Chapter 2

Physical and Biological Factors Determining the Spatial Distribution of Zooplankton Near the Monterey Bay Upwelling Shadow Front, Monterey Bay, California

Introduction

The term “front” has been used to define a physical manifestation marked by steep horizontal gradients in the ocean. While fronts can be generated by many different physical processes and can exist over different scales of space and time, they all share the common feature of vertical flow around the convergence of water masses of different origins (Owen, 1981). The interplay of flow dynamics at fronts and the resulting distribution of zooplankton have been studied for over a century (Haeckel, 1893). The aggregation of biological and non-biological materials at fronts is well reported in the literature (e.g. Haeckel, 1893; Beebe, 1926; Knauss, 1957), yet in most frontal aggregation studies, the behavior of the animals themselves has been neglected, and thus the concentration of animals at fronts has been assumed to be the result of flow characteristics acting solely in concert with buoyant forces (e.g. Kosobokova and Hirche, 2000; Labat *et al.*, 2002; and many others). Nonetheless, aggregations of animals can have profound ecological, evolutionary and behavioral consequences (Owen, 1981; Wolanski and Hamner, 1988; Haury and Pieper, 1988). Any behavior that promotes aggregation at fronts and which enhances feeding, survival, and/or reproductive success should be conserved over evolutionary time. Indeed, the life histories of many coastal marine and estuarine fish and invertebrates are tied to the formation and movement of fronts. For example, pulse recruitment events have been shown to coincide with the relaxation of coastal upwelling fronts that collide with shore as winds decline

(Roughgarden *et al.*, 1991; Wing *et al.*, 1995a; Wing *et al.*, 1995b; Shanks *et al.*, 2000; Brubaker and Hooff, 2000).

Although researchers have begun to realize the extent to which animal behavior may contribute to patch formation (Omori and Hamner, 1982), few behavioral studies of plankton in fronts are reported in the literature (Shanks, 1986; Epifanio, 1987; Chapter 1, this dissertation). This is likely due to the difficulty of measuring behavior around an oceanographic feature that is not fixed in space or to the problem of inferring behavior from net tows when direct observation is not possible. The traditional method of estimating species abundance and diversity at sea usually involves observing changes within a grid or fixed frame of reference. However, such a scenario never exists when measuring abundance and diversity around fronts, where are always shifting in space and time. Furthermore, in any water mass, organisms are invariably patchy, often quite abundant at small scales when surrounding waters are seemingly depauperate. Averaging the concentration of animals in the patch over an area that includes much empty space can yield an inappropriate measure of spatial abundance (Omori and Hamner, 1982), a fact that has been appreciated for many years (Haeckel, 1893). Therefore, repeated sampling using the front as the frame of reference is often the only way to collect meaningful data on abundance and diversity of organisms at sea.

Further, it is often exceptionally difficult to make direct behavioral observations of animals at sea. The ecological relevance of behavioral studies conducted in a laboratory setting is often questionable because reproducing open ocean frontal conditions in a laboratory is generally not feasible. The most realistic way to evaluate animal behavior at sea is by *in situ* observation (Hamner *et al.*, 1975, Hamner *et al.*, 1987), even though many of the difficulties associated with making accurate biological measurements at fronts using nets are further complicated when the researcher is effectively underwater. Direct observation of plankton has been confined to three methods – manned submersibles (Beebe, 1934; Youngbluth, 1989), blue-water scuba diving techniques (Hamner, 1975), and remote operated vehicles (Robison, 2004).

Data on plankton behavior can also be gathered by indirect methods. For example there have been numerous studies of diel vertical migration, where discrete-depth tows over time can document changes in depth distribution over a 24-hour period of time (e.g. Mileikovsky, 1973; Bryars and Havenhand, 2004). Recently, Genin *et al.* (2005) used acoustics to track zooplankton at the edge of a coral reef, demonstrating vertical swimming behavior against flow in order to maintain a fixed vertical distribution. Lastly, one might compare the distribution of actively swimming zooplankton to that of natural passive tracers, but this approach appears missing from the frontal literature. Such an approach may offer insight into whether or not plankton can actively regulate their horizontal distribution irrespective of prevailing surface currents. If the distribution of swimming zooplankton is significantly different from that of passive tracers, then one can infer some degree of behavior as a potential cause. However, if the distributions are the same, then three interpretations are possible. Either (1) swimming ability is irrelevant, and the observed aggregation is entirely the result of advection, (2) swimming ability is only important at the frontal boundaries where horizontal velocities are reduced and vertical velocities become important, where animals need only swim vertically to maintain their concentration at the front, or (3) despite the similar distribution, competent swimmers will actively seek those currents that transport them to the nutrient enhanced frontal zones, thus reducing energy expenditure and the need for active searching.

The aim of this study was to investigate the behavior of zooplankton as it contributes to their fine-scale spatial distribution around the seasonal “upwelling shadow” frontal system in Monterey Bay (Graham *et al*., 1992), where large concentrations of zooplankton had been noted. While many plankton studies have been conducted in Monterey Bay (e.g. Baduini, 1997; Garrison, 1976), few investigations have focused specifically on the seasonal front (Graham et al, 1992). We make inferences about the behavior of zooplankton by comparing the distribution of different species of motile zooplankton to that of passive fish and euphausiid eggs, which serve as slightly buoyant, non-swimming tracers whose spatial distribution is determined entirely by physical properties. Some or much of the difference in distribution between active swimmers and passive particles must relate to behavior of the zooplankton. We hypothesize that while plankton distribution will generally be greater at fronts, certain animals, particularly meroplankton whose development necessitates movement towards or away from shore, may not follow this pattern, and that even if such species are more abundant at the front, they will be skewed in their distribution differently than fish and invertebrate eggs. Additionally, preference for certain water properties may be equally important in explaining the distribution of holoplanktonic species, as was the case for large jellies that were observed in high abundance on the Monterey upwelling shadow front and in the inshore warmer water mass, compared to the lower abundance in the colder offshore water mass (Chapter 1, this dissertation). Finally, the distribution of eggs can qualitatively reveal the nature of the flow around a front, where a proportionally large amount of eggs at the front would suggest a strong convergence, whereas a proportionally smaller aggregation may indicate a shear front where leakage can occur.

The general flow characteristics of the Monterey Bay upwelling shadow are well known (Breaker and Broenkow, 1994; Graham and Largier, 1997). Offshore advection of surface waters north of Monterey Bay result from equatorward winds, particularly around the Pt. Año Nuevo headland. The colder bottom waters that are brought to the surface are then blown southward and are entrained into the bay, creating an upwelling shadow. During times of especially intense sustained winds, the entrained colder waters will contact the coastline in the vicinity of Moss Landing, where the waters must veer north and south. In the northern portion of the Bay, solar insolation eventually heats the surface waters as it travels in a counter clockwise direction. A front is formed where the heated waters meet the newly upwelled colder waters, as characterized by a pronounced thermal discontinuity, usually just offshore of Santa Cruz.

Materials and Methods

Zooplankton was collected during two research cruises in 2000. The first occurred on April 24, 2000 aboard the vessel RV Sea World UCLA, and the second occurred on August 23-24, 2000 aboard the Moss Landing Marine Laboratory vessel RV Ed Ricketts. We examined sea surface temperature satellite images for the development of upwelling conditions off Pt. Año Nuevo, north of Monterey Bay, prior to each field effort. In early April 2000, satellite images of sea surface temperature indicated an upwelling event had begun off Pt. Año Nuevo (CoastWatch West Coast Regional Node website, www.coastwatch.pfel.noaa.gov). The colder, upwelled surface waters were transported via northwest winds into the bay. A sea surface temperature satellite image from the April sampling day indicated that an upwelling shadow was present, creating a steep thermal gradient approximately 4 km south of Santa Cruz (Figure 2-1).

Four vertical plankton tows were conducted along one transect extending in a southwest direction beginning approximately 3.5 km south of Santa Cruz (Figure 2-2). Tows were spaced approximately 2 km apart beginning at 33^{o} 55.65' latitude and 121^{o} 00.05' longitude, and ending at 33^{o} 53.65' latitude and 121^{o} 03.26' longitude, for a total of 6 km traveled. A temperature sensor on the boat was used to plot surface temperature along the length of the transect. Plankton collections for all four tows were completed by 1300 hrs.

A paired plankton net was used for sample collections. Each of the 333-μm mesh, 3 m-long nets was affixed to one side of a stainless steal frame in the shape of a figure eight (Figure 2-3). The paired nets were fastened midway between the two nets, thus eliminating the use of a bridle in front of the nets. At the cod ends, a cross-brace joined the cod ends and was attached to the wire, thereby holding the nets extended. The nets were sunk to depth, cod-end first, by a 23 kg lead weight. The wire went slack when the weight rested on the sea bed. The winch operator thus kept the mouths of the nets about 3 m above the bottom, preventing sediment from fouling the nets and reducing the chance of inadvertently capturing benthic animals. Nets were retrieved at a steady pace. This procedure was used for all depths shallower than 40 m. For the deeper stations, the nets were only lowered to 40 m. In this way, two zooplankton samples were collected at each station.

Water volume sampled was estimated using a General Oceanics Model 2030 mechanical flowmeter mounted in the middle of the mouth of each net. These flowmeters were calibrated for distance before the field expedition began by hand towing them along a dock of a known length. Ten readings were recorded at three distances (25, 50 and 100 m), averages were taken, and a regression was made over distance. During the vertical tows, the flowmeters spun freely both on descent and ascent, and so overall distance was divided in half. The angle of descent was noted during each cast because in strong winds ship drift did not permit vertical deployment. In the event that the wire angle was greater than 10^{o}, the net was lowered further until it reached 40 m. The first two casts occurred in the morning when winds were light and the wire was vertical (less than 5^{o} deviation), and the distance sampled was calculated by the flowmeters and the amount of wire out; these two measurements differed by less than 0.5%. However, during the last two casts, later in the morning when wind speeds exceeded 10 kn, more than 40 m of line was deployed to reach sampling depth. The flowmeters indicated that distances sampled were 2 and 6% greater than 40 m. This increase coincided with a respective deviation in the wire angle by 10 and 20^{o} from vertical, as predicted from depth and angle geometry.

No quantitative effort was made to determine the depth distribution of plankton in the vertical hauls, although we noted the location of particularly dense plankton patches, as determined by the signal intensity on the fathometer. In every tow, the greatest acoustic signal intensity was at or above the thermocline, with very little sound reflection from below the thermocline. This indicated that the overwhelming majority of acoustically detected zooplankton was in the upper 12 m of the water column. Using the entire distance of the tow to calculate plankton densities produced conservative density estimates, particularly for the deeper stations.

Samples were transferred from the cod ends into 250 μm sieves to concentrate the animals, and then immediately moved into 500 ml plastic containers where they were fixed in 4-5% buffered formalin and seawater. Samples remained in the fixative for eleven months, after which plankton volumes were estimated using the displacement method of Kramer *et al.* (1972). Each sample was divided using a Folsom plankton splitter until roughly 1000 animals remained. This sub-sample was stored in a glass vial and kept with its parent split. The sub-samples were transferred to seawater with less than 0.5% buffered formalin and refrigerated at approximately 3^{o}C. Samples were kept in this state for three weeks before sorting. Before animals were actually identified and enumerated beneath the microscope, they were transferred into one of two containers of either 1% buffered formalin and seawater for gelatinous animals (cnidarians, ctenophores, salps and chaetognaths), or 70% ethanol for all other animals. All animals in the sub-sample were identified and counted. A coarse visual examination of the parent sample was also conducted so as to ensure the proper enumeration of rare species that may have been under-represented in the sub-samples. For most zooplankton, numbers in the sub-sample split were multiplied proportionally to estimate the total abundance in the sample, and these numbers were then divided by the volume of water sampled to estimate the number of plankton per cubic meter.

Our second collecting effort commenced on August 23-24, 2000 as part of a larger study coordinated by the Monterey Bay Aquarium Research Institute (MBARI) entitled Monterey Ocean Observing System (MOOS) Upper-Water-Column Science Experiment (MUSE). Some supplementary data from other participating investigators have been used in the analysis of our plankton data. The upwelling shadow that was sampled in April had gone through multiple relaxation events from April through August, but satellite images examined in the first two weeks of August indicated a sustained upwelling event again occurring off Point Año Nuevo with colder upwelled surface waters being transported southeast into the bay. A satellite image of sea surface temperature from August 11, 2000 provided one of the few clear views of an upwelling shadow (Figure 2-4), since on most other days clouds obscured at least a portion of the study site.

The August sampling effort was more extensive than for April, with the addition of a physical characterization of the study site described in Chapter 1 of this dissertation. Three transects were completed over a much larger area in the northern part of Monterey Bay, with each extended roughly 10-11 km in a south-southwest direction, beginning approximately 2 km from shore (Figure 2-5). Data from transects 1 and 2 were gathered on August 23, 2000 while transect 3 was carried out on August 24, 2000. A Seabird

SeaCat Profiler SBE 19 (unpumped) CTD (conductivity-temperature-depth) water profiler was used to record in-water physical measurements. Along transects 1 and 2, vertical profile casts were evenly spaced at 1 km intervals, culminating in 13 casts for transect 1 and 12 casts for transect 2. Vertical plankton nets were towed in the same manner as in the April collections, with the net descending to the bottom, except when the bottom depth exceeded 50 m in which case the net was only lowered to 50 m. Tows were spaced 2 km apart along the length of Transects 1 and 2, where plankton collections coincided with a vertical CTD profile. The spacing of vertical casts along transect 3 was less even. Seven vertical CTD casts were gathered along the 11.2 km transect, with the first 4 casts (starting from inshore) being spaced at 1 km intervals and the remaining 3 casts being spaced at various distances apart. Five vertical plankton casts were gathered along transect 3, with each collection coinciding with a CTD cast. Plankton samples in August were processed identically to those collected in April with the exception that plankton from only one side of the paired net was processed; the unprocessed samples were archived.

In addition, we used a Guideline Minibat Towed Profiler 8820 housing an Applied Microsystems Ltd. Smart CTD, a SeaTech/WetLabs fluorometer, and a WetLabs C-Star transmissometer along transect 2. This device was towed from the RV Ed Ricketts and directed via computer control in a surface-to-bottom oscillation. Upon completing the vertical casts along Transect 2, we returned to the beginning of the transect and began the Minibat deployment approximately 1 km south of the original starting point and completed the transect 1 km north of the original ending point. Thus, the Minibat transect covered an 8 km distance of Transect 2.

Seasave™ version 1.17 (Seabird Electronics) and SmartTalk™ version 1.10 (Applied Microsystems) were used to convert the raw data from the Seabird 9 profiler and Applied Microsystems™ CTD to tab-delimited format where further data reduction could be made using Microsoft Excel. The data were then imported into Tecplot version 7.5 (Amtec Company) where individual vertical casts along each transect were integrated into a two-dimensional temperature plot over depth and distance for each of the three transects. This was done using an inverse distance interpolation over a grid with the number of interpolation points being no more than twice the number of stations. This was done to minimize over-processing and generating a false interpolation.

To analyze the distributional data from the April and August sampling efforts, a multiple linear regression (MLR) model was generated to determine which measured physical variables best explained the distribution of each taxa. A forward stepwise MLR approach was used to identify the minimum number of significant variables and to avoid strong multicollinearity between each physical variable. In this way, the regression of the abundance (normalized for sampling volume) of each taxonomic group on to the physical measurements provided the proportions of the variation explained by each independent variable. In April, only surface temperature was measured along the transect. Therefore the only independent variables included in the model were (1) distance along the transect, (2) surface temperature, (3) ocean depth, and (4) horizontal temperature change over a 0.5-kilometer distance centered on each station. The latter served as our variable defining any fronts. In the August survey, the independent variables used were (1) distance along the transect, (2) surface temperature, (3) surface salinity, (4) surface density, (5) approximate thermocline depth to within one meter, (6) temperature change in the upper 5 meters, (7) temperature change in the upper 12 meters, and (8) horizontal temperature change over a 0.5-kilometer distance centered on each station. Afterward, salinity was removed from the analysis since it effectively did not change over the study site and did not correlate with temperature. Most variables were normally distributed, except one independent and two dependent variables in the August data set. These variables were log transformed to meet the normality criteria.

