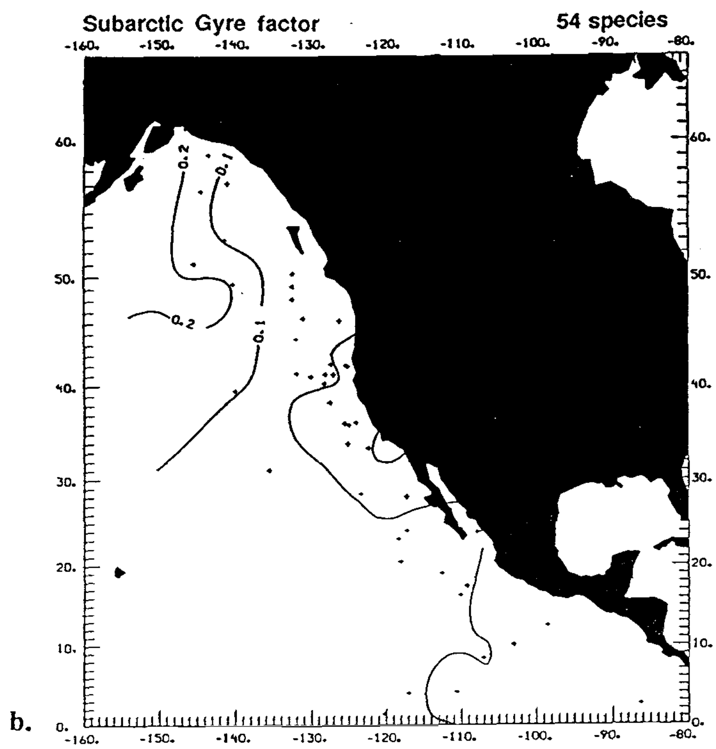


Figure 21. Representation of sediment trap factors from reduced species model in the surface sediments beneath the California Current System. a) Central Gyre factor, b) Subarctic Gyre factor.

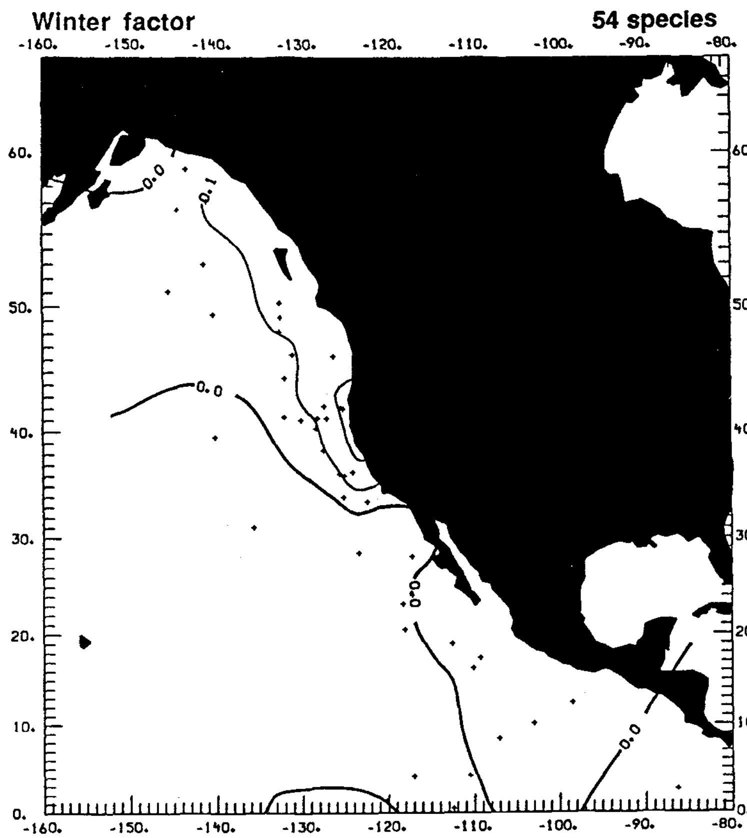


Figure 22. Representation of Winter factor from the reduced species model in the surface sediments beneath the California Current System.

DISCUSSION

Our results suggest a strong relationship exists between changes in radiolarian abundance patterns and fluctuations in the physical oceanography in the eastern North Pacific. The most important process controlling radiolarian variability in this region appears to be related to fluctuations in the intensity of equatorward-flow in the California Current. Very different assemblages dominate this region in the summer and fall, when southward flow is strong, as compared to wintertime, when southward flow is weak, or nonexistent. Based on sediment distributions alone, this seasonality would undoubtedly not be discriminated. Sediment distributions of *Spongurus* sp. (S1), a species showing high abundances in summer (Fig. 10), and *Porodiscus* sp. (S48), a species important in the winter (Fig. 11) are very similar; both are associated with cold water and the eastern boundary of the North Pacific. Only by examining the differences in their temporal fluctuations from the trap samples can one discern that they represent very different oceanographic and, therefore, environmental conditions.

Differences between years are also apparent. One rather subtle difference can be seen in the timing of when the Winter factor begins to wane and the California Current factor becomes strong. This change occurs later in the spring of 1989 than in 1988 (Figs. 4a and 4b). This is probably related to the timing of the physical spring transition, which occurred in May 1989 but in March 1988 (Figs. 8a-8b). This difference is also reflected in the pattern of increase of the Transition factor as well as *P. zancleus* (N40), a representative species for that factor (Figs. 4d and 9c). The increased influence of transition zone water, which seems to lead the actual spring transition, doesn't appear to occur until late February or March in 1989. This increase apparently begins sometime between December and February in 1988.

A particularly noteworthy difference between years is the clear indication of a stronger influence of cold Subarctic water during the 1988/89 sample year than during the previous year. This interpretation is based on radiolarian evidence from both onshore and offshore environments and is supported by sea surface temperature data from the offshore meteorological buoy in the Multitracers study region.

Such differences between years may be due to variability in the strength of the geostrophic current, in the magnitude and direction of basin-wide winds, or even variations in the latitude of divergence of the West Wind Drift. Since both oceanic and atmospheric forcing mechanisms contribute to interannual fluctuations in the northeast Pacific (e.g. Huyer and Smith, 1985; Pares-Sierra and O'Brien, 1989; Johnson and O'Brien, 1990), such changes in the physical regime are not entirely independent phenomena. Johnson and O'Brien (1990) determined that remotely-forced coastal Kelvin waves are the dominant signal in coastal variability for the mid-latitudes, but that local wind forcing modifies the offshore propagating signal.

The proportional influence of specific water masses can be difficult to measure physically in the California Current System because source water characteristics are always diluted and several water masses in this region have similar characteristics (e.g. Hickey, 1979; Lynn and Simpson, 1987; Huyer et al., 1990; Kosro et al., 1990). Several species of radiolaria, however, appear to reflect even subtle changes in the proportions of various water masses influencing the eastern North Pacific. Further refinement of these relationships can provide valuable tracers of water masses and circulation processes for both modern and ancient environments.

The usefulness of radiolaria as tracers of changes in paleo- export production is not so straightforward. The results from the regression analyses show that while statistical relationships between radiolaria and organic carbon exist, no strong predictive relationship emerges from these two years of trap data. While equation 1 (based on individual species with $r=0.75$) seems to be significant, three of the five species in the equation, *D. clevii* (GN2), *L. hystrix* (GN3), and *Dictyoceras acanthicum* (GN27) are not well preserved in the sediments. This obviously precludes the use of this equation for paleo-prediction.

Differential preservation complicates our ability to unravel the various input processes from the sediment record. Since some species of radiolaria are more susceptible to dissolution than others, the effects of dissolution obviously bias the sediment record. The improved ability to describe the sediments with the reduced species model demonstrates that the proportions of these species are significantly less in the sediment than in the trap samples. The question is how much information is lost? In this case, several species which are apparently important in the nearshore region and are possibly related to high productivity environments are poorly represented in the sediment record. It may be that less robust species are able to respond quicker than other forms and that their tests are consequently more weakly silicified and more susceptible to dissolution. If this is true, this may be an important environmental signal to lose. Still, since the amount of information contributed to the total data set by the GN species is not large, it appears that much of the important information about the overlying water column in this region is preserved in the sediments.

Other species that are not so easily dissolved also have a significant relationship to organic carbon flux. Looking only at the species correlation matrix (Table 4), the three which have a positive correlation, *T. davisiana davisiana*, *B. aquilonaris*, and *Spongurus* sp., are important in the California Current factor and one form which is negatively correlated, *T. octacantha & O. stenozoa*, is a major species in the Central Gyre factor. These relationships were not evident from the regression equations but deserve further investigation.

The rather complicated patterns for carbon flux suggests more than one process is important in controlling export production in this region (Fig. 13). Based on these two years of data, one cannot invoke one or two prominent processes, for example upwelling, the spring transition, or southward advection of cold nutrient rich water to account for times of maximum flux. Clearly investigations which consider only one or two processes as being of primary importance to carbon cycling in this region will overlook a significant component of the signal. This brings up an interesting and important question. How representative of the long-term average are the carbon fluxes for these two years? While high material fluxes during the winter may be more frequent than has been previously thought, it is possible, and even likely, that the importance of wintertime fluxes is over represented in this data set. We are optimistic that the additional two years of sediment trap data from this study will yield a statistical relationship between radiolaria and organic carbon flux which better reflects all the processes controlling carbon flux and thus will have more predictive value.

Comparison of sediment trap assemblages to sediment samples has allowed us to better evaluate what information is present and absent from the sediment record. Both factor models presented here have more difficulty explaining the radiolarian variability in the more offshore sediments than at sites closer to shore. This pattern is understandable and even predictable if one takes into account the much higher sedimentation rates in the nearshore environment. Consequently, the offshore samples represent a much longer time average than those closer to shore and are probably more dissolved, making it more difficult to explain offshore sediments on the basis of two years of sediment trap data. Also, even though the three Multitracers mooring sites span a high degree of oceanographic variability, the gradients across which the traps sample reflect the variability of a regional system and do not encompass complete end-members for this mixing regime.

Onshore gradients in the sediments are evident in several of the factors. This is reasonable for factors that exhibit nearshore affinities in the traps, such as the California Current and Winter factors. However, the onshore sediment pattern for the Transition factor, which shows an offshore affinity in the trap samples, suggests these patterns may in part reflect enhanced preservation in the nearshore environment. Enhanced preservation in nearshore sediments has been observed in this region for silica preservation and also for carbon burial (Lyle et al., 1989 and 1990). Apparently the nature of the coastal system inhibits degradation of organic matter and dissolution of silica as compared to the more offshore environment.

The Transition factor appears to be related to large-scale advection of water eastward via the West Wind Drift as southward-flow in the California Current intensifies in the spring. This change in regional circulation patterns coincides with the physical transition from winter to summer oceanographic regimes which is initiated at the coast by a major upwelling event (Huyer et al., 1979). The spring transition is often associated with a large-scale phytoplankton bloom which can be centered in the offshore region some years (Thomas and Strub, 1990). Enhanced burial may perhaps occur at these times due to pulsed inputs associated with mixing and upwelling events. Evidence from the CTZ program has suggested that mixing and downward advection of biomass out of the euphotic zone occurs along the coastal jet (Kadko et al., 1990; Washburn et al., 1990). Frontal regions, such as those which occur within the California Current System may thus provide an active mechanism for transporting material (and organisms associated with the current) out of the euphotic zone and into the sediments where they are rapidly buried.

CONCLUSIONS

Radiolaria appear to provide a particularly valuable tool for indicating changes in the physical oceanographic regime both in the present and in the past. Their relatively long life span coupled with a high diversity and ubiquitous distribution throughout the world oceans presents them as excellent tracers of the differential influence of water masses and the currents which deliver them. This function is especially useful in the highly variable eastern North Pacific where the physiochemical characteristics of source waters, such as temperature and salinity, are rapidly diluted.

The strongest amount of variability exhibited by the radiolaria from these two years of sediment trap deployment is associated with southward flow in the California Current. In addition to the strong seasonality in this current system we detect clear differences between years. Radiolarian evidence from both onshore and offshore environments suggest the influence of Subarctic water was stronger during the winter of 1988/89 than it was during the previous winter. Two species representing the influence of cold, northern water *S. osculosa* (S43) and *T. davisiana davisiana* (N35), exhibited higher relative abundances during the fall and winter of 1988/89 than during the previous sample year. Temperature records from an NDBC buoy located approximately 500 km offshore substantiate that the offshore environment was approximately 1.5°C colder in the winter of 1988/89 than in 1987/88.