Results

April

Physical Data

Advanced Very High-Resolution Radiometry (AVHRR) satellite images prior to the study showed that upwelling was occurring off of the Pt. Año Nuevo headland. Upwelling persisted through the sampling date, as seen in the satellite image of April 24, 2000 (CoastWatch West Coast Regional Node website, www.coastwatch.pfel.noaa.gov, Figure 2-1). Vertical CTD casts were not performed for this portion of the study, although surface temperature was recorded along the transect. A prominent line of flotsam was observed at Tow 2, including kelp, sea grasses, plastics and a number of large gelatinous organisms were seen at the surface during sampling. Upon traveling through the slick, the sea surface temperature dropped from 12.1 to 10.8 ^{o}C in a distance of less than 200 m. No other physical data were gathered during this reconnaissance cruise, however continuous temperature readings along the transect permitted us to calculate a horizontal temperature gradient over a 0.5 km distance centered on each station. Depth of the ocean bottom at each sampling location was also included as an independent variable for analysis even though the nets were never lowered below 40 m.

Plankton Data

Table 2-1 summarizes plankton abundance per cubic meter for each sample. Grouping of species into higher taxa was based on taxonomic relatedness, although certain species were kept separate if their distribution was strikingly different than that of other related members. The majority of meroplankton was grouped in this way because of the difficulty of identifying larvae to the species level. For example, many fish eggs were distinctly different from one another, with unequal representation of some species over others. However, the exact taxonomic placement was unclear for the various fish eggs, and therefore the different eggs were kept separate for the purposes of estimating diversity and species richness but were pooled for numerical comparison. Also, those species that were numerically rare were lumped as “all other species”. The concentration of animals was greatest at the front, as indicated by the almost two-fold increase in numbers of individuals per cubic meter in Tows 2A and B compared to all other tows (Table 2-1). The number of species was generally higher at the front, although the highest species count was seen offshore in Tow 3B, which also had the highest abundance of stations away from the front. Shannon-Weiner diversity index was greatest at one front tow (Tow 2A), although the second highest diversity occurred equally in both inshore Tows 1A and B and in offshore Tow 3B.

Overwhelmingly, the most abundant taxa were copepods and juvenile euphausiids, which comprising 45.0% and 28.0% of the overall total, respectively. The most common genera among the copepods were *Acartia*, *Calanus*, *Tortanus*, *Corycaeus*, and *Rhincalanus*, while the euphausiid juveniles were represented equally by *Euphausia pacifica* and *Thysanoessa spinifera* (confirmed by A. Townsend, Scripps Institution of Oceanography). Roughly 70% of the juvenile euphausiids were calyptopis larvae, with the remainder consisting of mostly early- and mid-stage furcilia. Few late-stage furcilia and no adult euphausiids were captured during the study. Copepods and euphausiids were most abundant in the front samples (Figure 2-6a), and showed a significant association with surface temperature gradient (Table 2-2, Appendix A-1). In the regression of euphausiid juveniles, surface temperature and depth contributed a small but significant amount in explaining the variance.

The remaining holoplanktonic animals consisted mainly of gelatinous organisms. *Sagitta* sp., *Oikopleura* sp., *Pleurobrachia bachei*, *Muggiaea* sp., and *Sphaeronectes* sp. were concentrated along the front (Figure 2-6a), and the distribution of all was significantly explained by surface temperature gradient (Table 2-2, Appendix A-1). Hydromedusae and thaliacia were not associated with the surface thermal gradient, where variance in the former was explained by surface temperature and the latter by distance from shore (Table 2-2, Appendix A-1). An abundance of siphonophore fragments, not including solitary species, were caught in all tows, although it was impossible to establish whether they were from living colonies or were shed particles. The fragment data were not explained by any physical measurements, nor did they correlate with any other taxa (see Pearson correlation summary, Appendix C). Of the two remaining holoplankton crustaceans, *Evadne* sp. abundance decreased along the transect, and amphipods were most abundant at the front (Figure 2-6a). In both cases, the data were explained by surface temperature and surface temperature gradient, with distance from shore contributing in explaining the variance of the latter (Table 2-2, Appendix A-1).

Of the meroplankton, brachyura zoea was numerically dominant, particularly at the front (Figure 2-6b), with the surface temperature gradient explaining 57% of the variance (Table 2-2, Appendix A-2). Fish eggs, *Magelona* sp. and echinoderm larvae also showed a strong association with the front (Figure 2-6b), with the variability in all being explained by the surface temperature gradient, (Table 2-2, Appendix A-2). Pagurid zoea were only found inshore of the front, although their distribution was explained by surface temperature and surface temperature gradient (Table 2-2, Appendix A-2). Cirriped nauplii, brachyura megalopa, and gastropod veligers were present in almost every sample along the transect, although their distributions were heavily weighted inshore of the front. Their distributions were explained by surface temperature, though horizontal surface gradient also contributed a small amount in explaining veliger variance (Table 2-2, Appendix A-2). The distribution of no other taxa was explained by the measured variables.

In an effort to elucidate some measure of zooplankton behavior, all animal distributions were compared to that of fish eggs using a Pearson correlation. The rationale being that fish eggs would serve as passive tracers defining the distribution one would expect in the absence of swimming behavior. Half the taxa from the April cruise showed a significant correlation with fish eggs, including animals that were both competent and incompetent swimmers (Appendix C). Brachyura zoea, generally known to be comparatively good swimmers (Chia *et al.*, 1984), were highly correlated with fish eggs (Pearson correlation R = 0.8032, p = 0.016). Of the animals not correlated with fish eggs, most were competent swimming larvae and adults. Curiously, the distribution of motile ichthyoplankton was not correlated to that of fish eggs (Pearson correlation R = 0.2573, p = 0.538), a phenomenon that has been seen in other studies (Moser and Pommeranz, 1999).

August

Physical Data

Advanced Very High-Resolution Radiometry (AVHRR) satellite images prior to the study revealed that an upwelling event was occurring off of the Pt. Año Nuevo headland. The AVHRR image closest to the sampling dates with least cloud cover was from August 11, 2000 (CoastWatch West Coast Regional Node website, www.coastwatch.pfel.noaa.gov, Figure 2-4). The satellite image shows a strong thermal front extending from the Pt Año Nuevo headland into Monterey Bay south of Santa Cruz.

A warm water mass in the northeastern portion of the bay was present with a steep surface thermal discontinuity offshore of Santa Cruz.

Surface temperatures taken from the integrated vertical temperature profiles along the three transects revealed that the upwelling shadow front had persisted throughout the time period of our study (Figure 2-7). The vertical temperature profiles of the three transects are shown in Figure 2-8. The starting point of each transect appears on the right side of each plot, approximately 2 km from the coast and extending in a south-southwest direction. The thermocline was at 8-10 m for transects 1 and 2, and at 12 m for transect 3. At roughly 4.5 km into each transect, a flotsam line consisting of kelp, surf grass, anthropogenic materials, and a pinniped carcass, was observed oriented roughly perpendicular to our course heading. The strongest flotsam line was seen along transect 1, with a less intense, broader line visible along transect 2. A line was also seen along transect 3, although the more intense winds and wave chop outside the bay made it difficult to visualize. Shoreward of these lines, a buoyant warm water mass was present that was slightly greener in color than offshore of the front. The color contrast was intense along transect 3, which made the convergence more apparent in spite of the partial destruction of a surface slick. The minibat transect data were consistent with that obtained from the vertical CTD profiles (Figure 2-9). The minibat profiles showed a 10 m deep thermocline decreasing in intensity to the south. The location of the greatest horizontal gradient at the surface coincided with that seen in the vertical CTD plot, occurring at 4 km along the transect. Corresponding with this zone, a chlorophyll maxima was observed at the surface, as indicated by elevated fluorescence at the 4 km mark. This feature was also mirrored by a decrease in light transmissivity near the slick.

Surface current information from high frequency coastal radar (CODAR) was gathered as part of MUSE in August and September 2000, although the processed data from the northern-most part of the bay was absent from much of the study site closest to the northern coast. This included the area in which the shoreward half of transects 2 and 3 passed, thus rendering invisible any fronts that may have been present. Nonetheless, reasonable data did exist in the offshore halves of these transects as well as the entire area of transect 1. A composite image of surface currents was generated using vector data from 1200 – 1400 hrs on August 24, 2000 provided by the Naval Postgraduate School, Department of Oceanography, Radar And Drifter (RAD) Lab (Figure 2-10). The data were obtained after being interpolated through a 33-hour low pass filter (available online, www.mbari.org/muse/). Erroneous results were omitted. The vector lengths indicate the magnitude of the flow at each grid point within the study site. Red lines were hand drawn on the map to roughly indicate where convergences would be predicted by CODAR alone. It is important to note that the magnitude and direction of any vector was not measured along the entire length of the vector, but rather only at the vector's origin. Therefore, the hand drawn lines are only rough approximations of where one might expect to find frontal zones. In the case of transect 1, the CODAR data did show a front in almost the exact location that we witnessed one visually and in the CTD vertical casts.

Plankton Data

The overall average abundance of zooplankton caught in the August net tows was almost two orders of magnitude less than that obtained in the April samples (Tables 2-1 and 2-3), although the density of plankton was high enough to appear on the fathometer. Plankton was often seen on the fathometer to occur in layers varying in thickness of 1 meter to tens of meters. These layers never occurred deeper than 50 m and were mostly confined to depths shallower than 25 m. Although the nets were never lowered below 50 m, we were confidant that the net always passed through the densest part of the water column, and that our catches in deeper waters accurately reflected the true abundance and assemblage, except where noted below. Species richness and Shannon-Weiner diversity were also lower in the August samples. Zooplankton abundance along each August transect was consistently more dense along fronts, although this pattern was not necessarily seen in all taxonomic groups. More independent variables were included in the analysis of plankton distribution since CTD data were gathered along all transects in August. After a preliminary analysis of which variables to include, surface salinity was thrown out since it remained fairly constant throughout the study site. A Pearson correlation of temperature, salinity and density revealed a strong relationship between temperature and density, and no correlation was found between these variables with salinity. Therefore, virtually all variation in density was explained by change in temperature (Figure 2-11).

As in the April samples, copepods dominated the catch in the combined August samples, comprising 46.0% of the abundance (Table 2-3). Copepods were aggregated mostly on the fronts seen along transects 1 and 3, and while they were also abundant at the front in transect 2, they were equally abundant in the offshore-most tow along that transect (Figure 2-12a). The variation in distribution of copepods was strongly explained by distance along the front, and horizontal temperature gradient and to a lesser degree by temperature change with depth (Table 2-4, Appendix B-1).

Euphausiid eggs, which were not present in the April samples, were the second most abundant group representing 25.4% of the overall catch and were found in every tow except inshore-most T1-1 (Table 2-3). In transects 1 and 3, euphausiid eggs were most abundant on the front, but exhibited an offshore distribution along transect 2 (Figure 2-12a). Surface temperature contributed the most in explaining the distribution of euphausiid eggs, though horizontal temperature gradient and temperature depth gradient contributed to explaining variation (Table 2-4, Appendix B-1).

Euphausiid juveniles were also present in all tows except T1-1 and were far less dense than in the April samples. In all three transects, euphausiid juveniles were generally more abundant at the fronts, except in transect 3 where they were equally abundant in the tow just offshore of the front (Figure 2-12a). In all transects, the distribution of euphausiid juveniles declined more gradually in the offshore direction from the front than onshore. Many variables contributed in explaining the distribution of euphausiid juveniles (Table 2-4), but the strongest association was with distance from shore, followed by vertical temperature gradient above the thermocline and horizontal temperature gradient (Appendix B-1).

Of the remaining holoplankton groups, only *Sagitta* sp and *Oikopleura* sp. contributed more than 1% of the total abundance. The distribution of the former could not be explained significantly by any of the measured variables, although it was slightly more abundant in tows offshore of the front (Figure 2-12a). The latter tended to be more abundant in the tows offshore of the front, with the distribution skewed towards greater densities near the front (but not on it) in transect 1 and greater densities offshore in transect 2. Variability in *Oikopleura* sp. density was explained by distance from shore and surface temperature (Table 2-4, Appendix B-1).

As in April, the medusae in transects 1 and 2 in August were more abundant inshore, although greater densities in transect 3 occurred at the front (Figure 2-12a). While distance was an important contributor explaining variance in transects 1 and 2, the results including transect 3 rendered this variable insignificant in the final analysis. Horizontal temperature gradient was the most significant contributor explaining variability over all three transects, followed by vertical temperature gradient (Table 2-4, Appendix B-1). Where siphonophore fragments showed no distributional pattern in April, the August distributions showed siphonophore fragments concentrated offshore of the front, although they did appear in small proportions in the inshore tows along transect 3 (Figure 2-12a). Variation in siphonophore distribution was explained by four variables, the two strongest being distance from shore and surface temperature (Table 2-4, Appendix B-1). The remaining two species, *Pleurobrachia bachei* and *Evadne* sp., were caught in most tows, but were thinly distributed (Table 2-3, Figure 2-12a) and, unlike in the April samples, showed no association with the measured variables in August.

Large jellies, mostly *Chrysaora fuscescens* and *Aurelia* sp., were observed at the surface in April and August, with the greatest densities seen at the fronts (see Chapter 1, this dissertation), however the number of jellies captured in our vertical tows did not reflect the observed densities, suggesting that using vertical plankton nets is an inappropriate tool for quantifying the abundance and distribution of large jellies. Two *C. fuscenscens* were captured, each caught separately in tows T2-2 and T2-3, and one *Aurelia* sp. was captured in tow T3-2. Each *C. fuscescens* was 6 and 7 m in length, and individually weighed approximately 20 kg. The single *Aurelia* sp. captured was just under 0.5 m in bell diameter and weighed approximately 1.5 kg. The presence of the large, heavy jellies in the net made it impossible to retrieve the smaller species of zooplankton in the sample. These three samples were therefore discarded and re-sampled.

Larvae of the infaunal polychaete *Magelona* sp. were the most abundant species of meroplankton, comprising 7.7% of the total abundance. In all transects *Magelona* sp. was aggregated on fronts, with density tapering offshore of the fronts in transects 1 and 2 (Figure 2-12b). Along transect 3, *Magelona* sp. was highly aggregated at the front with 95.5% of individuals along the transect being captured there (Table 2-3). Horizontal temperature gradient, surface density and vertical temperature change in the upper 12 m significantly explained much of the variation in distribution (Table 2-4, Appendix B-2).

Gastropod veligers comprised at least 3 unidentified species, with one contributing to more than 99% of the total of the taxon. As a group, they were the second most abundant meroplankton at 4.5% of the total (Table 2-3). In transects 1 and 2, gastropod larvae were mostly distributed offshore, and were highly aggregated on the front in transect 3 (Figure 2-12b). In the inshore tows, gastropod veligers were either sparse or absent. Surface temperature was the only variable that significantly explained the variation in gastropod veliger distribution (Table 2-4, Appendix B-2).

As in the April samples, brachyuran crab zoea in August consisted of a mix of at least four families. The numerically dominant family in all transects was Pinnotheridae. Crab larvae were most dense on the front in transects 1 and 2, but they were slightly more dense inshore of the front in transect 3 (Figure 2-12b). Only horizontal temperature gradient contributed to explaining the variability in crab larvae distribution, though its contribution, as determined by the adjusted R^2 value, was lower than any other group in the August samples (Table 2-4, Appendix B-2).

At least five distinct species made up the assemblage of fish eggs, although only northern anchovy eggs (*Engraulis modax*) could be identified. Fish eggs were caught in all tows and were most abundant at the fronts along all three transects (Figure 2-12b). Surface temperature was the only variable that significantly explained fish egg distribution (Table 2-4, Appendix B-2).

Caridea zoea were caught in almost every vertical tow, and included the families Hippolytidae, Crangonidae, Pandalidae, and two other unidentified shrimp species. Their greatest abundance occurring in tows at or near the fronts in transects 1 and 2, and at or inshore of the front in transect 3 (Figure 2-12b). The distribution of caridea zoea was significantly explained by thermocline depth, and although it was the sole contributor of all the included variables, it provided a low degree of explanation, as evidenced by the low adjusted R^2 value (Figure 2-4, Appendix B-2).

The last meroplankton group whose distributional abundance was significantly explained by the measured variables was the polychaete scaleworm family Polynoidae. These worms were present in most tows, being absent in the inshore-most tows in transects 1 and 2. Polynoids were aggregated along the front in transect 3, but not in transects 1 and 2, where there tended to be an offshore bias (Figure 2-12b). Vertical temperature gradient in the upper 12 m explained one quarter of the scaleworm distributional variability (Table 2-4, Appendix B-2).

None of the remaining meroplankton groups could be explained by the variables measured, likely due to the greater number of tows with zero values over actual numerical values. This was true of the Pacific sand crab *Emerita analoga* zoea stage 1, bryozoan cyphanautes, and porcellanid zoea, which were rare or absent in tows offshore of the fronts. Curiously, cirriped nauplii, which were found in virtually all plankton tows, were not associated with any measured variables. Although there were clear patterns seen in each individual transect, they collectively could not be explained by any variables in our analysis. Along transect 1, barnacles larvae were aggregated on the front, and diminished in abundance with distance from the front (Figure 2-12b). In transects 2 and 3, there was a clear propensity for aggregation inshore of the front, with this relationship seen most strongly in transect 3.