While a statistical relationship exist for these two years between radiolaria and organic carbon flux, the high variability of carbon flux in this region combined with the effects of dissolution, greatly reduces the predictive value of these relationships. Two species associated with strong southward flow in the California Current, *T. davisiana davisiana* (N35) and *Spongurus* sp. (S1) also exhibit significant positive correlations to flux of organic carbon. These relationships can be seen in the correlation matrix, even though they were not brought out by the regression equation. Hopefully the remaining two years of data collection from this region will shed more light on this subject.

The temporal records from the sediment traps clearly help in interpreting the sediment record. Two species which have similar sediment distribution patterns, *Spongurus* sp. (S1) and *Porodiscus* sp. (S48), are present in this region at completely different times of the year and thus represent very unique oceanographic and environmental conditions. The differences between these two species could never have been discerned from their sediment distributions alone.

This study has given us insight about what information is selectively removed through dissolution in the transfer of environmental signals to the sediments. We identified a group of 22 species that are clearly under-represented in the sediment as compared to the trap samples. These species have not been well documented, presumably because of poor preservation. They seem to be important primarily in the nearshore environment and several exhibit a significant relationship to organic carbon flux. However, their overall contribution to total radiolarian variability in this data set in not large. By removing this group from the analysis we increased our ability to describe the sediments in this region considerably, especially in the immediate vicinity of the Multitracers moorings where the new factor model could account for up to 85% of the sediment variability. Thus, while these species may contain some significant environmental information, their removal did not seem to alter the fundamental trends and patterns of radiolarian variability that we observed from the factor analysis.

Further insight is gained about information which seems to be selectively preserved in the coastal environment, possibly due to active input processes at certain times of the year. On the whole, while radiolarian sediment compositions do contain preservational effects, the sediments in this region seem to provide much of the information about the overlying oceanographic environment. The relationships that have emerged from this analysis between species and groups of radiolaria and physical processes will clearly be valuable tools for unraveling the sediment record and understanding the physical and biological history of the California Current.

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APPENDICES

APPENDIX A

Relative abundances of radiolaria in Multitracers sediment traps.

Species Key

Tot	unk	S1	S1A	S3	S4	S5	S7	S8	S9	S10
S12	S13	S14	S17	S18	S19	S23	S24	S29	S30	S32
S34	S36	S36a	S36c	S40	S41	S42	S43	S44	S47	S48
S50	S51	S52	S53	S54	N1	N1c	N2	N3	N4	N5
N7	N8	N9	N10	N11	N14	N15	N18	N19	N23	N24
N25	N26	N28	N29	N32	N33	N34	N35	N35a	N36	N38
N39	N40	N42	N43	N44	N45	GN1	GN2	GN3	GN4	GN5
GN8	GN9	GN14	GN15	GN16	GN18	GN19	GN21	GN22	GN27	GN28
GN29										

See Table 1 for species abbreviation guide. Note S5, S12, S32, S36a, S40, S50, N2, N9, N19, N39, and N43 are not in Table 1. They were not included in the analyses because their abundance for these two years is always zero.

Data - Year 1 (9/87-9/88) 1000m traps

species percents

Nearshore	cup 1	261	36.30	5.36	0.00	0.00	0.38	0.00	0.38	1.14	0.00	0.77
		0.00	0.00	0.00	1.53	0.00	0.00	0.00	2.68	2.68	0.00	0.00
		1.14	0.00	0.00	0.00	0.00	0.00	0.38	1.53	0.38	0.38	1.53
		0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.77
		0.00	0.00	0.00	0.77	0.38	3.44	0.00	0.38	0.00	0.38	0.00
		0.38	0.00	0.00	0.00	0.38	0.77	1.14	3.06	0.38	1.91	0.38
		0.00	0.00	0.00	0.00	0.00	0.77	1.14	4.59	1.53	1.14	5.74
		0.00	0.77	0.00	0.00	0.00	8.42	0.38	1.91	0.77	0.00	0.00
		1.14										
	cup 2	424	35.30	3.06	0.00	0.00	0.24	0.00	0.71	0.47	0.00	0.71
		0.00	0.00	0.00	0.71	0.00	0.00	0.00	2.12	5.89	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.24	5.18	0.24	0.24	3.30
		0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	1.17
		0.00	0.24	0.00	0.00	0.24	0.94	0.00	1.88	0.00	0.24	0.00
		0.00	0.00	0.00	0.24	1.65	0.00	0.71	0.00	0.24	0.47	1.41
		0.00	0.71	0.00	0.00	8.25	0.24	1.17	4.48	2.12	1.88	1.88
		0.24	0.00	0.00	0.00	0.00	6.60	0.71	2.59	0.24	0.00	0.47
		0.00										
	cup 3	469	37.30	0.85	0.00	0.85	0.00	0.00	0.85	0.64	0.00	0.21
		0.00	0.00	0.00	0.85	0.21	0.21	0.00	1.27	4.90	0.21	0.00
		0.21	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.21	1.06	6.18
		0.00	0.00	0.00	0.00	2.13	0.00	0.43	0.00	0.00	0.00	1.70
		0.00	0.00	0.00	0.43	3.62	0.21	0.00	1.70	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.21	0.64	0.43	2.55	0.00	0.43	1.27
		0.00	1.49	0.00	0.00	3.62	0.00	0.64	2.98	4.26	2.55	2.13
		0.00	0.21	0.21	0.00	0.43	6.39	0.00	0.64	1.70	0.64	0.00
		0.00										
	cup 4	473	34.20	0.85	0.00	1.05	0.21	0.00	0.63	0.85	0.00	0.42
		0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.63	4.43	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.63	4.22
		0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.63	2.53
		0.21	0.21	0.00	1.26	4.86	0.21	0.21	1.47	0.00	0.00	0.00
		0.21	0.00	0.42	0.00	0.21	0.63	0.21	0.63	0.42	0.42	0.85
		0.00	4.01	0.00	0.00	3.80	0.00	1.05	3.17	4.43	5.07	1.90
		0.00	0.21	0.00	0.00	0.85	3.80	0.42	2.32	1.47	0.63	0.63
		0.42										
	cup 5	427	32.30	1.17	0.23	0.00	1.17	0.00	0.47	0.70	0.00	0.47
		0.00	0.00	0.00	0.70	0.00	0.23	0.00	3.27	3.51	0.00	0.00
		0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.23	0.23	0.70	1.40
		0.00	0.00	0.00	0.00	1.17	0.00	0.23	0.00	0.00	0.94	3.04
		0.00	0.00	0.00	0.47	0.47	0.00	0.47	0.23	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	1.40	0.47	2.10	0.23	0.47	4.68
		0.00	5.15	0.00	0.00	6.32	0.47	0.47	2.57	2.10	2.57	0.47
		0.23	0.23	0.00	0.23	1.17	10.30	0.23	2.34	0.94	0.23	0.23
		0.00										
	cup 6	253	30.00	4.34	0.00	0.00	0.00	0.00	0.40	1.18	0.00	1.18
		0.00	0.00	0.00	1.18	0.00	0.40	0.00	2.76	1.18	0.00	0.00
		0.00	0.40	0.00	0.00	0.00	0.00	0.00	2.37	0.00	0.40	1.97
		0.00	0.79	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	4.34
		0.00	0.40	0.00	1.58	0.00	0.00	0.40	0.40	0.00	0.00	0.00
		0.00	0.00	0.00	1.18	0.40	1.58	0.00	5.13	0.40	0.00	1.18
		0.00	0.40	0.00	0.00	4.34	1.18	0.00	4.34	0.40	1.58	9.48
		0.00	1.18	0.00	0.00	0.40	6.32	0.00	3.55	0.79	0.00	0.00
		0.00										
Midway	cup 1	221	38.40	2.71	0.00	0.00	0.00	0.00	1.35	0.90	0.00	0.00
		0.00	0.00	0.00	2.26	0.00	0.00	0.00	4.97	5.42	0.00	0.00
		1.35	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	0.00	3.16
		0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	3.16
		0.00	0.00	0.00	1.35	0.90	0.00	0.00	0.00	0.00	0.00	0.45
		0.00	0.00	0.00	0.00	0.00	1.80	0.90	4.07	0.00	0.00	1.35
		0.00	2.26	0.00	0.00	7.23	0.90	0.00	2.71	0.90	0.90	0.00
		0.00	2.26	0.00	0.00	0.45	5.42	0.45	2.71	1.35	0.00	0.90
		0.00										

species percents

Midway	cup 2	202	28.70	1.48	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
		0.00	0.00	0.00	0.99	0.00	0.00	0.00	1.48	6.43	0.00	0.00
		1.48	0.00	0.00	0.00	0.00	0.00	0.50	2.97	0.00	0.50	0.50
		0.00	0.00	0.00	0.00	2.47	0.00	0.99	0.00	0.00	0.00	3.46
		0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.50	0.00	0.00	0.99
		0.00	0.00	0.00	0.00	0.50	0.00	0.00	3.96	0.00	0.00	1.48
		0.00	0.00	0.00	0.00	5.94	0.99	0.50	3.46	3.96	2.47	3.96
		0.50	0.50	0.00	0.00	0.99	13.30	0.50	1.98	0.99	0.00	0.50
		0.00										
	cup 3	375	23.40	0.53	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.27
		0.00	0.00	0.00	2.66	0.80	0.53	0.00	0.53	5.60	0.53	0.00
		1.06	0.00	0.00	0.00	0.00	0.00	0.00	3.46	0.00	0.27	14.10
		0.00	0.00	0.00	0.00	4.00	0.00	0.53	0.00	0.00	0.00	2.13
		0.00	0.00	0.00	1.06	8.53	0.00	0.27	0.53	0.00	0.00	0.53
		0.00	0.00	0.27	0.00	0.00	0.53	0.00	2.40	0.00	0.80	2.40
		0.00	4.00	0.00	0.00	2.66	0.00	0.00	2.66	4.00	3.73	0.80
		0.00	0.27	0.00	0.00	0.80	2.93	0.53	1.06	1.06	0.80	0.00
		0.00										
	cup 4	438	30.50	0.91	0.00	0.68	0.00	0.00	0.23	0.23	0.00	0.23
		0.00	0.00	0.00	2.51	0.23	0.46	0.00	1.59	5.25	0.46	0.00
		0.46	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.00	1.82	7.07
		0.00	0.46	0.00	0.00	0.91	0.00	0.23	0.00	0.00	0.23	2.05
		0.00	0.00	0.00	1.82	4.10	0.46	0.00	1.82	0.00	0.00	1.36
		0.00	0.00	0.00	0.23	0.00	1.36	0.68	0.68	0.00	0.68	0.46
		0.00	4.56	0.00	0.00	2.51	0.00	0.23	3.88	5.47	5.70	2.05
		0.23	0.00	0.00	0.00	0.00	5.02	0.23	0.68	2.28	2.05	0.91
		0.00										
	cup 5	438	30.50	1.59	0.00	0.00	0.23	0.00	0.46	0.23	0.00	0.00
		0.00	0.00	0.00	2.05	0.00	0.00	0.23	2.96	3.42	0.46	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.23	1.14	0.00	1.82	1.59
		0.00	0.68	0.00	0.00	0.68	0.00	0.46	0.00	0.00	0.00	4.56
		0.00	0.00	0.00	0.91	0.46	0.00	1.14	0.00	0.00	0.00	1.14
		0.46	0.00	0.00	0.00	0.00	4.33	1.14	3.65	0.00	0.91	2.73
		0.00	3.42	0.00	0.00	5.93	0.46	0.23	1.59	0.68	1.82	0.68
		0.00	0.68	0.00	0.23	0.91	9.36	0.00	3.19	0.91	0.23	0.68
		0.23										
	cup 6	498	41.90	5.42	0.00	0.00	0.00	0.00	0.60	1.40	0.00	0.20
		0.00	0.00	0.00	1.40	0.20	0.00	0.00	3.01	1.00	0.00	0.00
		1.20	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	2.20	0.40
		0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.60	4.41
		0.00	0.00	0.00	0.20	0.40	0.20	0.00	0.40	0.00	0.40	2.00
		0.00	0.00	0.00	0.00	0.00	2.00	0.40	4.61	0.00	0.20	2.20
		0.00	1.20	0.00	0.00	7.83	0.40	0.20	2.40	0.80	2.20	1.40
		0.80	0.60	0.00	0.00	0.40	8.43	0.60	2.40	0.40	0.40	0.80
		0.20										
Gyre	cup 1	184	25.00	2.17	0.00	0.00	0.00	0.00	1.63	1.08	0.54	1.08
		0.00	2.71	0.00	1.08	0.00	0.00	0.00	3.80	4.34	2.17	0.00
		1.08	0.00	0.00	0.00	0.00	0.00	0.00	3.26	0.00	0.54	1.63
		0.00	0.54	0.00	0.00	5.97	0.00	0.00	0.00	0.00	1.63	5.97
		0.00	0.00	0.00	0.00	3.80	0.00	0.54	0.00	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.54	0.00	1.08	1.63	0.00	0.54	3.80
		0.00	1.63	0.00	0.00	6.52	0.00	1.08	0.00	0.54	2.71	0.54
		0.00	0.54	0.54	0.00	1.63	3.26	0.00	2.17	0.54	0.00	0.00
		0.00										
	cup 2	491	28.50	0.81	0.00	0.00	0.00	0.00	0.81	1.42	0.41	0.00
		0.00	1.22	0.00	0.81	0.41	1.01	0.00	2.44	4.07	0.00	0.00
		0.81	0.00	0.00	0.00	0.00	0.00	0.61	2.85	0.00	0.41	1.01
		0.00	0.20	0.00	0.00	5.70	0.00	0.61	0.00	0.00	0.41	6.10
		0.00	0.00	0.00	0.41	4.27	0.00	0.00	0.20	0.00	0.00	1.42
		0.00	0.00	0.00	0.00	0.00	0.41	0.00	2.03	0.00	0.61	0.41
		0.00	0.81	0.41	0.00	8.14	0.20	1.22	1.22	4.27	0.81	0.61
		0.00	0.61	0.00	0.00	0.41	7.53	0.61	1.42	0.20	0.41	0.61
		0.00										