With multiple transects in the August data set, it was possible to apply MLR to the summary statistics in Table 2-3. The variation in three summaries was explained by the independent variables. For the number of individuals per cubic meter, total species, and sample volume, surface temperature contributed most significantly in explaining their variance (Table 2-4, Appendix B-2). In the first two summary statistics, multiple variables contributed significant in explaining their distribution, although to lesser amounts. Species diversity never appeared to be highest on the front and could not be explained significantly by any measured variables.

Eggs were again used to demonstrate where passive tracers would aggregate. Two tracers, euphausiid and fish eggs, proved useful in this analysis. Euphausiid eggs, whether caught in tows over deep water or shallow water were most likely released in, or at least over, deep water where adult euphausiids are found during the daytime. On the other hand, the fish eggs in our samples could have had multiple zones of origin, including estuaries, nearshore rocky reefs, along the continental shelf, within the submarine canyons, or advected from distant locations. Therefore, euphausiid egg distribution should have reflected a release from an offshore source, whereas the source of fish eggs could be on either side of the front. A Pearson correlation matrix of all species revealed those that were significantly correlated (Appendix D). The spatial pattern of five species were correlated with that of euphausiid eggs, and four species distributions correlated with fish eggs. Four summary statistics were correlated with euphausiid eggs, and none with fish eggs. Interestingly, euphausiid and fish egg distributions did not correlate with each other, yet *Oikopleura* sp. and siphonophore fragments correlated with both euphausiid and fish egg, though the former only marginally so with fish eggs (Appendix D). Of the thirteen non-egg groups, the distribution of six did not correlate with either euphausiid or fish eggs.

Discussion

In this study, the importance of convergence zones to the distribution of zooplankton is underscored. Collectively, in both April and August, zooplankton densities were always highest along the front. This general pattern has been observed numerous times in a variety of frontal investigations over more than a century (e.g. Haeckel, 1893; Beebe, 1926; Knauss, 1957; Pingree *et al.*, 1975; Le Fevre, 1986; Govoni, 1993, DiGiacomo *et al.*, 2002, and others). Such studies have yielded much useful information on the distribution of holoplankton and larvae, yet it is uncommon that investigators are concerned with behavior as a mechanism of aggregation near fronts, where it is often assumed that passive transport and buoyancy are the sole driving mechanisms (but see Shanks, 1985; Shanks, 1986; Epifanio, 1987; Larson, 1992; Shanks *et al.*, 2000).

We observed the distribution of plankton at the beginning and end of the upwelling season in Monterey Bay, at which times the overall productivity in the bay was markedly different. An upwelling shadow was present during both sampling efforts, although the horizontal thermal gradient across the front was greater during April (Figures 2-1 and 2-4). In April, the average plankton biomass was more than two orders of magnitude greater and the species richness was 22% higher than in August (Tables 2-1 and 2-3). Pulses in plankton biomass during the spring and late fall have been reported in other studies of Monterey Bay (Graham *et al.*, 1992; Baduini, 1997). In our investigation, we observed a large pulse in biomass in April but not in August. Even with the far lower biomass, similar patterns were seen in a number of plankton groups in August, suggesting that some may respond to general flow characteristics in similar ways, regardless of season. This generalization appeared to apply more to the gelatinous holoplankters than any other group.

Holoplankton generally followed a pattern of increased abundance on the fronts in both surveys. This was exemplified by the distribution of copepods, which were the most abundant group throughout the study site in both seasons and are among the most competent swimming zooplankton (Mauchline, 1998). In April, when the waters were highly productive, copepods were abundant everywhere, although they exhibited their highest density on the front. In August, they were also highly abundant on the fronts in transects 1 and 3, and they appeared to decrease in density with distance from the front less rapidly in the offshore direction. Transect 2 also had a high density on the front, but they were most abundant offshore. When correlated with the distribution of eggs, the April copepod spatial pattern was strongly similar to fish eggs (Appendix C), however a correlation was not revealed between fish or euphausiid eggs and copepods in August (Appendix D-1), but when the data from transect 2 were removed from the case-wise deletion, the copepod distribution was significantly correlated to euphausiid eggs, although still not to fish eggs (Appendix D-2). One possible explanation for this finding is that the general flow in the vicinity of transects 1 and 3 were characteristically similar to each other, but both were different from transect 2.

In their hypothetical description of the general flow pattern of the upwelling shadow, Graham and Largier (1997) proposed that the convergent nature might not be the same along the entire length of the front. They suggest that the area closest to the upwelling center would likely be a buoyant front, while the area south of Santa Cruz may resemble a shear front. A strong convergent front was observed during sampling along transect 3, despite the rough seas, and euphausiid eggs were highly aggregated along the convergence, with proportionally many fewer euphausiid eggs offshore (Figure 2-12a). In contrast, euphausiid eggs were not abundant on the front along transect 2, which offers the possible explanation that along transect 2 was a shear front where a greater amount of leakage could occur (Emsley *et al.*, 2005). Unfortunately, no CODAR data were available for the shoreward halves of transects 2 and 3, which might have clarified the flow patterns along the entire lengths of these transects. However, CODAR data were available for much of transect 1, where directly opposing currents were seen in an almost identical location to where we visualized one along transect 1 (Figure 2-10). Euphausiid eggs were aggregated most densely along the front in transect 1, which suggest that, like transect 3, transect 1 was also a convergent front (Figure 2-12a). Owing to their deeper shelf break origin (Simard and Mackas, 1989; Mackas *et al.*, 1997), euphausiid eggs never effectively crossed the fronts, with very few eggs caught in tows inshore of the fronts. This suggests that the fronts, whether buoyant or shear, are effective barriers to movement of passive buoyant particles.

Copepod abundances did not correlate with fish eggs since they were weighted differently along the transects, although they both were generally most abundant at the front (Figures 2-12a and 2-12b). We assume that the more normal distribution of fish eggs about the front is due to the many possible origins of egg release. It was not possible to determine the various origins of release since species identification of eggs is exceedingly difficult for most species. Only one egg type, northern anchovy (*Engraulis mordax*), could be identified with confidence, and this species supplied 30% of the total egg abundance (Appendix F). Northern anchovy actively schools in coastal waters and release eggs year round (Moser, 1996; Moser and Pommeranz, 1999), and as adults are decidedly nektonic, the point of origin of eggs would not likely be confined to either side of a front.

Euphausiid juveniles were abundant in both sampling efforts, with the highest densities always on fronts. Adult euphausiids are able swimmers that exhibit strong schooling behavior (Zhou and Dorland, 2004; Hamner and Hamner 2000) and engage in deep diel vertical migration in temperate latitudes (Brinton, 1962; Nakagawa *et al.*, 2003). However our studies were conducted during the daytime when adult euphausiids generally aggregate beneath the shelf break margin in deeper waters (Simard and Mackas, 1989; Mackas *et al.*, 1997), a phenomenon known to occur in Monterey Bay (Schoenherr, 1991). Juveniles do not swim as well as adults and hence tend to remain closer to the surface. Stuart and Pillar (1990) reported that calyptopis and early furcilia-stage euphausiids exhibited weak migration. Similar results were reported by Bollens *et al.* (1992), who found that late stage furcilia exhibited predictable vertical migration, whereas younger stages showed no migration. In both of our surveys, the juvenile euphausiid catch was dominated by calyptopis and early furcilia stages with proportionally very few late-stage furcilia and no adults. A comparison of offshore to nearshore euphausiid abundance in our surveys revealed that euphausiids were generally more abundant offshore of the front. Euphausiid distribution did not correlate to that of fish eggs in either survey. Intriguingly, euphausiid juveniles did not correlate significantly with euphausiid eggs (Appendices C and D-1). While the general distributions were similar in transects 1 and 3, which were likely both buoyant convergences, they were distinctly different in transect 2 where euphausiid eggs were strongly skewed offshore, due to the apparent adjacent flow along the front. Despite the higher offshore density of euphausiid eggs in transect 2, euphausiid juveniles were aggregated on the shear front. Other studies have addressed differing horizontal distributions of various ontogenetic stages of euphausiids. Lu *et al.* (2003) observed that all ontogenetic stages of euphausiids, including eggs, exhibited different patterns of distribution around a shelf-break front. In conjunction with the findings of Lu *et al.* (2003), our study suggests that, while younger juvenile euphausiids lack the capacity to swim to depths deeper than 100m, as do adults, some aspect of behavior is contributing to the difference in distribution of eggs and early juvenile stages. While advection may explain a portion of the distribution around transects 1 and 3 (at buoyant convergences), some level of behavior must be responsible for the aggregation of juvenile euphausiids along transect 2 (a shear convergence).

A comparison of other holoplankters to fish and euphausiid egg distributions revealed intriguing patterns, some of which can be attributable in part to behavior. The appendicularian *Oikopleura* sp. was highly aggregated on the front during April, but were only weakly associated with the front during the August transects. This group was correlated very strongly with euphausiid eggs in August and with fish eggs in both seasons. Along transect 2 in August, *Oikopleura* sp. were strongly skewed in the offshore direction (Figure2-12a), likely resulting from the comparatively slow swimming ability of this animal (Selander and Teselius, 2003). This offshore skew further suggests a shear front along transect 2, which starkly contrasts the denser aggregation of this group on the buoyant convergence seen in April and August, although to a lesser extent in transect 3. A similar scenario was found with the predatory chaetognath *Sagitta* sp., which is known to be a very competent swimmer (Saito and Kiørboe, 2001). *Sagitta* sp. were very abundant along the front in April, showing a strong correlation with the distribution of fish eggs but in August were not correlated with either fish or euphausiid eggs. *Sagitta* sp. is known to prey heavily on copepods (Alvarez-Cadena, 1993; Saito and Kiørboe, 2001), and *Sagitta* sp. and copepods were strongly correlated in April when copepod abundance was very high on the front (Appendix C). However during August, when copepod numbers were an order of magnitude less abundant (Tables 2-1 and 2-3), *Sagitta* sp. were not statistically associated with copepods (Appendix D-1) and were distributed mostly offshore, although they had a somewhat more even distribution in transect 3 (Figure 2-12a).

Hydromedusae and small scyphomedusae did tend to have higher abundances on the front, despite being captured in all tows during both surveys, yet they appeared to be associated more with the warmer inshore water mass rather than offshore (Figures 2-6a and 2-12a). This pattern is consistent with that observed for hydromedusae along the Argentine shelf (Mianzan and Guerrero, 2000) and for large macrogelatinous animals observed during our August survey (Chapter 1, this dissertation). In Chapter 1, the pattern of increased distribution around the front by *Chrysaora fuscescens* was attributed to directional swimming orientation, where jellies on both sides of the front were oriented towards the front. A similar pattern of abundance of *C. fuscescens* was also seen in the smaller medusae in April and August, where jellies were most abundant on the front, and more abundant in the warmer nearshore water mass than offshore of the front, except in transect 3 where abundance decreased equally away from the front. While swimming modes and abilities are different between scyphomedusae and hydromedusae, and even among different species of the latter taxon (Colin and Costello, 2002), it is likely that the response mechanism enabling *C. fuscescens* to orient and swim to the front is also characteristic in smaller hydromedusae. Therefore, it may be possible that the similar pattern in distribution of large and small jellies is the result of a similar behavioral response of the two. In any case, a descriptive quantification of the distribution of small hydromedusae and large scyphomedusae near a front has not been attempted, and we emphasize that this is only possible because the contrasting sized jellies are quantified using different methods. The large jellies were enumerated using a video transects conducted with a remotely operated vehicle, a technique that would likely under-report the presence of small medusae. Likewise, while vertical plankton nets will adequately quantify small medusae, such a technique is inadequate for the study of gelatinous macrozooplankton distribution.

The cydippid ctenophore *Pleurobrachia bachei* was the only other abundant gelatinous species for which statistical analysis could be conducted. This hermaphroditic species can attain impressive population sizes during the spring months (Hirota, 1974), which is well documented in Monterey Bay (Matsumoto, 1990). *P. bachei* was very abundant during our April survey, with 85% of the total occurring at the highly productive front, while numbers in August were far reduced. The distribution of *P bachei* in April was most strongly explained by the sharp temperature gradient at the front (Appendix A-1), while no variable measured in August could explain the variance in distribution of this species, which was absent entirely from transect 1. In transect 2, *P. bachei* abundance was highest along the shear front, while in transect 3, it was most dense offshore of the convergence (Figure 2-12a), which is incongruous with what would be predicted by flow alone. One possible explanation is that in August, ctenophores tended to be deeper than animals aggregated in the surface layer. In all of our tows, the net penetrated well below the thermocline, allowing for the possibility that the distribution of *P. bachei* was influenced by subsurface flow patterns not apparent at the surface. Swimming behavior may also have contributed to the observed distribution. *P. bachei* is a very competent swimmer (Matsumoto, 1990) with the capacity to swim at or exceed the average flow speeds calculated in this region (Graham and Largier, 1997), and it is therefore feasible that it could aggregate on or away from a front by active swimming.

Brachyura zoea were the most abundant meroplanktonic group in April, when it was in greatest abundance on the front. Horizontal temperature gradient was the only measured variable to significantly explain the spatial distribution of crab larvae in April (Table 2-2), indicating that they were associated with the front. As with most other animals in the study, crab zoea were an order of magnitude less abundant during August (Tables 2-1 and 2-3). A less abundant group, caridea zoea, mirrored the distribution of brachyura zoea in August, although they appeared to have a different distribution in April. Distributions along transects 1 and 3 were similar for crab and shrimp zoea, with high densities on the fronts, and higher abundance inshore compared to offshore. Transect 2 had a more normal distribution about the front. Larval crabs and shrimp are in general among the most competent swimming zooplankton. Crab zoeae in particular are known to travel throughout the water column to take advantage of favorable current directions for dispersal and onshore migration (Shanks, 1983; Sulkin, 1984; Shanks, 1985; Shanks, 1986; Wing *et al*., 1995a; Wing *et al*., 1995b; Shanks *et al*., 2000). While there are far fewer studies of larval shrimp swimming speeds, the few that have been done indicate similar swimming competency of shrimp zoea to that of crab zoea (Foxon, 1934; Chia e*t al*., 1984). It is therefore likely that shrimp larvae migrate to exploit favorable flow fields as crab larvae do. It is possible that crab and shrimp zoeae may utilize the Monterey upwelling shadow front, not only as a rich food source but also as a transport mechanism to shore once they reach the age of settlement (Shanks *et al*., 2000). Further study will be necessary to test this hypothesis.

Juveniles of the polychaete *Magelona* sp. were common in both surveys, with twice as many occurring on average in April (Tables 2-1 and 2-3). Konstantinova (1969) studied the larval movement of twenty-five polychaete species, most of which are morphologically different from *Magelona* sp. Only one cursory mention of *Magelona* sp. swimming ability has been reported in the literature (Johnson and Shanks, 2003), where vertical swimming speeds were observed to be 0.3 cm s^{-1}, which places it at the higher end of swimming competence compared to other polychaete larvae (Konstantinova, 1969). In April, *Magelona* sp. was in highest abundance on the front with over 50% captured there, while in August, 67% were captured in tows on the fronts. There was a slight offshore distribution in August transects 1 and 2, however in transect 3, *Magelona* sp. was captured almost exclusively on the front with less than 5% of *Magelona* sp. along the transect occurring off the front (Figure 2-12b). This distribution was much more highly aggregated than either fish or euphausiid eggs. Although it is reported as a predator, the larval life history of this species is unknown (Johnson and Shanks, 2003), and its distribution has not been specifically considered in previous plankton studies in Monterey Bay, even though it previously was included as a part of the lumped "polychaete" category in such studies (e.g. Graham *et al*., 1992).