Data - Year 1 cont.

species percents

Gyre	cup 3	507	28.00	0.20	0.00	0.79	0.20	0.00	0.79	1.77	0.39	0.59
		0.00	0.00	0.20	0.59	1.18	0.79	0.39	1.57	9.27	0.99	0.00
		0.79	0.00	0.00	0.00	0.00	0.39	0.39	2.56	0.20	0.00	0.79
		0.00	0.00	0.00	0.00	7.88	0.00	0.59	0.00	0.00	1.77	1.77
		0.00	0.00	0.00	0.59	11.80	0.00	0.00	0.00	0.00	0.00	0.79
		0.00	0.00	0.00	0.00	0.00	0.99	0.00	1.38	0.00	0.20	1.38
		0.00	3.15	0.00	0.00	3.55	0.20	0.99	1.38	0.20	0.79	0.39
		0.00	0.00	0.00	0.00	0.99	4.14	0.00	1.38	0.20	0.20	0.39
		0.00										
Gyre	cup 4	542	28.70	0.18	0.00	1.47	0.18	0.00	0.37	2.02	0.00	0.55
		0.00	0.18	0.00	4.05	0.18	0.74	0.00	0.00	6.08	0.18	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.37	1.84
		0.00	0.18	0.00	0.00	2.58	0.18	0.00	0.00	0.00	0.74	3.50
		0.00	0.18	0.00	0.37	11.60	0.37	0.55	0.18	0.00	0.00	1.29
		0.00	0.00	0.18	0.18	0.00	0.00	0.18	0.55	0.00	0.74	2.02
		0.00	6.82	0.00	0.00	3.50	0.00	1.29	1.84	1.66	5.53	0.00
		0.00	0.55	0.18	0.00	1.29	0.00	0.18	2.02	0.37	0.55	0.55
		0.37										

species percents

Gyre	cup 5	521	22.60	1.15	0.00	0.38	0.96	0.00	0.77	1.34	0.00	0.19
		0.00	0.00	0.00	0.77	0.19	0.00	0.00	2.30	4.60	0.38	0.00
		0.58	0.00	0.00	0.00	0.00	0.00	0.38	0.58	0.00	0.58	1.72
		0.00	0.19	0.00	0.00	0.58	0.19	0.00	0.00	0.19	2.68	5.56
		0.00	0.00	0.00	1.53	7.67	0.19	0.58	1.15	0.00	0.00	0.58
		0.00	0.00	0.00	0.19	0.00	1.91	1.15	1.34	0.00	0.19	5.95
		0.00	11.50	0.00	0.00	3.07	0.38	0.38	1.53	0.58	2.11	1.72
		0.00	0.77	0.00	0.00	1.34	3.07	0.00	1.34	0.00	0.38	0.38
		0.00										
Gyre	cup 6	505	27.30	2.37	0.00	0.20	1.18	0.00	0.99	2.57	0.00	0.79
		0.00	0.00	0.00	1.38	0.20	0.00	0.20	2.77	1.58	0.20	0.00
		0.59	0.00	0.00	0.00	0.00	0.20	0.20	1.78	0.00	1.38	1.98
		0.00	0.20	0.00	0.00	0.40	0.00	0.40	0.00	0.00	1.58	4.15
		0.00	0.20	0.00	0.59	1.98	0.00	0.79	0.40	0.00	0.40	2.17
		0.00	0.00	0.00	0.20	0.00	1.98	0.79	6.13	0.00	0.00	4.35
		0.00	0.99	0.00	0.00	6.73	0.59	1.18	1.38	0.40	0.99	0.00
		0.40	0.59	0.00	0.40	1.18	5.94	0.20	2.57	0.79	0.20	0.79
		0.00										

Data - Year 2 (9/88-9/89) 1500m traps

species percents

Nearshore	cup 1	511	37.10	5.08	0.00	0.00	0.00	0.00	0.39	0.59	0.00	1.36
		0.00	0.00	0.00	0.78	0.00	0.00	0.00	1.56	1.36	0.00	0.00
		0.59	0.00	0.00	0.00	0.00	0.19	0.39	0.39	0.00	0.39	0.19
		0.00	0.39	0.00	0.00	0.39	0.00	0.39	0.00	0.00	0.19	2.73
		0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.78
		0.19	0.19	0.00	1.17	0.00	1.76	0.19	6.45	1.76	0.39	0.78
		0.00	0.59	0.19	0.00	4.50	1.95	0.00	6.26	0.59	1.17	1.36
		0.39	0.39	0.00	0.59	0.19	10.50	0.00	0.98	1.56	0.00	0.19
		0.19										
Nearshore	cup 2	536	33.90	6.15	0.00	0.00	0.00	0.00	0.37	0.37	0.00	0.56
		0.00	0.00	0.00	0.19	0.00	0.00	0.00	1.11	0.19	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.19	0.56	1.30	0.00	1.11	1.49
		0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	2.79
		0.00	0.00	0.00	0.19	0.19	0.00	0.00	0.56	0.00	0.19	0.19
		0.37	0.00	0.00	0.37	0.75	4.47	0.19	8.02	0.56	0.37	1.67
		0.00	0.75	0.00	0.00	4.85	0.56	0.00	8.58	0.56	1.30	1.30
		0.37	0.37	0.00	0.37	0.19	6.52	0.00	2.98	0.19	0.75	0.56
		0.00										
Nearshore	cup 3	533	34.30	3.75	0.00	0.00	0.38	0.00	0.38	0.38	0.00	0.56
		0.00	0.00	0.00	1.12	0.19	0.00	0.00	2.25	0.38	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.38	0.19	0.94	0.00	2.06	3.75
		0.00	0.56	0.00	0.19	0.38	0.00	0.00	0.00	0.00	0.00	1.87
		0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.56
		0.19	0.00	0.00	0.00	0.00	3.37	0.00	14.00	0.00	0.19	2.81
		0.00	0.75	0.00	0.00	3.00	0.75	0.00	4.31	1.31	1.50	0.00
		0.19	0.94	0.00	0.00	0.19	5.25	0.00	3.75	0.56	0.56	0.75
		0.38										
Nearshore	cup 4	517	38.20	1.93	0.00	0.00	0.19	0.00	0.19	0.39	0.00	0.39
		0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.97	0.97	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.19	0.00	1.35	0.00	1.93	3.86
		0.00	0.19	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.19	2.90
		0.00	0.00	0.00	0.39	0.19	0.39	0.00	0.77	0.00	0.00	2.12
		0.00	0.00	0.00	0.00	0.19	0.39	0.00	8.51	0.00	1.35	0.00
		0.00	1.54	0.00	0.00	5.41	0.58	0.39	7.35	1.35	0.97	0.00
		0.00	0.19	0.00	0.58	0.39	5.22	1.93	2.32	0.97	0.58	0.39
		0.19										
Nearshore	cup 5	448	32.30	0.89	0.00	0.00	0.22	0.00	0.00	0.45	0.00	0.22
		0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.22	2.90	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.24	0.00	0.67	6.69
		0.00	0.22	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.45	2.90
		0.00	0.22	0.00	1.11	0.00	0.22	0.22	0.67	0.00	0.45	1.56
		0.00	0.00	0.00	0.00	0.45	1.33	0.67	5.58	0.00	1.11	2.00
		0.00	1.33	0.00	0.00	5.80	0.22	0.67	3.34	2.45	1.11	0.89
		0.22	0.67	0.00	0.45	0.22	8.48	0.89	1.33	1.33	0.45	0.00
		0.00										
Nearshore	cup 6	518	25.80	0.19	0.00	0.19	0.00	0.00	0.00	1.35	0.00	0.39
		0.00	0.00	0.00	1.73	0.77	0.19	0.00	0.58	2.50	0.19	0.00
		0.00	0.00	0.00	0.00	0.00	0.19	0.00	15.60	4.05	0.77	10.40
		0.00	0.00	0.39	0.00	0.58	0.00	0.00	0.00	0.00	0.00	3.08
		0.00	0.19	0.00	0.39	0.00	0.00	0.39	0.19	0.00	0.19	1.15
		0.00	0.00	0.00	0.19	0.00	2.89	0.19	3.66	0.00	0.19	1.15
		0.00	0.97	0.00	0.00	3.86	0.19	0.19	0.77	1.35	0.97	0.19
		0.58	0.97	0.00	0.00	0.58	4.63	0.39	1.93	1.73	0.39	0.00
		0.39										
Nearshore	cup 7	503	31.80	0.20	0.00	0.40	0.20	0.00	0.20	0.99	0.00	0.00
		0.00	0.00	0.00	1.19	0.00	0.40	0.00	1.78	3.77	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.60	0.20	2.38	0.00	1.19	9.14
		0.00	0.20	0.40	0.00	0.40	0.00	0.00	0.00	0.00	0.20	4.97
		0.00	0.20	0.00	0.60	0.40	0.00	1.59	0.60	0.00	0.00	0.99
		0.00	0.00	0.00	0.00	0.00	1.98	0.20	4.77	0.00	0.99	0.80
		0.00	2.98	0.00	0.00	3.57	0.20	0.60	3.57	4.97	1.59	0.40
		0.40	0.40	0.00	0.20	0.60	2.18	0.40	2.18	1.59	0.40	0.20
		0.20										
Nearshore	cup 8	507	34.50	1.18	0.00	0.79	0.20	0.00	0.99	1.77	0.00	1.38
		0.00	0.00	0.00	1.77	0.00	0.20	0.00	2.16	4.73	0.20	0.00
		0.00	0.00	0.00	0.00	0.00	0.20	0.59	0.99	0.20	1.18	5.32
		0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	5.71
		0.00	0.00	0.00	0.20	1.18	0.39	1.18	0.59	0.00	0.00	0.79
		0.00	0.00	0.00	0.00	0.00	2.16	0.00	1.97	0.00	0.99	1.38
		0.00	2.76	0.00	0.00	3.35	0.59	0.99	2.56	3.15	1.97	0.00
		0.20	0.59	0.00	0.59	0.20	3.35	0.00	2.16	0.79	0.20	0.79
		0.20										