Of the remaining polychaetes in the study, no one species was numerous enough for analysis in April, and thus for that survey, they were all grouped. Polychaetes were slightly more abundant in only one tow on the front in April and were not associated with any physical measurements, and while a significant correlation was found with fish egg distribution, polychaetes were not correlated with any other group. Since there were multiple taxa and multiple ontogenetic stages lumped in this group, the distribution of the group may not be meaningful when considering behavior. However, in August, the scaleworm Family Polynoidae was abundant enough to stand out as a distinct group, but distributional patterns along the three transects were inconsistent and no overall pattern could be distinguished. No association with physical variables or other species were found for polynoids

The gastropod veligers in our samples likely represented multiple species, but we did not feel confident in our ability to discern species differences. Fortunately, as a group, gastropod veligers appeared to have produced distributional patterns that were consistent with that of many of the above described groups. In April, veligers were most abundant on and inshore of the front. In August, veligers were distributed offshore in transects 1 and 2, and highly aggregated on the front in transect 3. Veligers are active swimmers that move by metachronal motion of the velar cilia (Chia *et al*., 1984) and their swimming speeds are not as fast as animals that swim by muscular locomotion (Young, 1995). However, veligers are reported in the literature to actively regulate their depth by vertical swimming upwards and by sinking or swimming downward (Lough and Gonor, 1971). In a case relevant to the Monterey upwelling shadow front, veligers were observed to aggregate near the bottom substrate by downward swimming in an effort to avoid being advected offshore by coastal upwelling (Poulin *et al*., 2002). It is possible that this may have occurred during the April cruise, when upwelling was likely very strong. While tows 1 and 2 reached the bottom, tows 3 and 4 were only lowered to 40 m depth, and therefore any veliger aggregation that may have existed near the bottom would not have been sampled adequately. Our data suggest that this scenario was probably not occurring in August when the greatest abundance of veligers was collected offshore of transects 1 and 2 and on the front in transect 3 (Figure 2-12b). In each of the tows where veligers were abundant, the net never reached the bottom. The distribution of veligers in August was highly correlated to that of euphausiid eggs (Appendix D-1). The difference in veliger distribution between April and August may be a larval life history characteristic. Veligers that are ready to settle will usually reduce their swimming as they grow and become more negatively buoyant (Chia *et al.*, 1984). No quantitative size or buoyancy measurements were made of the veligers in the April and August samples to determine if veligers were "heavier" in April than in August, although veligers were far more negatively buoyant than all other animals in samples from both surveys. We discovered during sorting our samples that when pouring samples into a graduated cylinder, one could easily extract most of the veligers that would sink quickly to the bottom by simply removing them with a pipette before the other animals had settled.

The distributions of all other meroplankton species that were associated with the measured physical variables were weighted either on or inshore of the fronts. In April, this was the case for cirriped nauplii and brachyura megalopa, although some animals were captured offshore (Figure 2-6b). The cirriped nauplii captured were newly released based on their very small size (Arnsberg, 2001), and since they were mostly balanomorphan, their origin was likely rocky intertidal or subtidal. Unlike the cirripeds, the megalopa were at the end of their larval life and were probably concentrated inshore in preparation for settling. Paguridae zoea and echinoderm larvae were not captured offshore in April, and while a significant result was found in explaining their distribution with physical variables, these two groups were not well represented in the catch.

In August, only cirriped nauplii were again numerous enough for its distribution to be explained by physical variables. Nauplii in transect 1 were a mix of lepadomorphan and balanomorphan species (Arnsberg, 2001), which is the likely explanation for the more offshore distribution seen in transect 1. In transects 2 and 3, where cirriped nauplii were weighted in the onshore portion of the transect, fewer lepadomorph nauplii were present. This pattern calls attention to the relatively effective role that such coastal fronts can have in hindering cross-shelf dispersal, causing some larvae to be retained or excluded inshore. Barnacles have been used as a model for study of dispersal in larvae of benthic sessile invertebrates (e.g. Roughgarden *et al*., 1988), and recently, researchers have become more focused on the importance of oceanography in dispersal (Jenkins et al., 2000; Botsford *et al.,* 2001). Seasonal wind-driven features such as the Monterey upwelling shadow may play an important role in enhancing or hindering dispersal in northern Monterey Bay, particularly during periods of frontal formation or relaxation when intense recruitment events have been observed (Roughgarden *et al*., 1991).

The Monterey Bay upwelling shadow front clearly influences the distribution of zooplankton locally, though different taxonomic groups apparently react differently to its presence. This feature is highly productive during conditions of upwelling favorable winds, and it would be logical that animals in general would take advantage of the rich feeding opportunity. However, ontogenetic developmental concerns will also drive behavior (Mileikovsky, 1973; Sulkin, 1984, Young, 1995; Poulin et al, 2002; Kingsford et al., 2002), and swimming competence and the ability to take advantage of deeper favorable flow directions can lead to accumulation of animals away from a surface convergence. Also, the tracking of a food source by chemoreception or hydromechanic perception (Saito and Kiorboe, 2001) can result in the aggregation of predators to prey, even if the prey are not aggregated on a front, such as in the case of the distribution of *Sagitta* sp. and copepods offshore of the front in Transect 2.

Also, the resolution of patterns of aggregation of each species was not the same in each survey. In April, the buoyant convergence was highly productive with a much larger average biomass that August, and even though only one transect was conducted, the larger abundance of plankton allowed us to see obvious patterns for some species, for example *Magelona* sp. and *Pleurobrachia bachei*. In August, plankton were thinly distributed, but the occurrence of large numbers of euphausiid eggs, which served as passive tracers, provided an opportunity to explain differences in species distributions, particularly since the distribution of animals along transect 2 in August was quite different from that along transect 1 and 3 in August and the transect in April. This is a significant finding in this study. Attributing behavior to the distribution of plankton along a buoyant convergence where the horizontal flow on either side of the front is opposing is subject to question since swimming in the same direction as the dominant flow will produce a similar result as if no swimming were occurring. That is, whether or not active horizontal swimming is occurring, an aggregation will result on the front.

However, in transect 2, despite the pronounced skewing of euphausiid eggs in the offshore direction, some animals continued to aggregate on the shear front (e.g. euphausiid juveniles, medusae, *P. bachei*, *Magelona* sp., brachyura and caridea zoea, and cirriped nauplii). This would not have occurred if flow were the only mechanism determining plankton distribution. Fish eggs, which we assume to also be passive particles, were also abundant on the shear front across transect 2, however the larger abundance inshore may imply that the nearshore zone fauna may have contributed considerably to the fish egg abundance, and this possible nearshore source would not be a direction from which euphausiid eggs would have been spawned.

When examining the distributions of multiple different taxa over an area the size of northern Monterey Bay, our study suggest that it is important to consider behavior as a contributor to spatial distribution. In studies of vertical distributions, this has been understood for some time (e.g. Harder, 1968), however behavior has only recently gained appreciation as a determinant of horizontal distribution (Omori and Hamner, 1982; Kingsford *et al*., 2002; Genin *et al.*, 2005). The present study calls attention to this point.

Tables

Table 2-1. Summary of abundance per cubic meter of each zooplankton taxa in the vicinity of the Monterey Bay front on April 24, 2000.

	Station									
	Inshore		**FRONT**					**Offshore**		
Taxa	**1A**	**1B**	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**	**Total**	**Percent Total**
HOLOPLANKTON										
Copepoda	4093.2	3733.6	5511.6	5825.3	2636.1	3855.5	3888.4	2989.6	32533.3	45.01
Euphausiid juveniles	827.0	928.9	4893.8	5053.1	2084.7	3227.7	2526.7	721.4	20263.3	28.03
Sagitta sp.	431.5	341.6	1283.8	685.3	245.5	205.3	196.7	189.0	3578.7	4.95
Siphonophora fragments	347.6	155.8	646.7	371.6	116.7	438.7	451.3	567.1	3095.5	4.28
Oikopleura sp.	125.9	143.8	279.9	251.0	48.3	96.6	46.3	131.2	1122.9	1.55
Pleurobrachia bachei	-	18.0	415.1	395.8	16.1	64.4	34.7	15.4	959.4	1.33
Muggiaea sp.	71.9	227.7	125.5	86.9	24.1	92.6	61.7	57.9	748.3	1.04
Hydromedusae	71.9	191.8	231.7	53.1	-	40.2	7.7	15.4	611.8	0.85
Thaliacea	95.9	95.9	77.2	43.4	4.0	104.6	-	-	421.1	0.58
Evadne sp.	77.9	47.9	29.0	43.4	8.0	16.1	3.9	77.9	304.2	0.42
Sphaeronectes sp.	-	18.0	38.6	19.3	-	4.0	3.9	-	83.8	0.12
Amphipoda	-	6.0	29.0	19.3	-	-	11.6	7.7	73.5	0.10
MEROPLANKTON										
Brachyura zoea	359.6	437.5	878.4	762.5	446.7	639.9	-	189.0	3713.6	5.14
Fish eggs	179.8	173.8	347.5	308.9	28.2	104.6	23.1	69.4	1235.3	1.71
Caridea zoea	125.9	47.9	77.2	62.7	124.8	277.7	34.7	27.0	777.9	1.08
Magelona sp.	30.0	47.9	241.3	144.8	76.5	88.5	73.3	65.6	767.9	1.06
Polychaeta (other)	89.9	-	154.4	57.9	32.2	112.7	23.1	61.7	532.0	0.74
Cirripedia nauplii	47.9	101.9	67.6	101.4	20.1	56.3	-	50.1	445.4	0.62
Brachyura megalopa	77.9	59.9	77.2	43.4	16.1	32.2	-	34.7	341.5	0.47
Paguridae zoea	24.0	30.0	19.3	14.5	-	4.0	3.9	24.0	119.6	0.17
Gastropod veliger	22.8	32.1	22.8	15.0	-	4.2	3.1	-	100.0	0.14
Fish larvae	6.0	6.0	19.3	-	4.0	16.1	3.9	7.7	63.0	0.09
Echinoderm larvae	-	-	19.3	24.1	-	-	-	-	43.4	0.06
Porcellanidae zoea	6.0	-	-	4.8	4.0	-	-	-	14.8	0.02
All other species	30.0	12.0	29.4	9.7	205.3	24.1	27.0	-	337.4	0.47
SUMMARY										
Individuals per m^3	7142.5	6858.2	15515.4	14397.2	6141.5	9506.1	7425.1	5301.9	72175.0	
Total species	44	52	57	57	38	63	36	36	103	
Diversity (H')	2.63	2.63	2.70	2.48	2.29	2.63	2.25	2.46	2.62	
Plankton ml per m^3	25.5	23.9	41.1	40.1	21.4	20.8	16.0	14.2		
Surface temperature ($^{\circ}$C)	12.4	12.4	12.1	12.1	10.5	10.5	10.2	10.2		
ΔT $^{\circ}$C horizontal (0.5km)	0.5	0.5	1.6	1.6	0.3	0.3	0.2	0.2		

Table 2-2. Forward step-wise multiple linear regression summary statistics for each significant zooplankton taxa in the vicinity of the Monterey Bay front on April 24, 2000. Details are presented in Appendix B.

	F	Adjusted R^2	p-level	Independent variable correlates
Holoplankton				
Copepoda	$F_{(1,6)} = 30.197$	0.8066	< 0.00152	Horiz. ΔT °C
Euphausiid juveniles	$F_{(3,4)} = 11.048$	0.8115	< 0.02095	Horiz. ΔT °C, Surface T °C, Distance (km)
Sagitta sp.	$F_{(1,6)} = 26.193$	0.7826	< 0.00218	Horiz. ΔT °C
Oikopleura sp.	$F_{(1,6)} = 38.925$	0.8442	< 0.00079	Horiz. ΔT °C
Pleurobrachia bachei	$F_{(2,5)} = 320.090$	0.9892	< 0.00001	Horiz. ΔT °C, Surface T °C
Medusae	$F_{(1,6)} = 6.890$	0.4569	< 0.03933	Surface T °C
Thaliacea	$F_{(1,6)} = 8.953$	0.5319	< 0.02425	Distance (km)
Evadne sp.	$F_{(2,5)} = 15.369$	0.8041	< 0.00732	Horiz. ΔT °C, Surface T °C
Sphaeronectes sp.	$F_{(1,6)} = 14.983$	0.6664	< 0.00826	Horiz. ΔT °C
Amphipoda	$F_{(3,4)} = 12.026$	0.8253	< 0.01804	Horiz. ΔT °C, Surface T °C, Distance (km)
Meroplankton				
Brachyura zoea	$F_{(1,6)} = 10.581$	0.5778	< 0.01740	Horiz. ΔT °C
Fish eggs	$F_{(2,5)} = 52.722$	0.9366	< 0.00044	Horiz. ΔT °C, Surface T °C
Magelona sp.	$F_{(2,5)} = 13.545$	0.7819	< 0.00958	Horiz. ΔT °C, Surface T °C
Cirripedia nauplii	$F_{(1,6)} = 6.5320$	0.4414	< 0.04315	Surface T °C
Brachyura megalopa	$F_{(1,6)} = 17.263$	0.6991	< 0.00598	Surface T °C
Paguridae zoea	$F_{(2,5)} = 24.322$	0.8695	< 0.00265	Horiz. ΔT °C, Surface T °C
Echinoderm larvae	$F_{(2,5)} = 131.79$	0.9739	< 0.00005	Horiz. ΔT °C, Distance (km)
Gastropod veligers	$F_{(2,5)} = 26.303$	0.8785	< 0.00220	Horiz. ΔT °C, Surface T °C
Plankton volume	$F_{(2,5)} = 147.47$	0.9767	< 0.00004	Horiz. ΔT °C, Surface T °C

Table 2-3. Summary of abundance per cubic meter of each zooplankton taxa in the vicinity of the Monterey Bay front on August 23-24, 2000.

	Transect 1							Transect 2						Transect 3						
	Inshore →						**Offshore**	**Inshore** →					**Offshore**	**Inshore** →				**Offshore**		
				F*						**F***						**F***				**Percent**
Taxa	**T1-1**	**T1-2**	**T1-3**	**T2-4**	**T1-5**	**T1-6**	**T1-7**	**T2-1**	**T2-2**	**T2-3**	**T2-4**	**T2-5**	**T2-6**	**T3-1**	**T3-2**	**T3-3**	**T3-4**	**T3-5**	**Total**	**Total**
HOLOPLANKTON																				
Copepods	3.1	97.5	278.3	628.2	420.0	341.0	245.3	41.9	150.2	293.3	135.7	154.2	293.5	224.7	303.7	509.4	412.6	398.5	4931.0	47.71
Euphausiid eggs	-	0.7	29.8	38.8	28.0	15.1	15.2	1.1	5.9	146.7	314.8	797.7	683.1	1.6	1.7	464.9	77.9	96.2	2719.2	26.31
Euphausiid juveniles	-	4.1	28.8	51.4	53.0	40.4	25.3	4.1	8.2	33.7	29.6	23.1	17.1	2.5	7.4	21.1	17.4	9.6	376.9	3.65
Oikopleura sp.	-	-	0.6	12.1	25.4	11.1	5.8	1.3	0.5	7.2	17.9	20.2	46.1	1.8	1.9	28.6	18.6	30.5	229.5	2.22
Sagitta sp.	-	-	1.6	14.2	7.8	44.7	9.8	0.2	1.8	3.2	7.3	9.9	4.7	0.5	1.7	1.6	1.8	1.1	111.6	1.08
Medusae	1.9	4.8	3.9	7.1	1.2	0.8	0.1	1.1	2.1	2.7	1.1	0.8	1.6	0.7	1.9	2.8	2.1	0.8	37.3	0.36
Siphonophore fragments	-	-	-	1.2	1.8	2.7	0.4	-	-	0.8	1.7	4.0	3.0	0.7	0.5	0.9	2.8	2.3	22.7	0.22
Pleurobrachia bachei	-	-	-	-	-	-	-	-	-	1.0	0.5	0.4	0.1	-	-	0.3	0.3	0.4	2.9	0.03
Evadne sp.	-	-	-	0.5	-	-	-	-	-	0.2	-	-	0.2	0.2	0.2	1.1	-	0.3	2.7	0.03
MEROPLANKTON																				
Magelona sp.	0.8	0.2	35.1	149.9	36.2	10.8	18.4	0.6	2.8	235.7	79.1	47.3	29.4	0.7	1.9	173.8	1.9	3.7	828.4	8.02
Gastropod veligers	-	-	0.8	5.7	7.2	14.4	2.2	0.2	2.7	10.3	6.8	21.6	70.0	1.2	3.5	281.0	53.5	4.9	486.1	4.70
Brachyura zoea	-	3.9	30.2	41.5	4.9	1.6	1.0	3.9	3.2	14.8	8.4	2.3	2.9	2.1	17.8	10.5	2.5	-	151.3	1.46
Fish egg	7.7	13.0	25.5	4.4	2.4	1.5	1.7	6.3	6.9	9.6	4.3	3.4	2.0	1.6	2.5	2.4	0.5	1.0	96.5	0.93
Caridea zoea	-	2.9	16.4	9.8	1.6	2.6	1.9	1.7	1.1	3.2	1.8	0.9	1.1	13.8	5.0	7.6	-	0.2	71.5	0.69
Cirripedia nauplii	-	0.2	5.7	7.9	4.3	2.2	0.5	1.5	2.5	2.7	0.6	0.5	0.6	16.1	4.9	1.6	-	-	51.7	0.50
Polynoidae	-	0.2	0.4	1.7	2.5	4.8	2.4	-	2.6	1.5	0.4	4.1	4.0	1.8	1.4	10.3	3.7	0.2	42.0	0.41
Cyphanautes	-	0.7	-	-	-	-	-	0.2	0.4	-	-	-	-	7.4	0.2	0.3	-	1.0	10.1	0.10
Emerita analoga zoea I	-	1.9	1.4	-	-	-	-	0.4	0.1	1.7	-	-	-	0.5	2.2	1.5	-	-	9.7	0.09
Porcellanidae zoea	0.8	0.2	-	-	-	-	-	0.9	-	-	-	-	-	5.3	-	-	-	-	7.2	0.07
All other species	5.4	6.0	22.5	39.8	6.2	1.4	1.7	2.2	1.7	13.1	6.4	6.0	19.1	8.3	0.8	3.5	1.7	1.4	147.1	1.42
SUMMARY																				
Individuals per m^3	20	137	481	1014	602	495	332	68	193	781	616	1096	1178	292	359	1523	597	552	10335	
Total species	9	26	49	41	24	26	25	25	26	43	25	27	31	32	33	40	26	23	64	
Diversity (H')	1.90	1.32	1.91	1.55	1.65	1.85	1.87	1.68	1.38	1.99	1.69	1.12	1.57	1.56	1.37	1.95	1.87	1.64	2.09	
Plankton ml per m^3	0.18	0.23	0.42	1.51	0.49	0.66	0.46	0.18	0.35	0.91	0.74	0.68	3.20	0.59	0.28	0.57	0.48	0.49		
Surface temperature (°C)	14.53	15.11	14.01	13.55	13.63	13.50	12.69	14.34	14.41	13.00	12.72	12.78	12.24	12.57	13.35	12.47	12.19	12.93		
Surface salinity (PSU)	33.75	33.70	33.74	33.67	33.71	33.71	33.69	33.66	33.70	33.67	33.74	33.67	33.68	33.76	33.71	33.75	33.69	33.72		
Surface density (kg/m^3)	25.11	24.95	25.21	25.25	25.28	25.29	25.44	25.08	25.10	25.36	25.47	25.40	25.52	25.52	25.32	25.53	25.50	25.31		
≈Thermocline depth (m)	8	7	9	5	4	10	7	9	6	7	3	2	5	14	12	16	6	8		
ΔT °C vertical (5m)	1.85	1.93	0.78	1.61	2.01	0.41	0.43	1.36	1.75	1.13	1.58	2.12	0.48	0.34	0.05	0.06	0.20	0.06		
ΔT °C vertical (12m)	2.68	3.92	2.73	2.36	2.97	2.24	1.61	2.91	3.56	2.36	2.40	2.41	1.53	0.64	1.60	0.54	1.31	2.09		
ΔT °C horizontal (0.5km)	0.05	0.12	0.02	1.11	0.01	0.05	0.11	0.11	0.03	1.02	0.02	0.01	0.01	0.04	0.10	0.62	0.01	0.02		