species percents

Nearshore	cup 9	512	29.80	1.17	0.00	0.19	0.00	0.00	1.36	1.75	0.00	0.19
		0.00	0.00	0.00	2.53	0.19	0.39	0.00	2.53	5.66	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.78	0.19	2.53	8.98
		0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.39	1.95
		0.00	0.78	0.00	1.17	0.00	0.19	3.32	0.59	0.00	0.00	1.75
		0.00	0.00	0.00	0.00	0.19	2.34	0.39	3.51	0.19	0.78	2.92
		0.00	1.95	0.00	0.00	1.36	0.78	0.00	1.56	4.68	1.36	0.98
		0.19	0.78	0.00	0.19	0.00	3.12	0.59	1.17	0.59	0.39	0.39
		0.19										
Nearshore	cup 10	509	31.40	0.39	0.00	0.00	0.00	0.00	1.17	1.96	0.00	0.39
		0.00	0.00	0.00	4.51	0.00	0.00	0.00	4.12	9.82	0.20	0.00
		0.00	0.00	0.00	0.00	0.00	0.20	0.79	0.59	0.00	0.59	3.14
		0.00	0.79	0.00	0.00	0.39	0.00	0.20	0.00	0.00	0.00	3.14
		0.00	0.20	0.00	1.17	0.00	0.00	0.59	0.39	0.00	0.00	0.59
		0.00	0.00	0.00	0.00	0.00	0.79	0.39	2.16	0.20	0.39	3.33
		0.00	2.35	0.00	0.00	4.12	0.39	0.20	2.35	3.33	2.16	0.20
		0.20	0.00	0.00	0.39	0.20	7.26	0.39	0.79	1.17	0.00	0.39
		0.00										
Nearshore	cup 11	525	29.30	1.71	0.00	0.00	0.19	0.00	0.57	0.95	0.00	0.38
		0.00	0.00	0.00	4.00	0.00	0.19	0.00	3.04	4.38	0.19	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09	0.00	1.52	3.61
		0.00	0.38	0.00	0.00	0.38	0.00	0.38	0.00	0.00	0.00	4.38
		0.00	0.19	0.00	1.71	0.19	0.19	0.95	0.00	0.00	0.00	0.57
		0.00	0.00	0.00	0.00	0.19	2.66	0.57	4.19	0.00	0.19	2.85
		0.00	4.19	0.00	0.00	4.76	0.38	0.57	2.66	0.57	3.23	0.76
		0.19	0.38	0.00	0.19	0.19	5.90	0.38	1.71	0.95	0.38	0.38
		0.00										
Nearshore	cup 12	515	40.30	1.94	0.00	0.00	0.00	0.00	0.39	2.13	0.00	0.39
		0.00	0.00	0.00	3.49	0.00	0.00	0.00	2.71	5.24	0.19	0.00
		1.16	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.19	0.39	1.35
		0.00	0.19	0.39	0.00	0.19	0.00	0.00	0.00	0.00	0.00	4.46
		0.00	0.00	0.00	0.58	0.00	0.00	0.39	0.19	0.00	0.00	0.39
		0.00	0.00	0.00	0.00	0.19	0.58	0.19	2.33	1.16	0.97	2.33
		0.00	2.52	0.00	0.00	2.13	1.16	0.19	3.68	1.16	0.00	0.00
		0.39	0.58	3.10	0.19	0.39	5.04	0.58	1.35	1.16	0.39	0.00
		0.00										
Midway	cup 1	149	41.60	1.34	0.00	0.67	0.00	0.00	0.00	1.34	0.00	2.01
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	0.00	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.00	0.67	0.00
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.35
		0.00	1.34	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.67
		0.00	0.00	0.00	0.00	0.00	0.00	0.67	4.69	1.34	0.00	2.01
		0.00	2.01	0.00	0.00	4.02	0.67	0.67	1.34	2.01	0.67	0.67
		0.00	1.34	0.00	0.00	0.00	18.10	0.00	1.34	1.34	0.00	0.00
		0.00										
Midway	cup 2	509	41.40	2.35	0.00	0.00	0.00	0.00	0.39	1.17	0.00	0.79
		0.00	0.00	0.00	2.16	0.00	0.00	0.00	2.55	1.17	0.20	0.00
		0.59	0.00	0.00	0.00	0.00	0.20	0.00	0.79	0.00	0.20	1.57
		0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	2.35
		0.00	0.39	0.00	0.39	0.39	0.20	0.20	0.20	0.00	0.00	0.98
		0.00	0.00	0.00	0.00	0.59	2.16	0.00	5.69	1.57	0.20	2.55
		0.00	1.96	0.00	0.00	4.51	0.00	0.98	2.55	1.37	0.98	0.98
		0.20	0.00	0.00	0.39	0.20	7.07	0.00	2.75	0.79	0.20	1.17
		0.00										
Midway	cup 3	514	37.90	2.52	0.00	0.19	0.00	0.00	0.78	1.75	0.00	0.19
		0.00	0.00	0.00	0.97	0.00	0.00	0.00	3.11	0.78	0.19	0.00
		0.00	0.00	0.00	0.00	0.00	0.19	0.39	0.58	0.00	0.58	3.11
		0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	1.75
		0.00	0.19	0.00	0.19	0.19	0.19	0.00	0.78	0.00	0.00	0.97
		0.00	0.00	0.19	0.58	1.55	1.55	0.39	7.00	2.14	0.00	1.75
		0.00	1.75	0.00	0.00	5.44	1.16	0.19	2.33	1.36	0.39	0.78
		0.19	0.58	0.00	0.39	0.39	7.19	0.00	2.52	0.78	0.19	0.58
		0.00										
Midway	cup 4	487	39.20	3.28	0.00	0.00	0.00	0.00	0.21	0.41	0.00	1.02
		0.00	0.00	0.21	1.23	0.62	0.00	0.00	1.84	1.23	0.00	0.00
		0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.41	0.00	2.05	3.69
		0.00	0.41	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	2.87
		0.00	0.00	0.00	0.00	0.41	0.00	0.41	0.21	0.00	0.00	2.25
		0.00	0.00	0.00	0.00	0.41	1.43	0.82	6.57	0.41	0.00	0.21
		0.00	0.62	0.00	0.00	8.82	0.21	0.62	2.87	1.84	0.62	1.02
		0.00	0.41	0.00	0.21	0.62	6.77	0.41	0.82	1.02	0.41	0.41
		0.00										

Data - Year 2 cont.

species percents

Midway — cup 5

506	36.10	1.77	0.00	0.00	0.00	0.00	0.59	0.20	0.00	0.00
0.00	0.00	0.00	1.58	0.59	0.00	0.00	1.97	1.77	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.40	0.00	1.77	0.00	1.58	8.89
0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	2.56
0.00	0.20	0.00	0.40	0.00	0.59	0.59	1.18	0.00	0.40	2.17
0.00	0.00	0.00	0.00	0.79	1.18	0.79	3.16	0.00	0.00	1.77
0.00	0.79	0.00	0.00	4.15	0.40	0.40	2.96	2.37	0.59	0.59
0.00	0.59	0.00	0.20	0.40	7.50	0.59	1.97	1.38	0.99	0.20
0.00										

Midway — cup 6

501	31.70	0.40	0.00	0.60	0.00	0.00	0.00	0.80	0.00	0.40
0.00	0.00	0.00	1.00	1.19	0.20	0.00	1.19	1.39	0.80	0.00
0.00	0.00	0.00	0.00	0.00	0.20	0.00	9.58	0.00	1.00	11.50
0.00	0.20	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.20	2.99
0.00	0.00	0.00	0.80	0.20	0.20	0.40	0.00	0.00	0.00	0.60
0.00	0.00	0.00	0.00	0.20	0.60	0.40	4.39	0.20	0.00	1.00
0.00	1.00	0.00	0.00	3.39	0.60	0.20	3.19	1.39	0.00	0.40
0.00	0.40	2.59	0.00	1.00	5.98	0.20	1.99	1.39	0.40	0.40
0.00										

Midway — cup 7

511	33.20	1.17	0.00	0.19	0.00	0.00	0.39	0.78	0.00	0.59
0.00	0.00	0.00	2.54	1.36	0.19	0.00	1.17	3.71	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.69	0.00	0.78	11.70
0.00	0.39	0.00	0.19	1.36	0.00	0.00	0.00	0.00	0.19	5.67
0.00	0.00	0.00	0.78	0.19	0.19	0.59	0.59	0.00	0.39	0.39
0.00	0.00	0.00	0.19	0.00	0.59	0.39	1.76	0.19	0.98	0.39
0.00	1.17	0.00	0.00	2.73	0.59	0.39	2.73	3.13	4.50	1.36
0.00	0.19	0.00	0.19	0.00	5.28	0.19	1.56	1.36	0.19	0.00
0.00										

Midway — cup 8

528	37.10	0.00	0.00	0.38	0.00	0.00	0.95	0.95	0.00	0.57
0.00	0.00	0.00	2.27	0.19	0.00	0.00	1.70	4.92	0.00	0.00
0.19	0.00	0.00	0.00	0.00	0.00	0.19	1.32	0.00	0.57	7.19
0.00	0.19	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.76	2.65
0.00	0.19	0.00	1.13	0.19	0.00	1.51	1.13	0.00	0.38	2.27
0.00	0.00	0.00	0.00	0.00	0.76	0.57	3.03	0.00	0.00	1.32
0.00	1.51	0.00	0.00	3.78	1.51	0.19	1.13	2.84	3.03	0.57
0.19	0.38	0.00	0.00	0.38	5.11	0.38	1.51	0.57	0.57	0.57
0.00										

Midway — cup 9

517	23.20	0.00	0.00	0.39	0.19	0.00	0.97	1.54	0.00	0.19
0.00	0.00	0.00	4.06	0.00	0.19	0.00	3.28	7.35	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.19	0.97	0.97	0.00	1.16	11.00
0.00	0.00	0.00	0.00	1.16	0.00	0.19	0.00	0.00	0.39	3.28
0.00	0.00	0.00	1.16	1.74	0.00	3.48	0.39	0.00	0.19	1.54
0.19	0.00	0.00	0.19	0.00	1.16	0.58	2.70	0.00	0.77	2.12
0.00	3.48	0.00	0.00	1.54	0.97	0.39	2.12	5.99	2.12	0.58
0.19	0.00	0.00	0.00	0.00	3.09	0.19	0.97	0.58	0.77	0.00
0.00										

Midway — cup 10

529	35.90	0.38	0.00	0.00	0.38	0.00	0.57	0.76	0.00	0.00
0.00	0.00	0.00	3.02	0.00	0.00	0.00	2.07	7.18	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.57	2.64
0.00	0.19	0.00	0.00	0.57	0.00	0.19	0.00	0.00	0.57	2.26
0.00	0.57	0.00	1.70	0.95	0.00	1.13	1.13	0.00	0.00	0.00
0.00	0.19	0.00	0.00	0.00	1.13	0.57	4.72	0.00	0.38	2.45
0.00	3.02	0.00	0.00	3.96	1.89	0.57	2.45	3.40	1.89	1.13
0.19	0.57	0.00	0.19	0.57	3.59	0.76	0.95	1.32	0.19	0.19
0.00										

Midway — cup 11

515	37.60	0.58	0.00	0.00	0.00	0.00	1.16	0.39	0.00	0.19
0.00	0.00	0.00	5.24	0.00	0.00	0.00	1.94	5.04	0.00	0.00
0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	2.13
0.00	0.78	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.19	2.91
0.00	0.00	0.00	2.13	0.39	0.19	0.58	0.39	0.00	0.00	2.13
0.00	0.00	0.00	0.00	0.19	1.55	0.19	3.10	0.00	0.19	1.55
0.00	1.74	0.00	0.00	4.27	0.39	0.39	2.91	2.13	1.55	1.16
0.19	0.78	0.00	0.19	0.19	7.76	1.16	2.13	0.78	0.19	0.19
0.00										

Midway — cup 12

501	34.70	0.40	0.00	0.00	0.00	0.00	1.39	2.79	0.00	0.40
0.00	0.00	0.00	3.39	0.00	0.00	0.00	1.99	8.18	0.20	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.80	2.79
0.00	0.40	0.00	0.00	0.40	0.00	0.60	0.00	0.00	0.40	5.38
0.00	0.00	0.00	0.60	0.20	0.20	0.40	0.40	0.00	0.00	1.59
0.00	0.00	0.00	0.40	0.00	1.79	0.20	2.99	0.00	0.60	2.19
0.00	3.39	0.00	0.00	2.59	0.60	0.40	1.99	0.80	1.59	0.00
0.00	0.20	0.00	0.20	0.80	6.18	1.00	2.39	0.80	0.00	0.60
0.20										

Midway — cup 13

510	36.60	1.37	0.00	0.00	0.39	0.00	1.17	0.00	0.00	0.59
0.00	0.00	0.00	3.92	0.00	0.00	0.00	2.35	5.68	0.00	0.00
0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.59	1.76
0.00	0.20	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.20	5.88
0.00	0.20	0.00	0.78	0.39	0.20	0.78	0.00	0.00	0.00	0.98
0.00	0.00	0.00	0.00	0.20	0.39	0.78	3.52	0.00	0.78	2.74
0.00	3.13	0.00	0.00	3.13	0.39	0.00	2.15	0.98	1.37	0.59
0.39	0.78	0.00	0.00	0.59	7.25	1.76	1.56	1.96	0.20	0.59
0.00										

Gyre — cup 1

81	44.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.23	0.00	0.00	0.00	0.00	0.00	1.23	2.46	0.00	0.00
1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	4.93
0.00	0.00	0.00	0.00	4.93	0.00	0.00	0.00	0.00	0.00	4.93
0.00	0.00	0.00	0.00	2.46	0.00	0.00	0.00	0.00	0.00	2.46
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.23	0.00	0.00	6.17	1.23	1.23	0.00	0.00	0.00	1.23
0.00	0.00	0.00	0.00	2.46	4.93	1.23	3.70	3.70	0.00	1.23
0.00										

Gyre — cup 2

527	47.20	1.70	0.00	0.00	0.00	0.00	0.95	0.38	0.00	0.19
0.00	0.38	0.00	1.13	0.00	0.00	0.00	1.13	1.89	0.19	0.00
0.57	0.00	0.00	0.00	0.00	0.19	0.57	0.19	0.00	0.38	1.89
0.00	0.00	0.00	0.00	3.79	0.00	0.00	0.00	0.19	0.57	2.27
0.00	0.00	0.00	0.38	0.19	0.00	0.00	6.83	0.00	0.19	1.32
0.00	0.00	0.00	0.19	0.19	0.57	0.00	0.76	0.38	0.76	1.89
0.00	1.13	0.00	0.00	4.36	1.13	1.89	0.38	2.46	1.13	0.57
0.00	0.38	0.00	0.38	0.57	0.00	0.57	3.03	2.08	0.19	0.19
0.00										

species percents

Gyre — cup 3

500	45.00	1.40	0.00	0.00	0.00	0.00	0.40	1.60	0.00	0.20
0.00	0.20	0.20	0.00	0.20	0.60	0.00	1.00	2.20	0.40	0.00
0.20	0.00	0.00	0.00	0.00	0.00	0.80	0.20	0.00	0.40	1.40
0.00	0.20	0.00	0.00	3.40	0.00	0.00	0.00	0.00	1.20	1.60
0.00	0.00	0.00	0.60	0.80	0.20	0.00	0.40	0.00	0.20	1.40
0.40	0.00	0.00	0.40	0.00	0.00	0.40	2.00	0.80	0.40	2.40
0.00	2.40	0.00	0.00	3.00	0.80	0.80	1.40	1.60	0.60	0.60
0.20	0.60	0.00	0.00	0.40	7.80	0.40	2.20	1.80	0.80	1.20
0.20										

Gyre — cup 4

541	65.90	1.29	0.00	0.00	0.18	0.00	0.00	0.55	0.00	0.00
0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.55	2.40	0.18	0.00
0.18	0.00	0.00	0.00	0.00	0.00	0.55	0.92	0.00	0.37	0.74
0.00	0.00	0.00	0.00	2.77	0.00	0.00	0.00	0.00	0.00	1.10
0.00	0.00	0.00	0.55	0.55	0.37	0.00	0.00	0.00	0.55	0.74
0.00	0.00	0.00	0.00	0.00	0.00	0.92	1.84	0.00	0.00	0.92
0.00	0.74	0.00	0.00	2.58	0.18	0.00	0.92	0.37	0.74	0.18
0.00	0.37	0.00	0.18	0.74	4.62	0.18	0.55	1.47	0.18	0.18
0.00										

Gyre — cup 5

451	35.00	2.43	0.00	0.00	0.00	0.00	0.44	1.55	0.00	0.00
0.00	0.44	0.22	1.55	0.00	0.00	0.00	0.67	3.99	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.22	0.00	15.50	0.00	2.88	1.77
0.00	0.22	0.00	0.22	1.55	0.00	0.44	0.00	0.00	1.55	1.77
0.00	0.00	0.00	0.67	0.67	0.22	0.00	0.44	0.00	0.00	0.89
0.00	0.00	0.00	0.00	0.00	0.44	0.67	1.77	0.22	0.22	0.67
0.00	1.55	0.00	0.00	3.76	0.00	1.10	1.55	0.44	0.44	0.00
0.22	0.67	0.22	0.00	1.10	6.20	0.00	0.89	1.99	0.22	0.22
0.00										

Gyre — cup 6

368	31.20	0.82	0.00	1.08	0.00	0.00	0.27	1.63	0.00	0.00
0.00	0.00	0.00	0.27	0.00	0.00	0.00	1.35	2.71	0.54	0.00
0.27	0.00	0.00	0.00	0.00	0.00	0.00	28.20	0.00	1.35	1.90
0.00	0.54	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.27	1.63
0.00	0.00	0.00	0.54	1.35	0.00	0.00	0.54	0.00	0.00	1.90
0.00	0.00	0.00	0.00	0.00	2.98	0.00	3.53	0.54	0.27	1.08
0.00	1.63	0.00	0.00	2.44	0.54	0.54	1.08	0.00	0.00	0.27
0.00	0.27	0.00	0.54	0.00	2.44	0.27	0.82	0.27	0.27	0.54
0.00										

Gyre — cup 7

518	36.60	0.39	0.00	0.97	0.00	0.00	0.39	2.12	0.00	0.58
0.00	0.00	0.00	0.58	0.77	0.19	0.00	1.15	10.60	0.77	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.77	2.89	0.00	2.70	1.15
0.00	0.19	0.77	0.00	0.97	0.00	0.00	0.00	0.00	2.12	1.73
0.00	0.39	0.00	0.77	3.08	0.00	0.00	0.97	0.00	0.19	1.35
0.00	0.00	0.19	0.00	0.00	0.97	1.54	1.93	0.00	0.19	0.39
0.00	3.08	0.00	0.00	1.73	0.39	2.12	2.12	0.00	0.58	0.00
0.58	0.19	0.00	0.00	0.00	5.98	0.00	1.54	0.39	0.19	0.39
0.19										

Gyre — cup 8

550	32.50	0.18	0.00	0.55	0.00	0.00	0.55	2.72	0.00	0.00
0.00	0.00	0.18	1.27	0.36	1.27	0.00	1.45	7.09	1.45	0.00
0.00	0.00	0.00	0.00	0.00	0.18	1.27	2.18	0.00	0.55	0.73
0.00	0.18	0.36	0.00	2.90	0.00	0.55	0.00	0.00	2.18	2.54
0.00	0.18	0.00	2.72	0.91	0.36	0.00	1.63	0.00	0.00	1.27
0.18	0.00	0.36	0.00	0.00	0.36	1.63	0.73	0.00	2.18	1.27
0.00	4.72	0.00	0.00	1.63	0.18	1.45	1.63	1.27	2.72	0.18
0.36	0.18	0.00	0.18	0.91	4.00	0.18	0.55	0.55	1.27	0.91
0.00										

Gyre — cup 9

554	35.90	0.36	0.00	0.18	0.36	0.00	0.72	1.80	0.00	0.54
0.00	0.00	0.18	1.08	0.18	1.08	0.00	0.72	7.03	0.36	0.00
0.18	0.00	0.00	0.00	0.00	0.00	0.72	0.72	0.00	0.54	0.90
0.00	0.36	0.18	0.00	1.44	0.00	0.18	0.00	0.00	2.88	1.44
0.00	0.36	0.00	1.62	2.34	0.00	0.18	0.72	0.00	0.00	0.72
0.18	0.00	0.00	0.00	0.00	0.00	1.80	0.72	0.00	0.54	1.62
0.00	8.12	0.00	0.00	1.98	0.72	1.62	1.44	1.80	3.79	0.36
0.00	0.18	0.18	0.36	1.98	3.97	0.00	0.54	0.36	1.44	0.18
0.00										

Gyre — cup 10

509	32.80	0.00	0.00	0.59	0.20	0.00	1.37	1.37	0.00	0.98
0.00	0.00	0.00	1.96	0.20	0.00	0.00	2.16	7.46	0.39	0.00
0.00	0.00	0.00	0.00	0.00	0.20	0.39	0.79	0.00	0.20	0.98
0.00	0.39	0.00	0.00	0.79	0.00	0.20	0.00	0.00	1.96	2.55
0.00	0.20	0.00	2.16	1.17	0.00	0.79	0.00	0.00	0.00	0.59
0.00	0.00	0.00	0.00	0.00	0.39	2.16	0.39	0.00	1.57	3.33
0.00	7.85	0.00	0.00	2.94	0.39	1.96	1.96	0.00	1.96	0.39
0.20	0.20	0.00	0.20	0.79	6.87	0.00	1.96	0.79	0.59	0.39
0.00										

Gyre — cup 11

508	36.20	0.39	0.00	0.59	0.20	0.00	0.98	1.18	0.00	0.59
0.00	0.00	0.00	2.75	0.20	0.20	0.00	3.34	7.08	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.79	0.00	1.96	1.57
0.00	0.59	0.20	0.00	0.79	0.00	0.39	0.00	0.00	2.55	1.96
0.00	0.00	0.00	2.95	1.57	0.00	0.39	0.79	0.00	0.00	1.57
0.00	0.00	0.00	0.20	0.00	1.77	1.37	1.37	0.39	0.20	2.95
0.00	8.85	0.00	0.00	1.96	0.20	0.39	1.18	0.00	2.16	0.20
0.00	0.39	0.00	0.20	0.39	4.13	0.00	1.37	0.39	0.79	1.18
0.00										

Gyre — cup 12

547	39.30	0.91	0.00	0.00	0.00	0.00	0.37	0.91	0.00	1.27
0.00	0.00	0.00	0.91	0.00	0.00	0.00	2.19	5.11	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.18	2.19
0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	1.27	2.92
0.00	0.18	0.00	2.19	1.64	0.00	0.55	0.73	0.00	0.00	0.73
0.00	0.00	0.00	0.18	0.18	0.55	0.55	0.55	0.18	0.55	1.82
0.00	6.58	0.00	0.00	2.55	0.91	1.27	2.19	0.18	2.55	0.37
0.18	0.37	0.18	0.18	1.09	7.31	0.18	1.64	2.01	0.37	0.55
0.00										

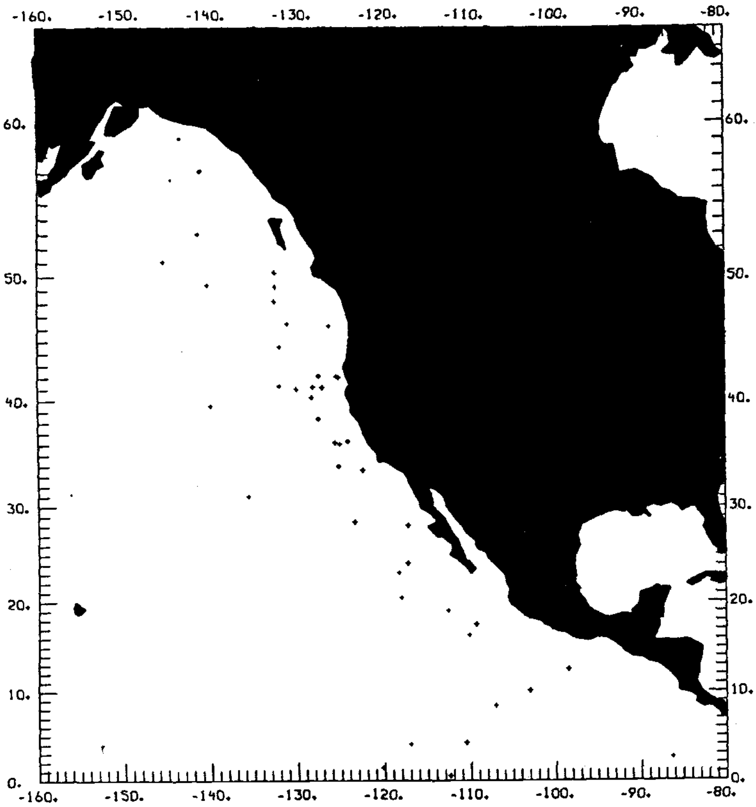
Gyre — cup 13

505	33.20	1.98	0.00	0.00	0.40	0.00	0.59	0.99	0.00	1.38
0.00	0.00	0.00	1.18	0.40	0.20	0.00	0.59	5.54	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.59	2.57	0.00	0.20	2.97
0.00	0.79	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.79	5.34
0.00	0.20	0.00	1.98	1.38	0.20	0.59	1.98	0.00	0.00	0.79
0.00	0.00	0.00	0.00	0.00	1.78	0.40	0.79	0.00	0.40	1.98
0.00	3.96	0.00	0.00	2.77	0.20	0.99	1.18	2.17	2.77	0.99
0.00	0.40	0.20	0.20	0.20	6.93	0.00	1.58	0.79	1.18	0.40
0.20										

APPENDIX B

Core locations and sediment data used for examining how the Q-mode factors are reflected in the sediments beneath the California Current System.