* F = Location of front

Table 2-4. Forward step-wise multiple linear regression summary statistics for each significant zooplankton taxa in the vicinity of the Monterey Bay front on August 23-24, 2000. Details are presented in Appendix B.

	F	Adjusted R^2	p-level	Independent variable correlates
Holoplankton				
Copepods	$F_{(3,14)} = 4.333$	0.3703	< 0.02338	Distance (km), LN(Horiz. ΔT °C), ΔT Depth (12m)
LN(Euphausiid eggs+1)	$F_{(3,14)} = 12.828$	0.6761	< 0.00026	Surface temp (°C), LN(Horiz. ΔT °C), ΔT Depth (12m)
Euphausiid juveniles	$F_{(4,13)} = 3.735$	0.3915	< 0.03099	Distance (km), LN(Horiz. ΔT °C), ΔT Depth (5m), Surface density (kg/m^3)
Oikopleura sp.	$F_{(2,15)} = 9.294$	0.4939	< 0.00237	Distance (km), Surface temp (°C)
Medusae	$F_{(2,15)} = 4.760$	0.3067	< 0.02507	LN(Horiz. ΔT °C), ΔT Depth (12m)
Siphonophore fragments	$F_{(4,13)} = 7.791$	0.6151	< 0.00197	Distance (km), Surface temp (°C), LN(Horiz. ΔT °C), ΔT Depth (5m)
Meroplankton				
Magelona sp.	$F_{(3,14)} = 22.698$	0.7929	< 0.00001	LN(Horiz. ΔT °C), ΔT Depth (12m), ΔT Depth (12m)
LN(Gastropod veliger+1)	$F_{(1,16)} = 18.288$	0.5042	< 0.00058	Surface temp (°C)
Brachyura zoea	$F_{(1,16)} = 5.118$	0.1950	< 0.03796	LN(Horiz. ΔT °C)
Fish egg	$F_{(1,16)} = 7.536$	0.2777	< 0.01438	Surface temp (°C)
Caridea zoea	$F_{(1,16)} = 5.127$	0.1953	< 0.03781	Thermocline (m)
Polynoidae	$F_{(1,16)} = 6.931$	0.2586	< 0.01810	ΔT Depth (12m)
Individuals per m^3	$F_{(5,12)} = 4.049$	0.4728	< 0.02192	Distance (km), Thermocline (m), Surface temp (°C), LN(Horiz. ΔT °C), ΔT Depth (5m)
Total species	$F_{(4,13)} = 8.164$	0.6277	< 0.00161	Thermocline (m), Surface temp (°C), Distance (km), ΔT Depth (12m)
Sample volume (ml)	$F_{(1,16)} = 6.193$	0.2340	< 0.02422	Surface temp (°C)

Figures

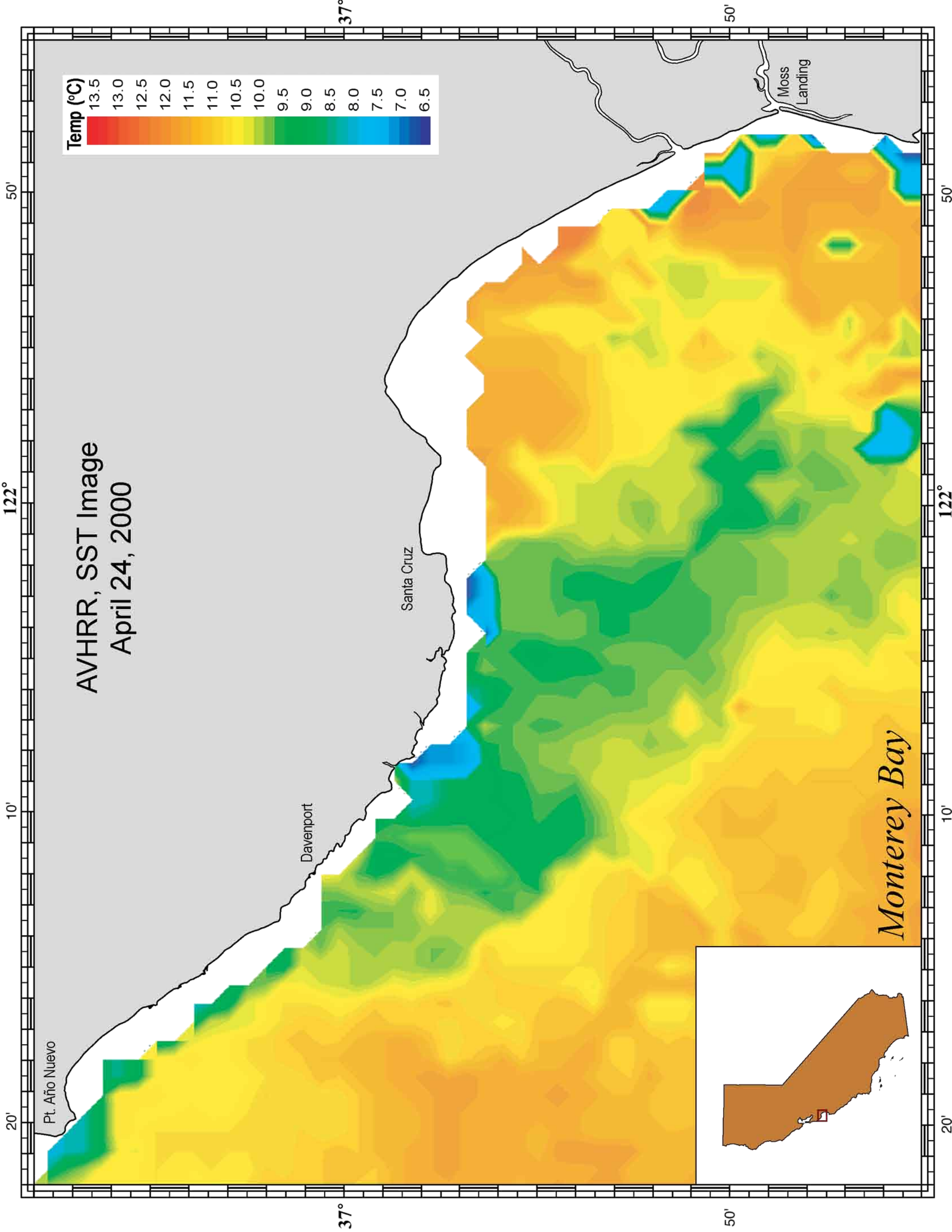

Figure 2-1. Advanced Very High Resolution Radiometry (AVHRR) sea surface temperature (SST) image from April 24, 2000. Data were obtained from the Coast Watch West Coast Regional Node website, www.coastwatch.pfel.noaa.gov.

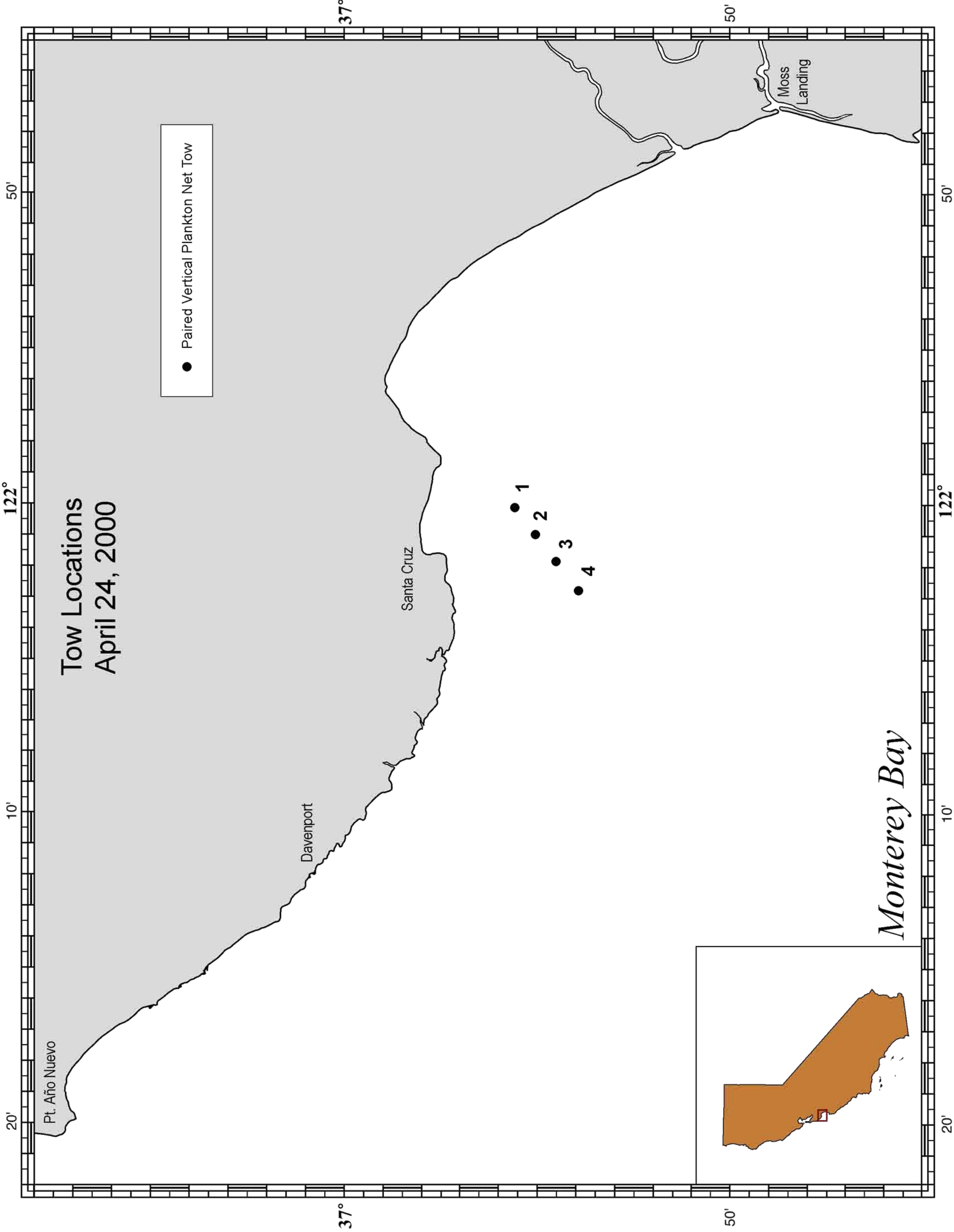

Figure 2-2. Location of paired vertical plankton net tows along a line transect, April 24, 2000.

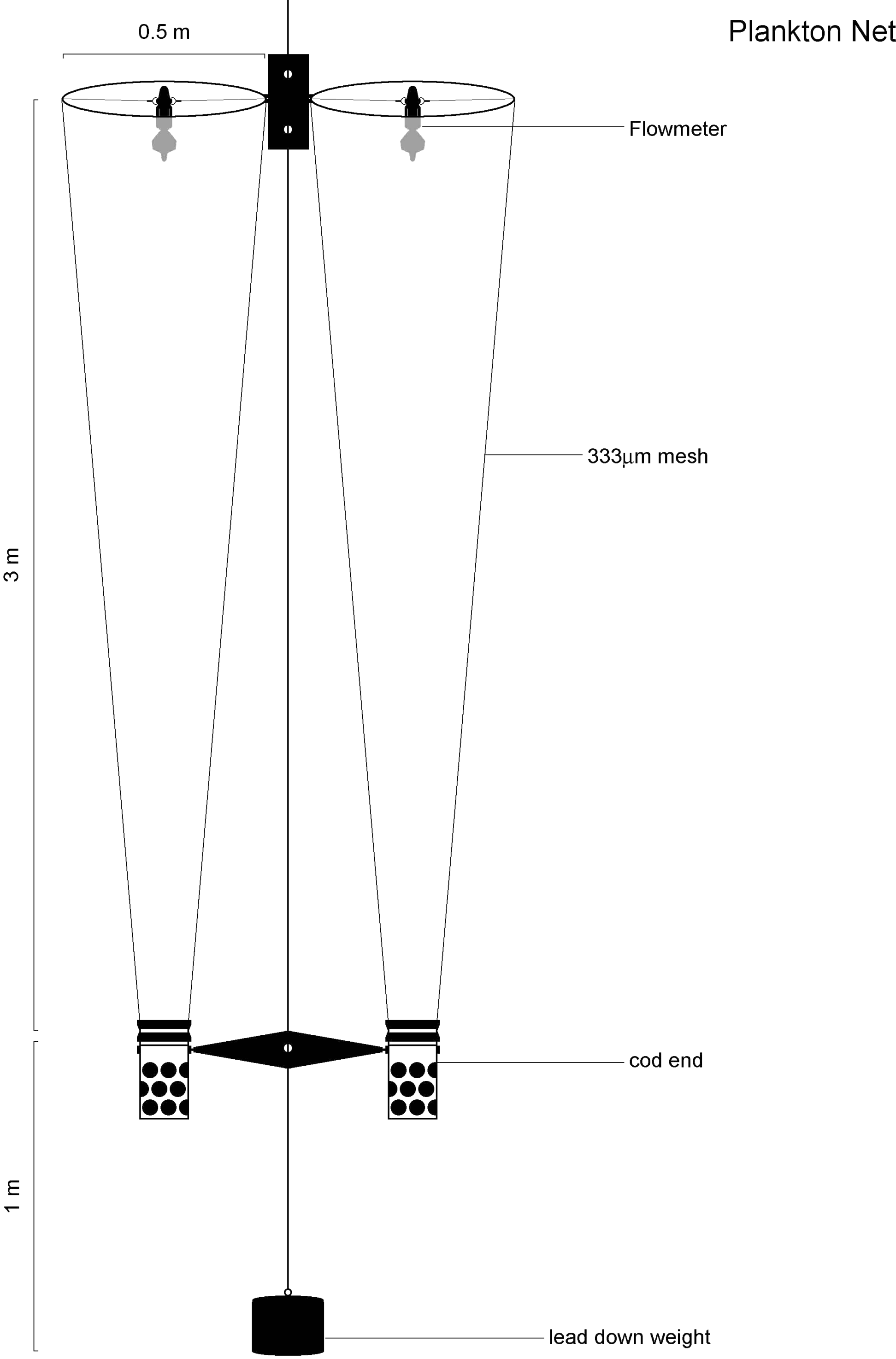

Figure 2-3. Illustration and dimensions of the towed vertical plankton net.