Core names and locations



core	lat	long
MUK-H-19	51.14	-145.40
RC10-88TW	16.39	-110.13
RC11-230	40.28	-128.25
RC11-176	56.57	-144.44
RC11-184	49.43	-140.31
RC11-193	39.57	-140.03
V18-319	4.14	-117.00
V18-324	8.46	-107.09
V18-328	10.16	-103.05
V18-333	12.54	-98.53
V21-203	4.23	-110.53
V24-51	1.40	-120.20
V24-49	0.49	-112.44
6705-6	46.25	-126.24
Y70-1-1	44.57	-132.00
Y70-2-41	57.10	-141.04
65-11-69	42.00	-125.20
6910-4	41.19	-128.09
Y70-5-63	50.28	-132.48
Y70-5-64	49.26	-132.46
Y70-5-67	48.17	-132.53
Y70-5-62	50.30	-132.42
Y70-4-56	53.01	-141.41
Y70-4-51P	59.05	-143.40
LFGS-48G	38.35	-127.45
LFGS 50G	36.19	-125.56
LPFG-68G	36.33	-124.06
SCAN-5PG	41.03	-130.04
R1S-36	24.15	-117.21
R15-127G	28.47	-123.36
TRI-8PG	19.06	-112.57
TR1-9G0	20.48	-118.01
TRI-11G	23.19	-118.26
ZTS-42G	31.10	-135.57
ZAP 2G	17.52	-109.31
6910-2PG	41.16	-127.01
FAN-HMS-1G	28.12	-117.16
MEN-36	33.58	-122.34
MEN-4G	34.02	-125.15
MEN-5G	36.04	-125.04
Y69-106-	2.59	-86.33
6808-8	46.42	-131.01
W8709-13TC	42.07	-125.46
-8tc	42.16	-127.38
-pc2	41.30	-132.00

Appendix B cont.

<u>Radiolarian data from surface sediment samples (see Appendix A for species key)</u>

species percents

MUK-H-19	530	47.70	0.19	0.00	0.00	0.57	0.00	0.94	1.88	0.00	6.03
	0.00	0.00	0.00	0.19	0.00	0.00	0.00	3.96	2.07	0.19	0.00
	0.00	0.00	0.00	0.00	0.00	0.75	0.00	1.32	0.19	3.39	0.75
	0.00	4.52	0.00	0.19	0.57	0.00	0.19	0.00	0.00	0.00	0.19
	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.38
	0.00	1.32	0.00	1.32	0.00	3.20	0.00	1.69	2.83	0.00	1.69
	0.00	0.19	0.00	9.24	0.57	0.38	0.00	0.57	0.00	1.13	0.19
	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00
	0.00										
RC10-88TW	507	42.20	0.39	0.59	0.00	0.00	0.00	0.00	0.00	0.20	0.20
	1.18	0.00	0.39	1.77	0.59	1.38	1.97	1.57	0.20	4.14	0.00
	2.95	0.00	0.59	0.20	0.59	0.00	0.00	0.20	0.20	0.00	0.79
	0.00	0.20	0.00	0.79	21.40	0.39	0.20	0.99	0.20	1.38	0.00
	2.36	0.00	0.79	0.79	0.20	0.20	0.20	0.20	0.59	0.00	0.00
	0.00	0.00	0.59	0.00	0.39	0.00	0.00	0.99	0.00	0.00	0.20
	0.00	2.36	0.00	0.00	0.20	0.00	0.00	0.00	0.39	0.39	0.00
	0.59	0.00	0.00	0.20	0.20	0.00	0.20	0.00	0.00	0.00	0.00
	0.00										
RC11-230	500	27.20	0.00	0.00	1.00	0.20	0.00	1.40	2.00	0.00	10.00
	0.00	0.00	0.40	0.00	0.00	1.20	0.00	14.40	0.80	0.40	0.00
	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.00	1.20	0.00
	0.00	3.60	0.20	0.20	10.40	0.00	0.00	0.00	0.00	0.80	0.40
	0.00	0.00	0.00	0.20	0.40	0.00	1.20	0.00	0.00	1.40	0.00
	0.00	0.00	0.00	2.20	0.00	10.40	0.00	5.60	0.00	0.00	0.60
	0.00	1.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
RC11-176	500	34.00	0.20	0.00	0.00	0.20	0.00	2.60	3.60	0.00	8.00
	0.00	0.00	0.00	1.80	0.00	0.00	0.00	9.20	3.20	0.40	0.20
	0.00	0.00	0.00	0.00	0.00	0.20	0.00	1.20	0.00	7.60	0.20
	0.00	2.20	0.20	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.60
	0.00	2.00	0.00	1.00	0.00	3.20	0.00	1.00	1.80	0.40	3.20
	0.00	0.00	0.00	8.80	0.40	0.20	0.00	0.00	0.00	0.40	0.00
	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.60	0.00	0.00	0.00
	0.00										
RC11-184	501	40.90	0.00	0.00	0.00	0.20	0.00	1.00	2.59	0.00	11.70
	0.00	0.00	0.60	0.40	0.00	0.00	0.00	9.38	2.79	0.00	0.20
	0.00	0.00	0.00	0.00	0.00	0.60	0.00	3.19	0.20	6.78	0.60
	0.00	4.59	0.00	0.40	1.99	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.40	1.00
	0.00	0.00	0.00	1.00	0.00	1.39	0.00	0.40	0.00	0.40	1.39
	0.00	1.19	0.00	3.19	0.00	0.40	0.00	0.40	0.00	0.20	0.00
	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
	0.00										
RC11-193	500	31.40	0.20	0.00	0.80	0.00	0.00	0.40	0.80	0.00	5.40
	0.00	0.00	0.40	0.00	0.20	1.60	0.40	8.39	0.20	2.40	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	2.60	0.00
	0.00	9.20	0.00	0.20	12.80	0.60	0.00	0.00	0.00	12.20	0.20
	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.20	0.80	0.00
	0.00	0.00	0.00	0.20	0.00	5.20	0.00	0.60	0.00	0.00	0.40
	0.00	0.20	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
	0.00										
V18-319	512	34.50	0.00	0.59	0.19	0.19	0.00	0.00	0.19	0.19	0.19
	1.75	0.19	2.14	0.39	0.39	0.78	5.27	1.17	0.19	6.64	0.19
	0.00	0.19	0.19	1.56	0.59	0.00	0.19	0.00	0.19	0.00	0.19
	0.00	0.00	0.00	1.36	19.50	2.34	0.19	0.19	0.59	2.14	0.19
	0.19	0.00	2.73	0.00	1.17	0.19	0.59	0.19	1.56	0.00	0.00
	0.00	0.00	1.36	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.19
	0.39	0.98	0.19	0.00	0.00	0.00	0.00	0.00	0.19	1.56	0.59
	1.17	0.00	0.59	0.19	0.00	0.39	0.00	0.59	0.00	0.00	0.00
	0.00										
V18-324	508	38.70	0.00	0.20	0.79	0.00	0.00	0.59	0.20	0.39	1.18
	2.36	0.00	1.77	0.98	1.37	0.79	3.74	0.79	0.20	4.13	0.00
	3.93	0.39	0.20	1.18	1.57	0.00	0.00	0.00	0.00	0.20	1.77
	0.00	0.79	0.00	1.18	15.70	0.39	0.20	0.98	0.39	1.18	0.00
	3.34	0.00	1.37	0.20	1.18	0.79	0.20	0.59	0.20	0.00	0.00
	0.00	0.00	0.20	0.00	1.96	0.00	0.00	0.20	0.00	0.00	0.39
	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00
	0.79	0.00	0.00	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.00
	0.00										
V18-328	506	37.90	0.00	0.20	0.00	0.00	0.00	0.40	0.00	0.20	0.20
	0.99	0.00	1.77	0.20	0.40	0.99	2.96	1.58	0.00	5.73	0.00
	8.49	0.59	0.00	0.59	2.37	0.00	0.00	0.00	0.00	0.99	1.38
	0.00	1.58	0.00	0.79	19.30	0.00	0.00	0.00	0.40	1.38	0.00
	1.77	0.20	0.20	0.00	0.20	0.40	0.59	0.99	0.20	0.00	0.00
	0.00	0.00	0.40	0.00	0.79	0.00	0.00	0.59	0.00	0.00	0.00
	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
V18-333	529	54.20	0.19	0.19	0.00	0.00	0.00	0.00	0.19	0.19	0.00
	1.13	0.00	0.95	0.38	2.26	0.19	3.78	1.13	0.00	0.38	0.00
	6.42	0.57	0.19	0.38	1.32	0.00	0.00	0.00	0.57	0.38	1.32
	0.00	0.57	0.19	0.38	15.50	0.19	0.38	0.00	0.00	0.38	0.00
	1.32	0.19	0.00	0.00	0.00	0.38	0.19	0.00	0.00	0.00	0.38
	0.00	0.00	0.19	0.19	0.19	0.00	0.00	1.32	0.00	0.19	0.19
	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00
	0.19	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										

species percents

V21-203	514	33.80	0.00	0.00	0.39	0.00	0.00	0.00	0.58	0.19	0.00
	0.97	0.78	2.14	0.78	0.39	0.78	6.42	0.97	1.55	7.19	0.00
	0.19	0.19	0.39	1.16	0.97	0.00	0.19	0.39	0.19	0.58	0.19
	0.00	0.58	0.00	0.97	23.30	1.55	0.19	0.78	0.39	0.39	0.00
	0.39	0.19	1.94	0.19	0.58	0.00	0.39	0.19	0.97	0.58	0.00
	0.00	0.00	0.58	0.19	0.19	0.19	0.00	0.00	0.00	0.00	0.00
	0.19	1.75	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00
	0.58	0.19	0.19	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00
	0.00										
V24-51	516	36.40	0.00	0.00	0.39	0.00	0.00	0.00	0.19	0.00	0.19
	0.97	0.39	2.32	2.13	0.19	1.35	3.29	1.16	1.16	2.90	0.00
	0.19	1.16	0.00	0.58	0.78	0.00	0.39	0.19	0.19	0.00	0.19
	0.00	0.00	0.00	0.19	19.30	0.58	0.39	0.19	0.00	2.32	0.00
	0.00	0.00	2.13	0.39	2.13	1.35	0.19	0.78	1.93	0.19	0.00
	0.00	0.00	0.39	0.00	0.19	0.19	0.00	0.00	0.00	0.39	0.19
	0.39	2.90	0.19	0.00	0.19	0.00	0.19	0.00	0.58	3.48	0.19
	0.58	0.00	0.39	0.00	0.00	0.58	0.19	0.19	0.00	0.19	0.00
	0.00										
V24-49	507	26.40	0.00	0.20	0.99	0.20	0.00	0.20	0.20	0.20	0.79
	0.79	0.39	3.55	0.79	0.20	0.59	3.35	0.99	0.79	6.70	0.00
	0.00	0.20	0.39	0.79	0.79	0.00	0.59	0.00	0.99	0.79	0.59
	0.00	0.20	0.00	0.00	24.00	1.18	0.20	0.39	0.39	2.36	0.00
	0.20	0.00	2.16	0.39	1.38	1.18	0.00	0.79	2.76	0.20	0.00
	0.00	0.00	0.59	0.00	0.39	0.39	0.00	0.20	0.39	0.00	0.20
	0.59	0.79	0.20	0.00	0.00	0.39	0.00	0.59	0.99	2.16	0.20
	0.20	0.39	0.20	0.00	0.00	0.59	0.00	0.59	0.00	0.00	0.00
	0.20										
6705-6	507	37.40	0.39	0.00	0.20	1.57	0.00	1.97	5.12	0.00	0.79
	0.00	0.00	0.00	4.93	0.39	0.00	0.00	3.74	2.95	0.99	0.59
	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.15	1.18
	0.00	0.59	0.00	0.00	4.14	0.00	0.00	0.00	0.00	0.00	3.35
	0.00	0.00	0.00	0.39	0.20	0.00	0.99	0.20	0.00	0.39	1.97
	0.00	0.39	0.00	0.20	0.00	2.56	0.00	3.94	0.20	1.18	2.16
	0.00	4.53	0.00	0.00	1.77	0.99	0.00	0.79	0.39	0.39	0.00
	0.20	0.59	0.00	0.00	0.20	0.20	0.20	0.79	0.20	0.00	0.00
	0.00										
Y70-1-1	504	53.30	0.20	0.00	4.36	0.40	0.00	0.79	2.77	0.00	2.77
	0.00	0.00	0.00	0.79	0.00	0.00	0.00	4.36	2.57	0.60	0.00
	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.99	0.20
	0.00	0.20	0.79	0.00	3.96	0.00	0.00	0.00	0.00	0.99	0.20
	0.00	0.00	0.00	0.40	0.60	0.00	0.99	0.20	0.00	0.00	0.00
	0.00	0.00	0.00	0.60	0.00	0.79	0.00	1.98	0.20	1.38	1.78
	0.00	6.34	0.20	0.00	0.20	0.00	0.00	0.60	0.20	1.19	0.00
	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.60	0.20	0.00	0.00
	0.00										
Y70-2-41	521	38.10	1.15	0.00	0.00	1.15	0.00	1.15	4.79	0.00	3.07
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.49	1.53	0.38	0.38
	0.00	0.00	0.00	0.00	0.00	0.96	0.19	0.00	0.58	3.64	1.72
	0.00	2.49	0.00	0.00	0.19	0.00	0.58	0.00	0.00	0.00	0.00
	0.00	0.38	0.00	0.00	0.00	0.00	0.19	0.19	0.00	0.38	0.00
	0.00	3.64	0.00	0.96	0.00	4.03	0.19	2.87	3.26	0.77	2.87
	0.00	0.19	0.00	10.30	3.07	0.38	0.00	0.38	0.38	0.58	0.96
	0.38	0.00	0.19	0.19	0.00	0.00	0.00	0.19	0.00	0.00	0.00
	0.00										
65-11-69	500	34.60	3.60	0.00	0.40	0.40	0.00	0.80	2.40	0.00	1.40
	0.20	0.00	0.00	3.00	0.80	0.40	0.00	4.00	2.00	0.20	0.00
	0.80	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.40	1.80	2.20
	0.00	1.00	0.00	0.00	1.00	0.00	0.20	0.00	0.00	0.00	4.00
	0.00	0.00	0.00	0.60	0.00	0.00	1.00	0.40	0.00	0.00	0.80
	0.00	0.60	0.00	0.20	0.00	5.20	0.00	10.80	0.20	0.20	2.80
	0.00	1.60	0.00	0.00	0.80	0.60	0.00	0.60	0.00	0.60	0.80
	0.60	0.20	0.00	0.40	0.20	0.40	0.60	0.80	0.60	0.00	0.00
	0.40										
6910-4	500	41.60	0.40	0.00	1.00	0.20	0.00	0.60	0.40	0.00	5.40
	0.00	0.00	0.20	0.80	0.20	0.60	0.00	9.20	0.20	0.40	0.00
	0.60	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	1.40	0.20
	0.00	1.20	0.40	0.20	7.40	0.00	0.00	0.00	0.00	2.20	1.00
	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.40	0.20
	0.00	0.00	0.00	0.80	0.00	11.40	0.00	5.80	0.00	0.00	0.60
	0.00	2.20	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00
	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.20	0.20	0.00
	0.40										
Y70-5-63	503	36.30	0.20	0.00	0.20	1.78	0.00	4.17	2.18	0.00	2.78
	0.00	0.00	0.20	2.78	0.00	0.00	0.00	7.75	3.97	0.40	0.00
	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	1.78	1.59
	0.00	1.39	0.20	0.20	1.39	0.00	0.20	0.00	0.00	0.40	1.39
	0.00	0.00	0.00	0.00	0.20	0.00	0.99	0.00	0.00	0.40	0.20
	0.00	1.39	0.00	0.40	0.00	8.15	0.20	2.18	0.20	0.60	3.57
	0.00	1.39	0.00	0.00	1.59	0.20	0.00	0.40	0.60	1.39	0.40
	0.20	0.00	0.00	0.00	0.40	0.99	0.00	1.39	0.00	0.00	0.00
	0.40										
Y70-5-64	511	41.40	0.19	0.00	0.00	0.78	0.00	1.36	3.52	0.00	5.28
	0.00	0.00	0.00	0.78	0.00	0.00	0.00	7.63	1.76	0.98	0.39
	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.19	2.34	1.56
	0.00	1.36	0.19	0.78	0.39	0.00	0.00	0.00	0.00	0.19	0.39
	0.00	0.00	0.00	0.00	0.39	0.00	0.78	0.19	0.00	0.39	0.00
	0.00	1.95	0.00	1.17	0.00	8.61	0.39	0.59	0.59	0.19	3.32
	0.00	3.32	0.00	0.00	0.39	0.19	0.00	0.98	0.78	0.98	0.00
	0.19	0.00	0.59	0.00	0.00	0.39	0.00	0.98	0.00	0.19	0.00
	0.00										

Appendix B: radiolarian data from surface sediments cont.

species percents

Y70-5-67	543	43.60	0.92	0.00	0.18	1.47	0.00	1.28	4.05	0.00	5.34
	0.18	0.00	0.00	2.02	0.18	0.00	0.00	5.70	0.55	0.37	0.37
	0.18	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.18	2.02	1.65
	0.00	0.55	0.18	0.00	1.47	0.00	0.00	0.00	0.00	0.55	0.00
	0.00	0.55	0.00	0.37	0.37	0.00	0.74	0.18	0.00	0.18	0.18
	0.00	2.76	0.00	0.92	0.18	5.34	0.00	0.00	0.18	0.37	2.20
	0.00	4.60	0.00	0.00	0.18	0.37	0.00	0.92	0.92	3.86	0.00
	0.00	0.00	0.55	0.00	0.00	0.92	0.18	0.55	0.00	0.00	0.00
	0.00										
Y70-5-62	512	38.40	0.39	0.00	0.59	1.95	0.00	3.71	3.12	0.00	3.32
	0.00	0.00	0.00	2.34	0.00	0.00	0.00	5.66	1.95	0.39	0.19
	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.59	0.00	1.95	1.56
	0.00	1.17	0.59	0.00	0.78	0.00	0.00	0.00	0.00	0.98	0.19
	0.00	0.39	0.00	0.59	0.00	0.00	0.59	0.19	0.00	0.39	0.59
	0.00	1.36	0.00	1.36	0.00	7.22	0.00	0.59	0.39	1.36	3.32
	0.00	5.07	0.00	0.00	1.36	0.00	0.00	0.00	0.39	0.39	0.00
	0.19	0.59	0.00	0.00	0.00	0.78	0.00	2.14	0.00	0.19	0.00
	0.39										
Y70-4-56	505	45.70	0.59	0.00	0.00	0.00	0.00	0.99	0.99	0.00	6.93
	0.00	0.00	0.40	0.00	0.00	0.20	0.00	5.14	0.00	1.18	0.20
	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.20	0.40	2.77	0.59
	0.00	4.95	0.00	0.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.79	0.00
	0.00	0.79	0.40	2.17	0.00	8.31	0.00	0.20	2.77	0.20	1.18
	0.00	0.40	0.00	6.33	1.38	0.00	0.00	0.40	0.40	0.20	0.00
	0.00	0.00	0.40	0.00	0.00	0.59	0.00	0.40	0.00	0.00	0.00
	0.00										
Y70-4-51P	501	37.10	0.20	0.00	0.00	0.40	0.00	1.79	3.99	0.00	4.19
	0.00	0.00	0.00	1.79	0.00	0.00	0.00	4.79	3.19	0.20	0.00
	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.40	0.60	2.79	0.00
	0.00	0.60	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.00	0.00
	0.00	0.20	0.20	0.40	0.00	0.00	0.40	0.00	0.00	0.00	0.40
	0.00	2.99	0.00	0.60	0.00	2.19	0.00	0.20	4.19	0.80	5.58
	0.00	0.40	0.00	6.38	3.99	0.40	0.20	2.99	0.00	0.40	0.20
	0.20	0.20	0.00	0.40	0.00	0.20	0.00	1.39	0.60	0.00	0.00
	1.00										
LFGS-48G	502	40.60	1.00	0.00	0.60	1.00	0.00	1.19	1.39	1.79	0.00
	0.00	0.40	0.20	1.00	0.20	3.38	0.80	6.57	2.39	3.18	0.00
	1.00	0.00	0.00	0.00	0.20	0.00	0.00	0.80	0.00	1.59	1.39
	0.00	1.19	0.00	0.00	7.96	0.20	0.00	0.00	0.20	2.19	1.39
	0.00	0.00	0.00	0.40	0.20	0.00	0.20	0.60	0.00	0.20	0.20
	0.00	0.00	0.40	1.39	0.00	4.58	0.00	2.39	0.00	0.00	1.59
	0.00	2.78	0.20	0.00	0.40	0.60	0.00	0.00	0.20	0.40	0.00
	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.00
	0.00										
LFGS-50G	525	39.40	0.57	0.00	1.14	2.09	0.00	2.09	1.52	0.00	1.33
	0.00	0.19	0.00	0.57	0.19	2.66	0.95	7.61	1.14	2.28	0.19
	1.52	0.00	0.00	0.00	0.00	0.00	0.38	0.57	0.00	1.14	1.33
	0.00	0.95	0.00	0.00	12.00	0.00	0.00	0.00	0.19	1.71	2.09
	0.00	0.00	0.00	0.19	0.57	0.19	0.76	0.00	0.00	0.19	0.00
	0.00	0.00	0.00	0.57	0.00	2.85	0.19	1.90	0.19	0.00	0.57
	0.00	3.23	0.00	0.00	0.38	0.38	0.00	0.19	0.00	0.95	0.00
	0.38	0.19	0.00	0.00	0.19	0.00	0.00	0.57	0.00	0.00	0.00
	0.00										
LPFG-68G	510	33.10	3.13	0.00	0.20	0.78	0.00	3.13	3.13	0.00	3.33
	0.00	0.00	0.00	2.74	0.39	0.59	0.39	6.27	1.96	0.59	0.00
	1.17	0.00	0.00	0.00	0.00	0.20	0.59	1.56	0.00	0.78	3.92
	0.00	0.59	0.00	0.00	4.90	0.00	0.00	0.00	0.00	0.59	2.35
	0.00	0.00	0.00	0.20	0.20	0.00	0.59	0.00	0.00	0.39	0.59
	0.00	0.20	0.20	1.17	0.20	3.72	0.20	8.03	0.00	0.20	2.15
	0.00	2.35	0.00	0.00	0.39	1.17	0.00	0.78	0.39	0.39	0.20
	0.39	0.20	0.20	0.00	0.20	1.17	0.20	1.56	0.00	0.00	0.00
	0.00										
SCAN-5PG	508	40.30	0.59	0.00	1.57	1.77	0.00	1.18	0.79	0.00	1.37
	0.20	0.20	0.20	0.59	0.20	2.36	0.00	3.14	0.59	1.96	0.00
	0.79	0.00	0.00	0.00	0.20	0.39	0.20	0.00	0.00	0.79	0.59
	0.00	1.57	0.98	0.00	13.30	0.00	0.00	0.00	0.00	1.37	2.36
	0.00	0.00	0.00	0.00	0.98	0.00	0.20	0.39	0.00	0.39	0.00
	0.00	0.39	0.00	0.00	0.00	5.11	0.00	3.34	0.39	0.00	1.57
	0.00	4.33	0.00	0.00	0.79	0.20	0.00	0.20	0.59	0.39	0.00
	0.00	0.39	0.20	0.20	0.00	0.00	0.20	0.20	0.00	0.00	0.00
	0.20										
R1S-36	502	26.20	0.00	1.00	0.60	0.00	0.00	0.60	0.00	0.00	3.38
	0.80	0.40	2.39	0.00	0.40	0.40	4.78	5.97	0.00	2.58	0.00
	0.20	0.00	0.00	0.40	0.20	0.00	0.00	0.60	0.40	1.59	2.58
	0.00	25.20	0.20	0.00	8.36	0.40	0.00	0.00	0.00	3.18	0.20
	0.00	0.00	1.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.60	0.40	0.00	0.00	0.00	0.00	0.00	0.20	0.20
	0.20	0.80	2.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
R15-127G	511	38.70	0.00	1.17	0.59	0.39	0.00	0.19	0.19	0.00	1.17
	0.78	2.54	0.98	0.39	0.98	0.19	1.17	6.84	0.00	2.34	0.00
	0.00	0.00	0.00	0.19	0.00	0.00	0.19	0.39	0.00	0.00	0.00
	0.00	18.70	0.00	0.00	10.70	1.17	0.00	0.00	0.19	3.32	0.00
	0.00	0.00	0.00	0.19	0.00	0.39	0.19	0.00	0.00	0.39	0.00
	0.00	0.00	0.98	0.19	0.00	0.98	0.00	0.19	0.00	0.00	0.19
	0.00	0.19	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
TRI-8PG	500	40.60	0.00	0.80	0.20	0.40	0.00	0.60	0.00	0.80	0.20
	1.20	0.20	1.60	1.20	0.40	0.60	2.40	1.20	0.00	0.80	0.00
	0.20	0.00	0.20	0.00	0.00	0.40	0.20	0.00	0.60	0.60	0.40
	0.00	2.00	0.00	0.00	15.40	0.20	0.40	2.00	0.60	1.80	0.80
	1.80	0.40	1.60	0.20	1.20	0.60	0.20	1.00	0.00	0.20	0.40
	0.00	0.00	0.80	0.20	0.40	0.40	0.00	1.60	0.00	0.20	0.20
	0.20	4.60	0.80	0.00	0.60	0.00	0.60	0.00	0.40	0.60	0.00
	0.40	0.20	0.00	0.00	0.00	0.20	0.60	0.40	0.00	0.00	0.00
	0.00										