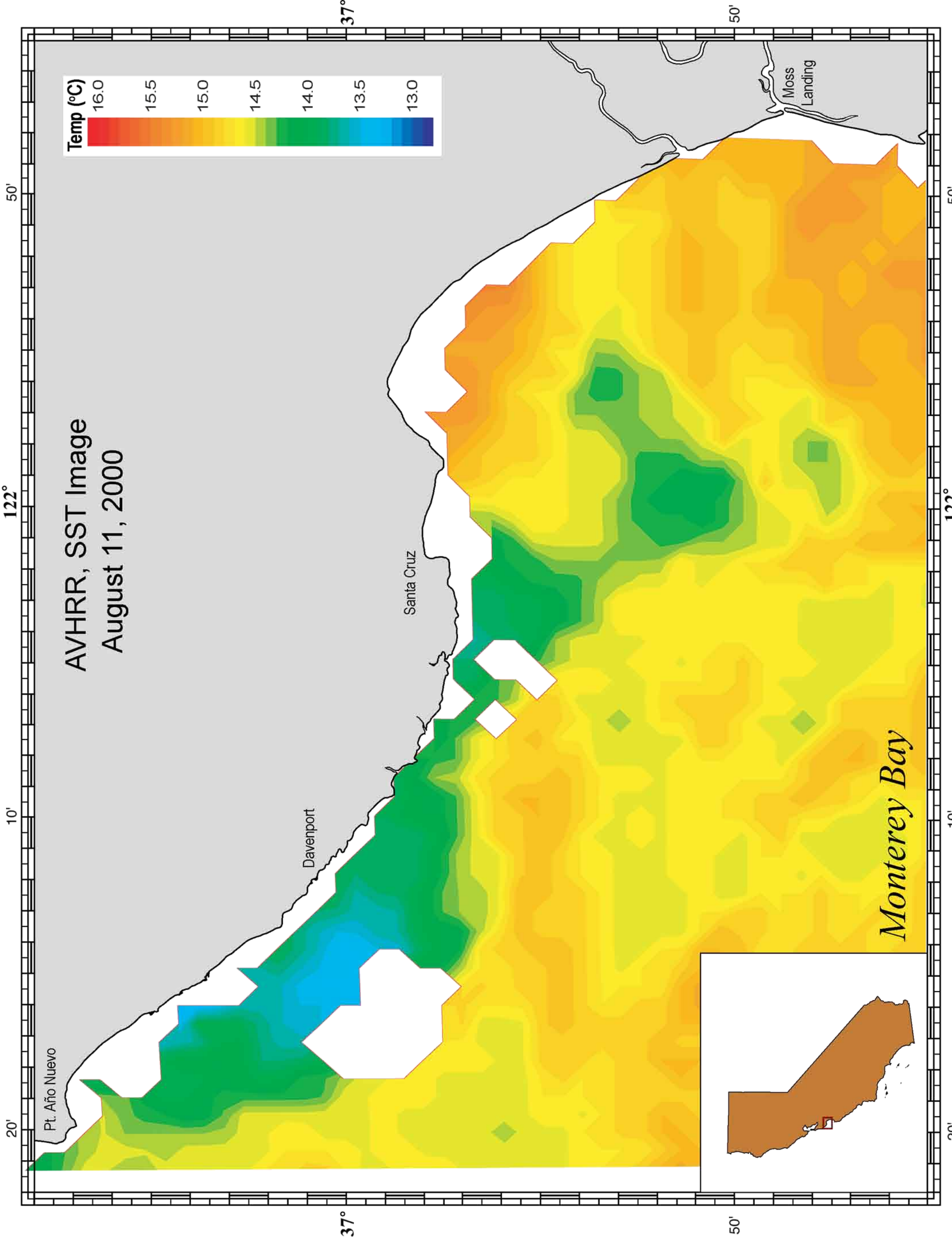

Figure 2-4. Advanced Very High Resolution Radiometry (AVHRR) sea surface temperature (SST) image from August 11, 2000. Data were obtained from the Coast Watch West Coast Regional Node website, www.coastwatch.pfel.noaa.gov.

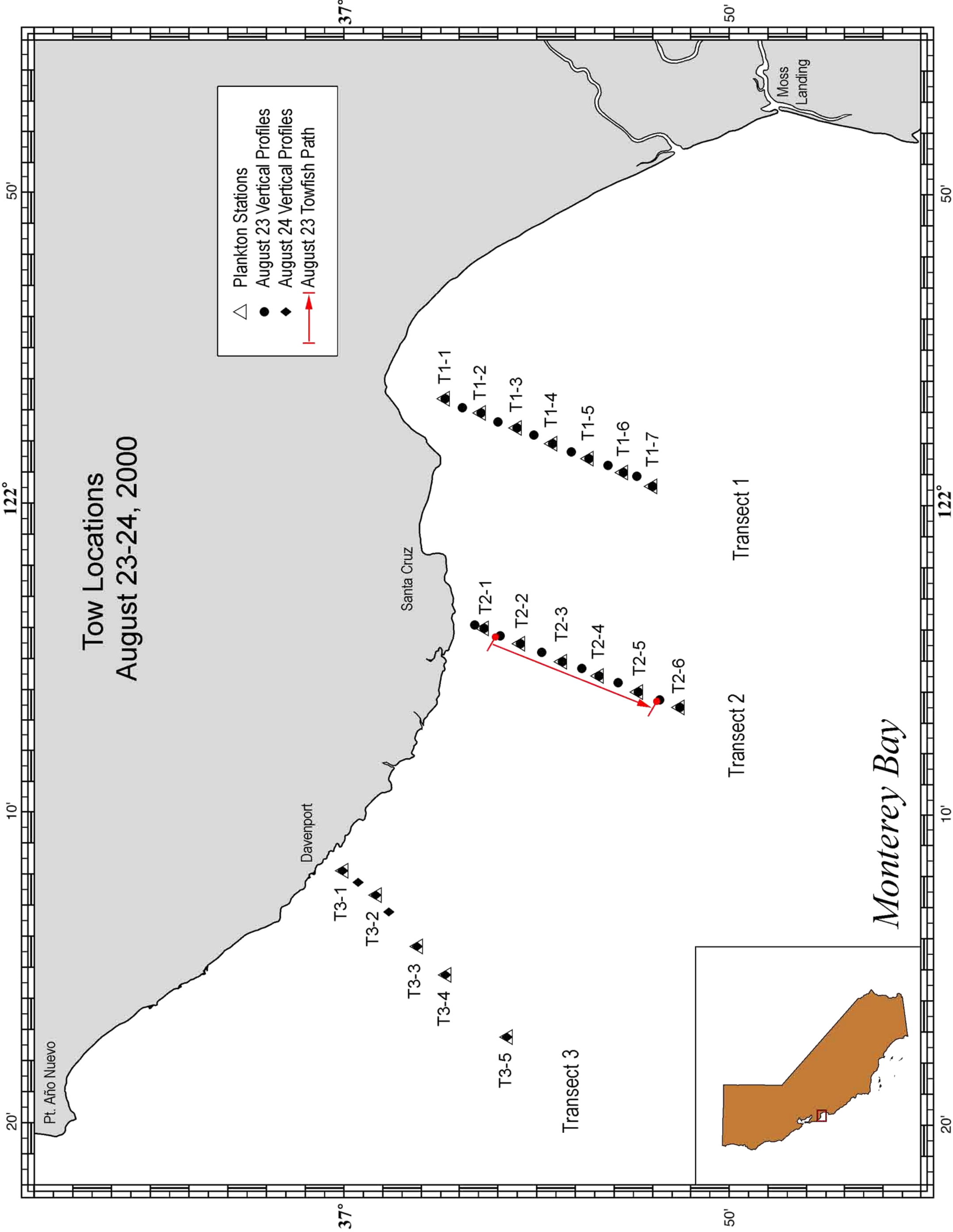

Figure 2-5. Location of vertical conductivity-temperature-depth (CTD) casts, plankton net tows, and minibat towed profiler (with CTD, fluorometer and transmissometer) along three line transects, August 23-24, 2000.

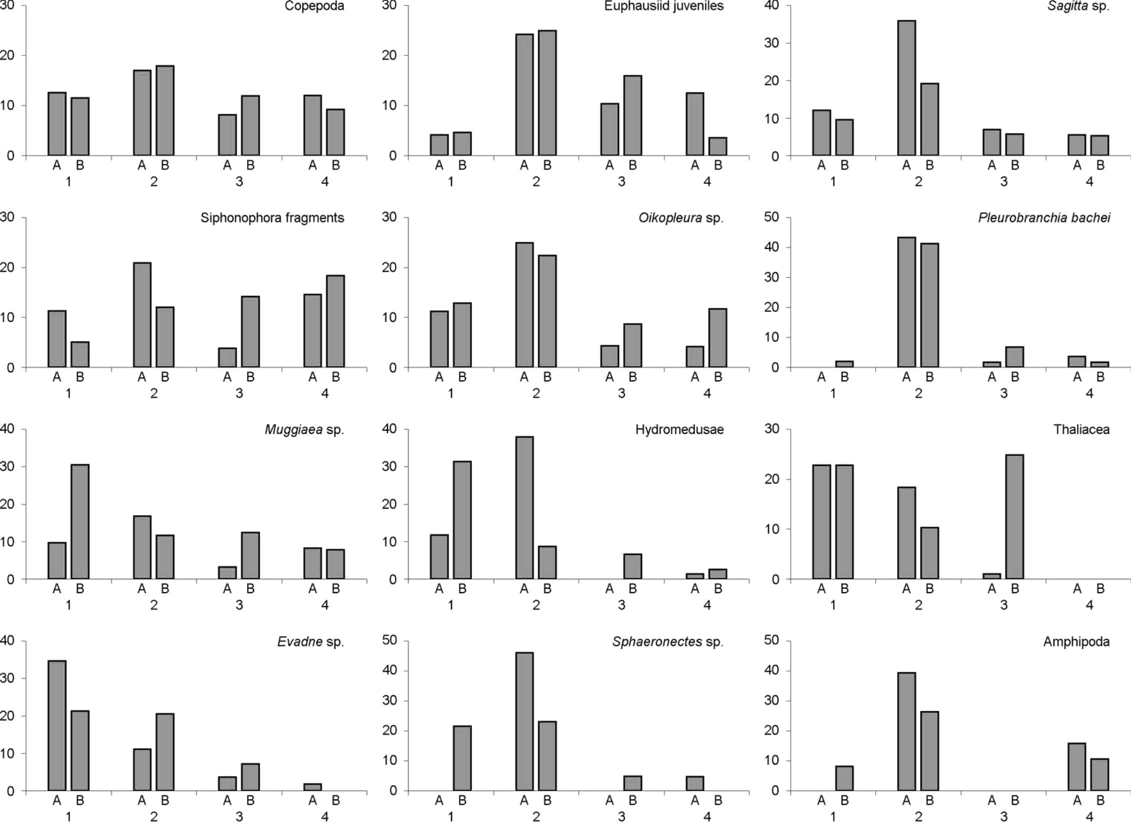

Figure 2-6a. Bar graphs of the proportion of each holoplanktonic taxa along the April 24, 2000 transect. The x-axis denotes the tow locations, each separated by a 2 km distance. The y-axis is the percentage of the total transect catch for each taxa, normalized for volume. A strong thermal front was located at tow 2.

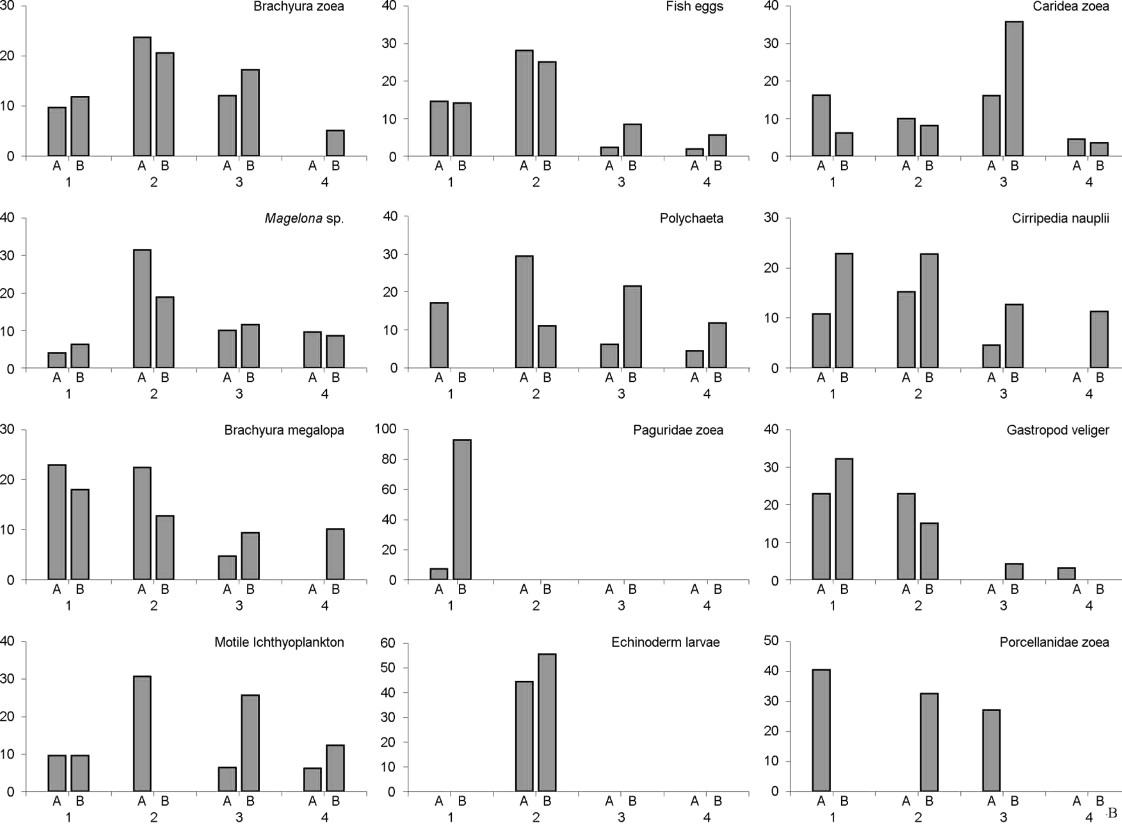

Figure 2-6b. Bar graphs of the proportion of each meroplanktonic taxa along the April 24, 2000 transect. The x-axis denotes the tow locations, each separated by a 2 km distance. The y-axis is the percentage of the total transect catch for each taxa, normalized for volume. A strong thermal front was located at tow 2.