species percents

TRI-9G0	528	25.90	0.00	0.38	0.38	0.00	0.00	0.38	0.19	0.00	0.95
	0.57	0.00	0.95	0.38	0.19	2.65	7.95	4.16	0.00	2.84	0.00
	1.51	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.38
	0.19	7.57	0.00	0.00	26.80	0.38	0.00	0.57	0.00	3.21	0.76
	0.00	0.19	3.21	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
	0.76	0.00	0.76	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.38	2.84	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.00
	0.19	0.00	0.00	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.00
	0.19										
TRI-11G	454	37.60	0.22	0.44	0.00	0.00	0.00	0.22	0.00	0.00	2.20
	3.08	0.44	0.00	0.00	0.00	0.44	2.86	3.74	0.00	2.86	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	1.10	0.00
	0.00	26.60	0.00	0.00	10.10	0.44	0.00	0.00	0.00	2.20	0.00
	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.44	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
ZTS-42G	512	63.00	0.00	0.78	0.39	0.00	0.00	0.00	0.00	0.00	0.39
	0.00	0.78	0.39	0.00	0.19	0.19	0.39	2.92	0.00	2.73	0.59
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.19
	0.00	14.20	0.00	0.00	5.27	2.34	0.00	0.00	0.00	1.56	0.00
	0.00	0.00	0.78	0.00	0.00	0.19	0.00	0.00	0.00	0.59	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
ZAP-2G	512	41.40	0.39	0.19	0.00	0.19	0.00	0.19	0.00	0.39	0.19
	0.98	0.00	0.00	1.36	0.00	0.78	3.71	0.39	0.78	2.34	0.00
	0.98	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.19	0.59
	0.00	0.00	0.00	0.39	22.40	0.19	0.39	0.98	0.59	1.56	0.59
	4.49	0.00	0.59	0.00	0.39	0.59	0.39	1.17	0.00	0.19	0.00
	0.00	0.00	0.39	0.00	0.59	0.19	0.19	1.17	0.00	0.00	0.00
	0.19	0.98	0.78	0.00	0.00	0.59	0.19	0.39	0.19	1.36	0.00
	0.98	0.59	0.19	0.00	0.19	0.00	0.39	0.59	0.00	0.00	0.00
	0.00										
6910-2PG	519	35.60	1.15	0.00	0.58	0.96	0.00	3.27	3.66	0.00	1.54
	0.00	0.39	0.00	2.11	0.39	0.96	0.00	8.28	3.27	1.34	0.19
	0.39	0.00	0.00	0.00	0.00	0.58	0.19	0.00	0.19	1.15	2.69
	0.00	1.15	0.39	0.00	5.20	0.00	0.00	0.00	0.00	0.19	2.50
	0.00	0.00	0.00	0.39	0.19	0.00	1.73	0.00	0.00	0.19	0.00
	0.00	0.77	0.19	1.15	0.00	1.54	0.00	6.93	0.00	0.39	2.11
	0.00	4.43	0.00	0.00	0.77	0.77	0.00	0.00	0.00	0.00	0.00
	0.00	0.19	0.00	0.19	0.00	0.00	0.00	0.19	0.00	0.00	0.19
	0.00										
FAN-HMS-1G	512	38.00	0.00	0.98	0.19	0.00	0.00	0.98	0.00	0.00	4.29
	0.59	1.95	1.56	0.00	0.00	0.78	4.29	6.25	0.00	0.59	0.00
	0.19	0.00	0.00	0.00	0.19	0.00	0.00	0.59	0.00	0.78	0.19
	0.00	9.17	0.00	0.00	18.90	2.53	0.19	0.19	0.00	1.36	0.19
	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00
	0.00	0.00	0.19	0.00	0.00	1.36	0.00	1.17	0.00	0.00	0.39
	0.00	0.78	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
MEN-36	500	39.60	2.20	0.00	0.60	0.20	0.00	0.60	2.60	0.00	8.00
	0.00	0.40	0.20	0.40	0.80	1.80	1.60	11.80	0.00	0.00	0.20
	2.20	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.20	1.80	0.00
	0.00	1.40	0.20	0.00	8.20	0.00	0.00	0.20	0.00	1.80	1.00
	0.00	0.00	0.20	0.00	0.00	0.00	0.80	0.20	0.00	0.40	0.00
	0.40	0.00	0.00	0.60	0.20	4.20	0.00	2.00	0.20	0.00	1.60
	0.00	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
	0.00										
MEN-4G	509	32.60	0.39	0.00	0.00	0.79	0.00	0.00	1.17	0.00	8.05
	0.00	0.59	0.20	0.00	0.00	1.37	1.57	15.10	0.39	0.00	0.00
	1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.59
	0.00	8.44	0.00	0.00	13.50	1.96	0.00	0.00	0.00	2.94	0.00
	0.00	0.00	0.00	0.00	0.39	0.00	0.20	0.00	0.00	0.98	0.00
	0.00	0.00	0.00	1.57	0.00	3.33	0.00	0.59	0.00	0.00	0.00
	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00										
MEN-5G	502	35.60	1.79	0.00	0.40	1.00	0.00	4.18	2.19	0.00	1.99
	0.20	0.00	0.20	1.19	0.80	2.58	0.20	7.56	1.00	1.19	0.00
	2.19	0.00	0.00	0.40	0.00	0.00	0.20	0.40	0.00	1.19	0.60
	0.00	0.80	0.00	0.20	11.70	0.00	0.00	0.00	0.00	1.19	2.19
	0.00	0.00	0.00	0.20	1.79	0.20	0.80	0.00	0.00	0.40	0.00
	0.00	0.20	0.00	0.20	0.00	6.37	0.00	2.19	0.00	0.00	0.80
	0.00	1.59	0.80	0.00	0.20	0.00	0.00	0.20	0.00	0.20	0.00
	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
	0.00										
Y69-106	500	32.80	0.00	0.60	0.40	0.00	0.00	0.80	0.20	0.00	1.00
	1.80	0.20	0.20	0.40	0.40	0.40	6.20	1.80	0.20	6.60	0.00
	0.80	0.60	0.20	0.00	0.20	0.00	0.40	0.00	0.20	0.60	0.20
	0.00	0.40	0.00	1.80	23.20	3.00	0.40	1.60	0.80	0.40	0.20
	0.40	0.20	3.00	0.00	0.40	0.40	0.60	0.60	0.00	0.20	0.00
	0.00	0.00	0.20	0.40	0.00	0.80	0.00	0.00	0.00	0.00	0.00
	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.60	0.00
	0.40	0.00	0.60	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00
	0.00										
6808-8	504	32.50	0.00	0.00	0.00	0.99	0.00	1.58	1.58	0.00	22.20
	0.20	0.00	0.20	0.40	0.00	0.40	0.00	5.95	4.56	0.40	0.00
	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.20	0.20	3.76	0.40
	0.00	4.76	1.38	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.40	0.00	0.00	0.40	0.00	0.00	0.60	0.40
	0.00	0.20	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.60	0.99
	0.00	3.96	0.00	5.95	0.20	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00
	0.00										

Appendix B: radiolarian data from surface sediments cont.

species percents

W8709-13TC	546	33.80	3.11	0.00	0.18	0.00	0.00	1.09	2.19	0.00	1.28
	0.00	0.00	0.00	1.28	0.37	0.55	0.00	2.56	4.39	0.73	0.00
	1.28	0.00	0.00	0.00	0.00	0.00	0.18	1.64	0.37	2.56	2.38
	0.00	0.92	0.37	0.00	1.09	0.00	0.18	0.00	0.00	0.18	4.76
	0.00	0.00	0.00	1.28	0.55	0.18	0.73	0.37	0.00	0.00	0.18
	0.00	0.73	0.00	0.73	0.18	4.02	0.18	10.40	0.92	0.55	2.01
	0.00	1.64	0.00	0.00	0.37	1.09	0.00	0.55	1.09	1.09	0.00
	0.18	0.18	0.00	0.00	0.55	0.92	0.37	0.18	0.37	0.18	0.55
	0.00										
W8709-8TC	615	37.70	1.95	0.00	0.49	0.81	0.00	0.81	0.98	0.00	0.49
	0.00	0.00	0.00	1.30	0.98	0.98	0.00	2.60	3.73	0.49	0.00
	2.76	0.00	0.00	0.00	0.16	0.00	0.49	1.46	1.30	0.98	2.11
	0.49	0.33	0.49	0.00	1.62	0.00	0.00	0.00	0.00	0.49	3.25
	0.00	0.00	0.00	1.30	1.13	0.16	0.49	0.33	0.00	0.16	0.65
	0.00	0.00	0.33	0.00	0.16	6.66	0.16	8.29	0.16	0.00	2.60
	0.00	2.76	0.00	0.00	0.33	0.33	0.98	0.16	0.81	0.98	0.00
	0.16	0.00	0.00	0.33	0.33	0.16	0.00	0.16	0.16	0.49	0.00
	0.00										
W8709-PC2	546	32.20	1.28	0.00	0.18	0.37	0.00	2.56	2.01	0.00	2.01
	0.18	0.00	0.00	0.18	0.73	2.56	0.00	4.76	4.21	0.18	0.00
	0.37	0.00	0.00	0.00	0.18	0.00	0.18	0.55	0.18	2.01	0.55
	0.00	0.55	0.18	0.18	9.15	0.00	0.00	0.00	0.00	3.66	1.09
	0.00	0.00	0.00	0.73	2.19	0.00	0.37	0.37	0.18	0.00	0.92
	0.00	0.00	0.18	0.73	0.00	4.76	0.37	2.93	0.00	0.18	2.74
	0.00	4.76	0.37	0.00	0.55	0.55	0.37	1.46	0.18	0.37	0.18
	0.00	0.00	0.18	0.00	0.18	0.18	0.18	0.92	0.18	0.37	0.00
	0.00										