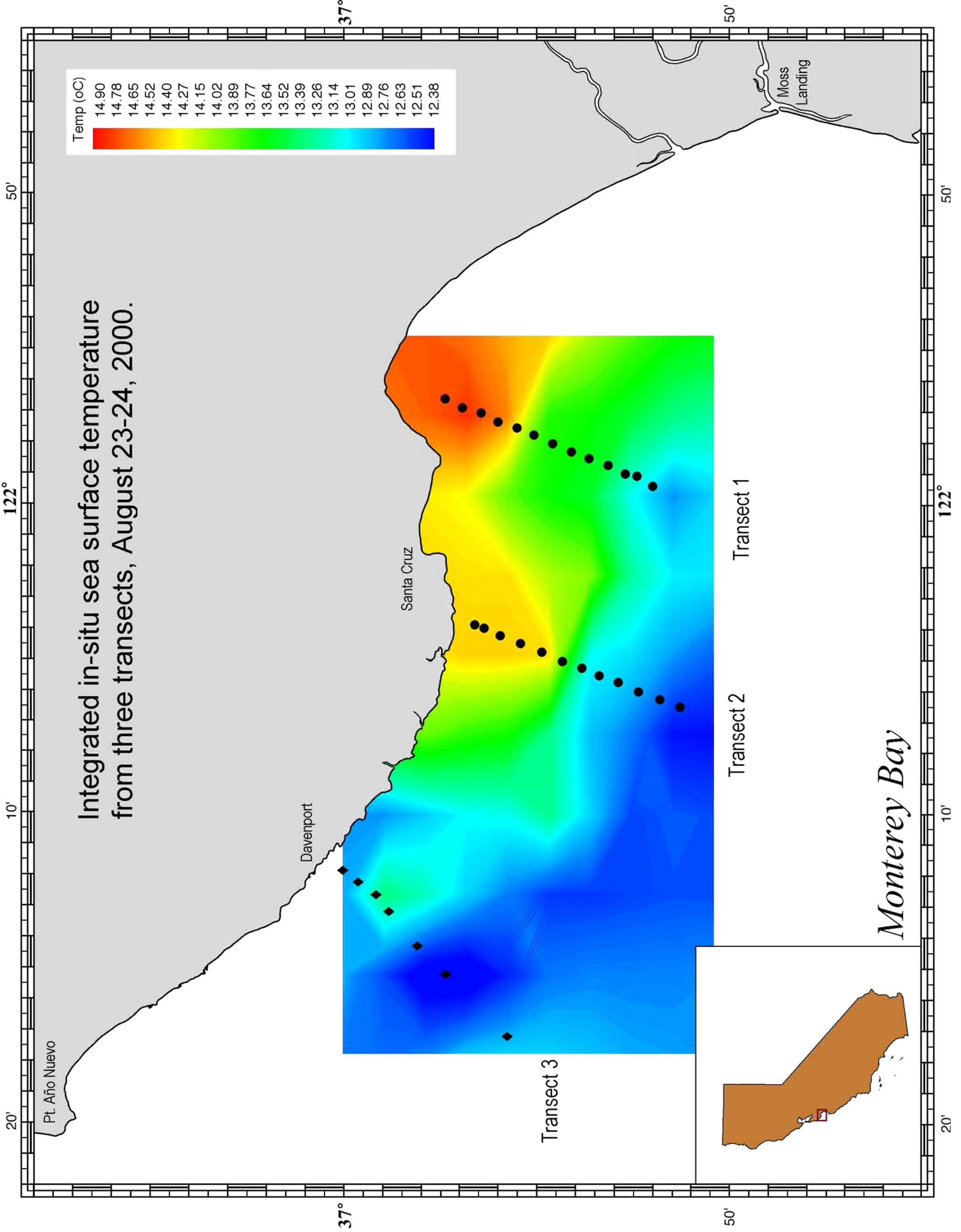

Figure 2-7. False color image of sea surface temperature (SST) on August 23-24, 2000, generated using an inverse-distance interpolation. Temperature values are at a depth of 1 m, taken from *in situ* CTD casts along all three transects.

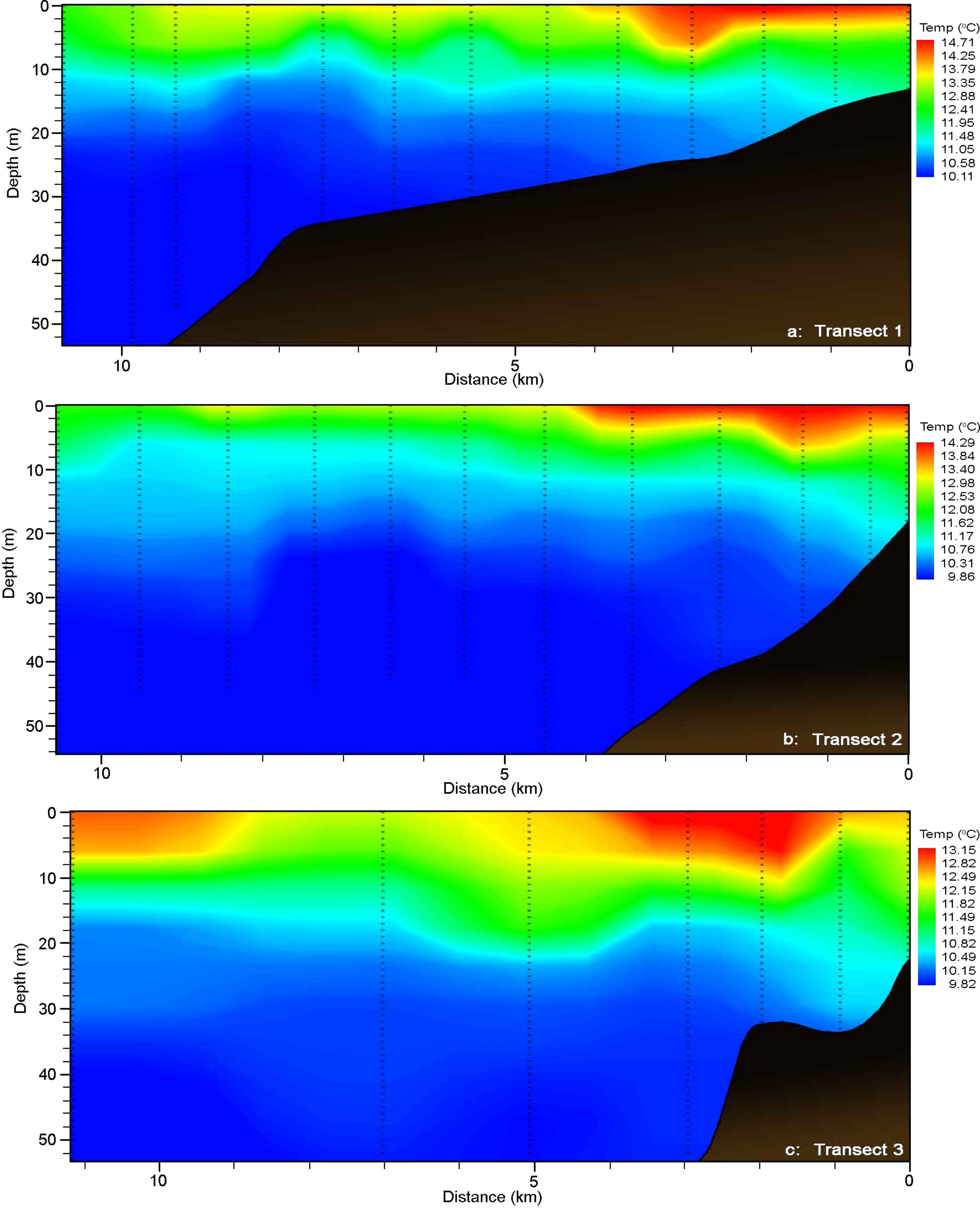

Figure 2-8. False color image of temperature profiles along three transects on August 23-24, 2000, generated using an inverse-distance interpolation. Surface fronts are visible between 4 and 5 km along the transect.

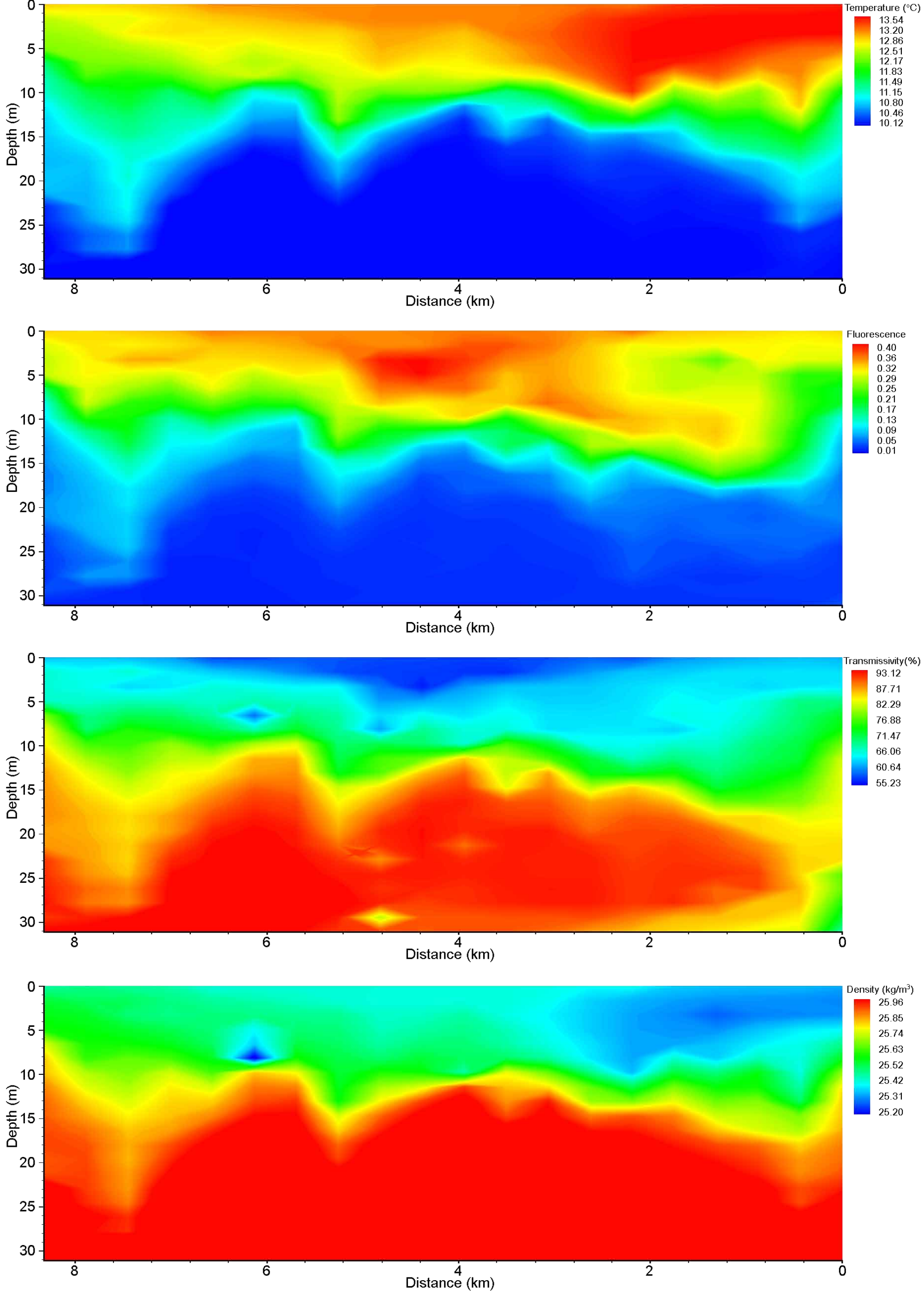

Figure 2-9. False color profiles of temperature, fluorescence, transmissivity and density along transect 2 on August 23, 2000, generated using an inverse-distance interpolation. A surface front was visible at 4 km along the transect.

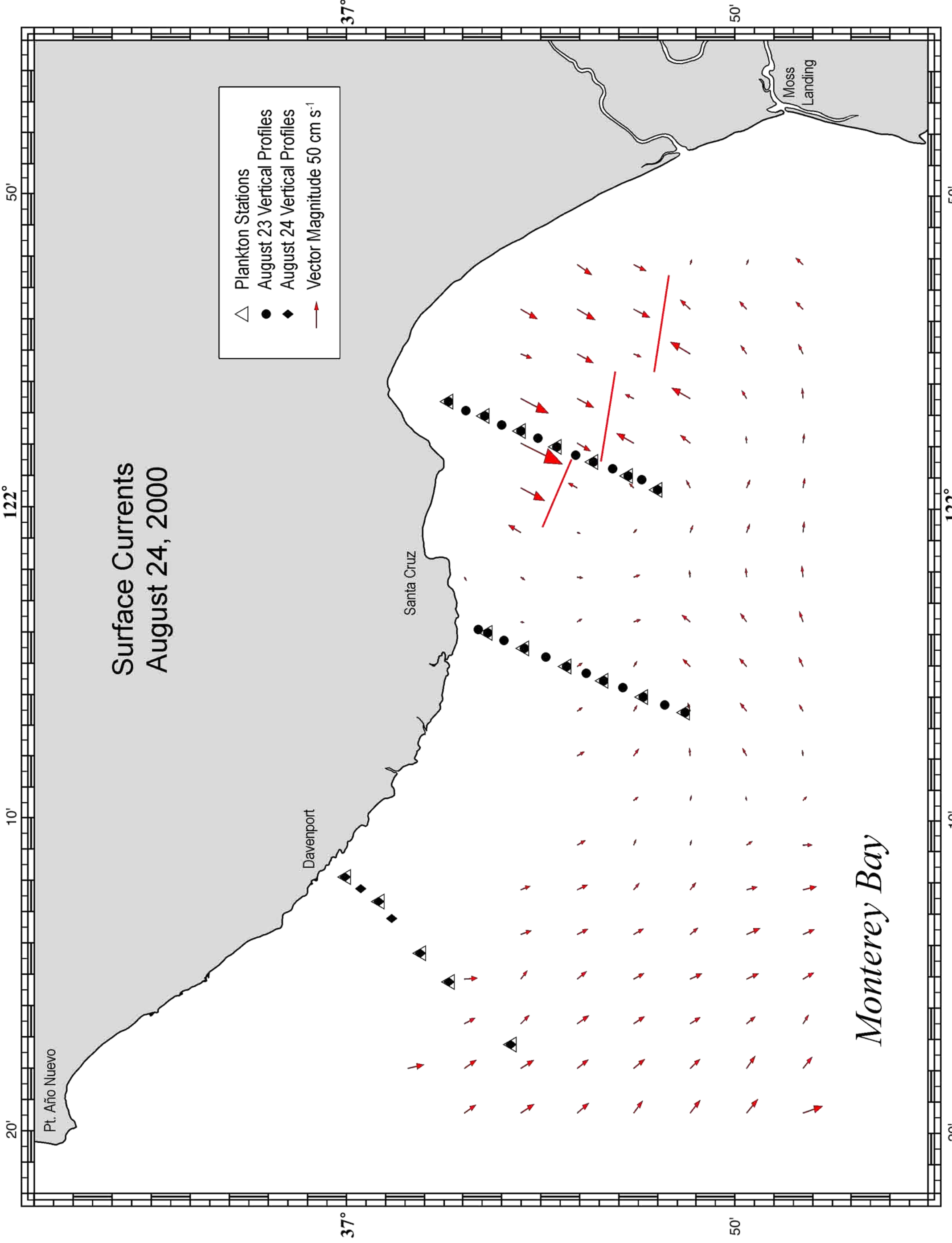

Figure 2-10. Surface currents from high frequency coastal radar (CODAR), averaged over 1200-1400 hrs, August 24, 2000. Raw data were provided by the Naval Postgraduate School Department of Oceanography, Radar and Drifter (RAD) Laboratory.

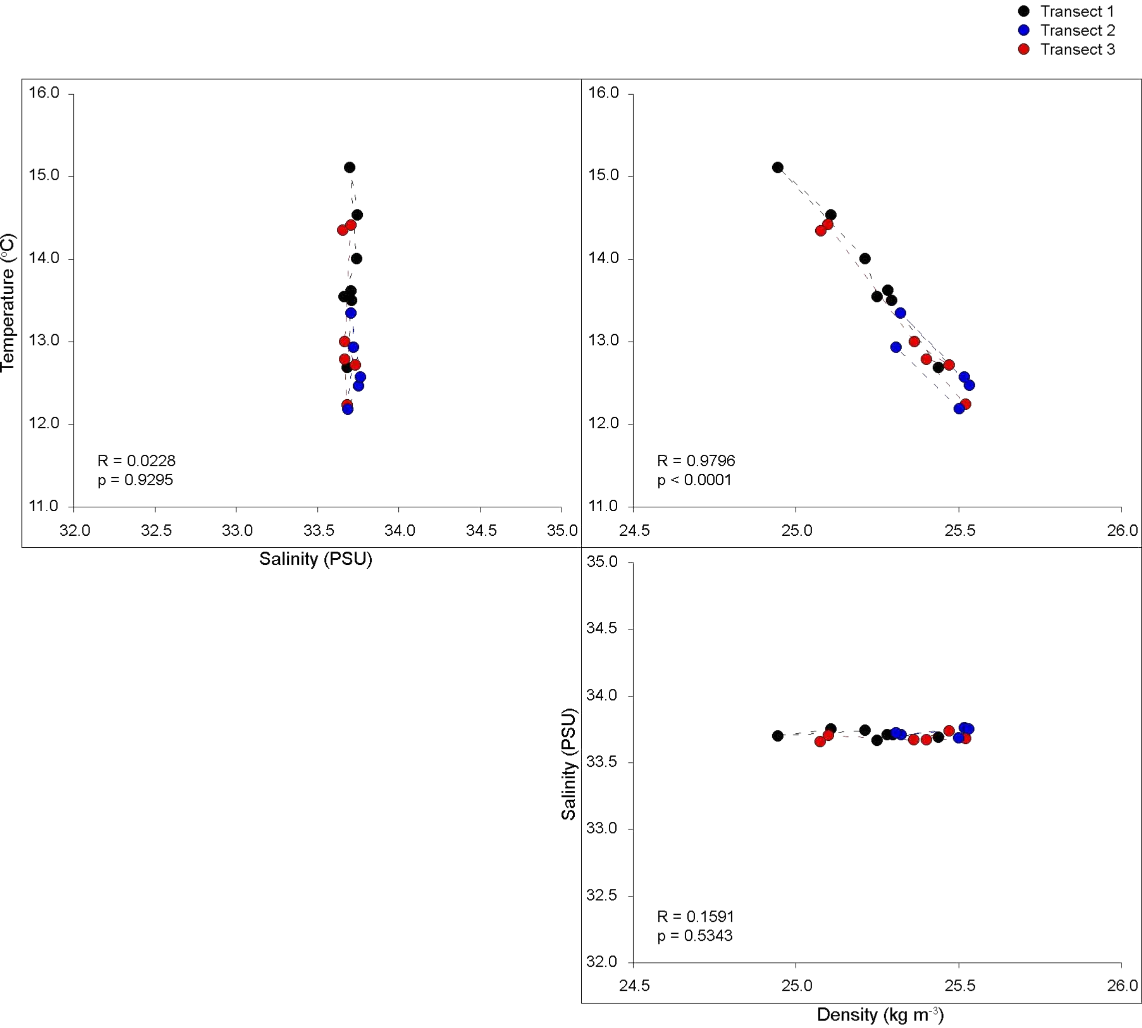

Figure 2-11. Scatterplots of temperature and salinity versus density, and temperature versus salinity. A Pearson correlation matrix revealed a highly significant correltation between temperature and density, and no significant correlation between salinity with either temperature or density. Therefore, any change in density can be explained entirely by temperature change alone.

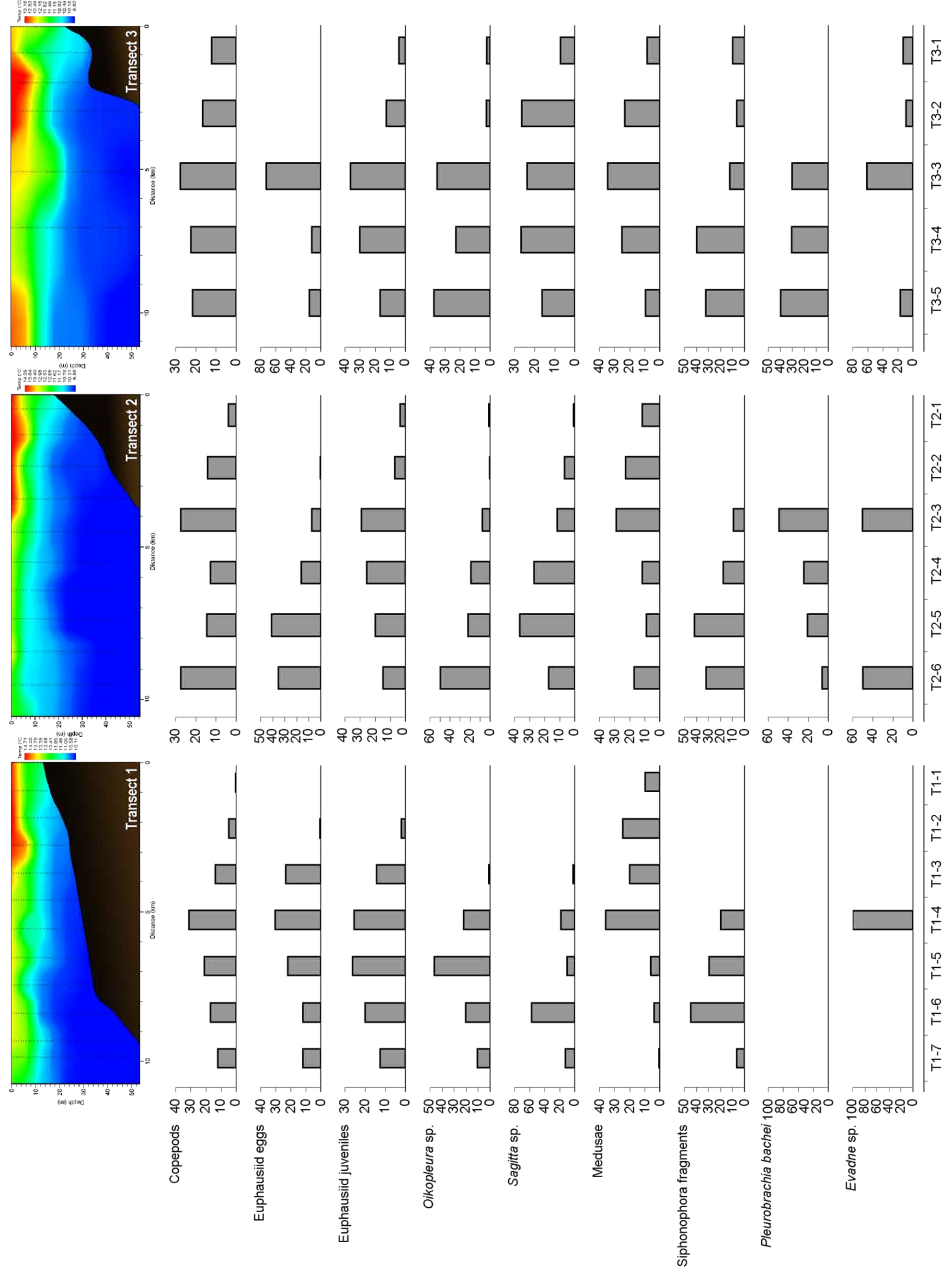

Figure 2-12a. Bar graphs of the proportion of each holoplanktonic taxon along the August 23-24, 2000, transects. The x-axis demonstrates the tow locations. The y-axis is the percentage of the total transect catch for each taxon, normalized for volume. A front was located along each transect at T1-4, T2-3 and T3-3.

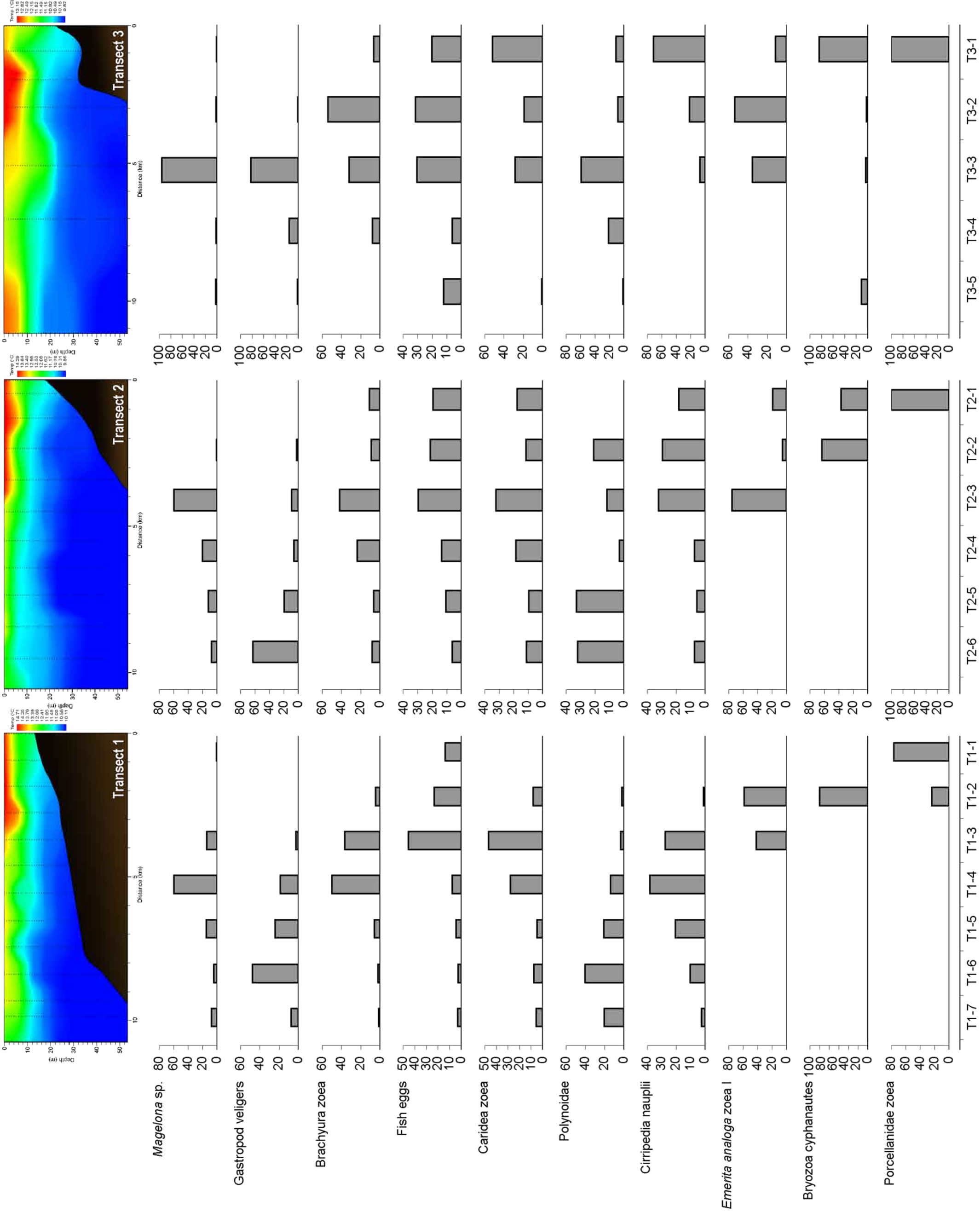

Figure 2-12b. Bar graphs of the proportion of each meroplanktonic taxon along the August 23-24, 2000, transects. The x-axis demonstrates the tow locations. The y-axis is the percentage of the total transect catch for each taxon, normalized for volume. A front was located along each transect at T1-4, T2-3 and T3-3.

Appendices

Appendix A-1. Forward step-wise multiple linear regression detailed summary statistics for each significant holoplankton taxa on April 24, 2000. Non-significant variables were omitted. All variables were regressed against (1) surface temperature, (2) 0.5 km horizontal change in surface temperature centered on each station, and (3) distance from shore.

Copepoda

R = 0.91337 R^2 = 0.83424 Adjusted R^2 = 0.80661
$F_{(1,6)}$ = 30.197, $p < 0.00152$, SE of estimate: 486.71

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			2967.26	263.90	11.244	0.000
Horiz. ΔT °C	0.913	0.166	1691.52	307.82	5.495	0.002

Euphausiid juveniles

R = 0.94462 R^2 = 0.89231 Adjusted R^2 = 0.81154
$F_{(3,4)}$ = 11.048, $p < 0.02095$, SE of estimate: 758.60

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			28579.99	13597.73	2.102	0.103
ΔT °C	1.310	0.237	3830.13	692.31	5.532	0.005
Surface T (°C)	-1.253	0.554	-2129.22	941.12	-2.262	0.086
Distance (km)	-0.630	0.481	-118.19	90.30	-1.309	0.261

***Sagitta* sp.**

R = 0.90201 R^2 = 0.81362 Adjusted R^2 = 0.78256
$F_{(1,6)}$ = 26.193, $p < 0.00218$, SE of estimate: 176.02

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			77.04	95.44	0.807	0.450
Horiz. ΔT °C	0.902	0.176	569.74	111.32	5.118	0.002

***Oikopleura* sp.**

R = 0.93083 R^2 = 0.86645 Adjusted R^2 = 0.84419
$F_{(1,6)}$ = 38.925, $p < 0.00079$, SE of estimate: 33.812

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			53.65	18.33	2.926	0.026
Horiz. ΔT °C	0.931	0.149	133.42	21.38	6.239	0.001

Pleurobrachia bachei

R = 0.99612 R^2 = 0.99225 Adjusted R^2 = 0.98915
$F_{(2,5)}$ = 320.09, $p < 0.00001$, SE of estimate: 18.475

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			502.88	93.82	5.360	0.003
Horiz. ΔT °C	1.165	0.051	345.85	15.16	22.816	0.000
Surface T (°C)	-0.312	0.051	-53.79	8.81	-6.105	0.002

Medusae

R = 0.73111 R^2 = 0.53452 Adjusted R^2 = 0.45694
$F_{(1,6)}$ = 6.8899, $p < 0.03933$, SE of estimate: 64.576

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-627.61	269.22	-2.331	0.059
Surface T (°C)	0.731	0.279	62.31	23.74	2.625	0.039

Thaliacea

R = 0.77379 R^2 = 0.59874 Adjusted R^2 = 0.53187
$F_{(1,6)}$ = 8.9531, $p < 0.02425$, SE of estimate: 31.773

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			198.81	50.13	3.966	0.007
Distance (km)	-0.774	0.259	-3.86	1.29	-2.992	0.024

***Evadne* sp.**

R = 0.92741 R^2 = 0.86009 Adjusted R^2 = 0.80412
$F_{(2,5)}$ = 15.369, $p < 0.00732$, SE of estimate: 11.989

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-294.32	60.88	-4.834	0.005
Surface T (°C)	1.120	0.217	29.51	5.72	5.162	0.004
Horiz. ΔT °C	-0.375	0.217	-17.01	9.84	-1.729	0.144

***Sphaeronectes* sp.**

R = 0.84502 R^2 = 0.71405 Adjusted R^2 = 0.66640
$F_{(1,6)}$ = 14.983, $p < 0.00826$, SE of estimate: 8.0389

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-2.29	4.36	-0.526	0.618
Horiz. ΔT °C	0.845	0.218	19.68	5.08	3.871	0.008

Amphipoda

R = 0.94879 R^2 = 0.90020 Adjusted R^2 = 0.82534
$F_{(3,4)}$ = 12.026, $p < 0.01804$, SE of estimate: 4.3589

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-146.79	78.13	-1.879	0.133
Horiz. ΔT °C	0.801	0.228	13.99	3.98	3.516	0.025
Distance (km)	1.147	0.463	1.29	0.52	2.477	0.068
Surface T (°C)	0.857	0.533	8.70	5.41	1.608	0.183

Appendix A-2. Forward step-wise multiple linear regression detailed summary statistics for each significant meroplankton taxa on April 24, 2000. Non-significant variables were omitted. All variables were regressed against (1) surface temperature, (2) 0.5 km horizontal change in surface temperature centered on each station, and (3) distance from shore.

Brachyura zoea

R = 0.79884 R^2 = 0.63814 Adjusted R^2 = 0.57783

$F_{(1,6)}$ = 10.581, p < 0.01740, SE of estimate: 189.36

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			211.04	102.67	2.055	0.086
Horiz. ΔT °C	0.799	0.246	389.56	119.76	3.253	0.017

Fish eggs

R = 0.97710 R^2 = 0.95473 Adjusted R^2 = 0.93662

$F_{(2,5)}$ = 52.722, p < 0.00044, SE of estimate: 30.881

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-399.53	156.82	-2.548	0.051
Horiz. ΔT °C	0.725	0.123	148.89	25.34	5.876	0.002
Surface T (°C)	0.339	0.123	40.47	14.73	2.748	0.040

***Magelona* sp.**

R = 0.91880 R^2 = 0.84419 Adjusted R^2 = 0.78187

$F_{(2,5)}$ = 13.545, p < 0.00958, SE of estimate: 31.560

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			390.22	160.27	2.435	0.059
Horiz. ΔT °C	1.155	0.229	130.65	25.89	5.046	0.004
Surface T (°C)	-0.511	0.229	-33.55	15.05	-2.229	0.076

Cirripedia nauplii

R = 0.72196 R^2 = 0.52122 Adjusted R^2 = 0.44143

$F_{(1,6)}$ = 6.5320, p < 0.04315, SE of estimate: 26.523

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-225.96	110.57	-2.044	0.087
Surface T (°C)	0.722	0.282	24.92	9.75	2.556	0.043

Sample volume

R = 0.99163 R^2 = 0.98333 Adjusted R^2 = 0.97666

$F_{(2,5)}$ = 147.47, p < 0.00004, SE of estimate: 7.3912

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			491.39	37.534	13.092	5E-05
Horiz. ΔT °C	1.2824	0.07491	103.8256	6.06433	17.121	1E-05
Surface T (°C)	-0.739	0.07491	-34.7678	3.52482	-9.8637	0.0002

Brachyura megalopa

R = 0.86144 R^2 = 0.74208 Adjusted R^2 = 0.69910

$F_{(1,6)}$ = 17.263, p < 0.00598, SE of estimate: 15.483

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-224.11	64.55	-3.472	0.013
Surface T (°C)	0.861	0.207	23.65	5.69	4.155	0.006

Paguridae zoea

R = 0.95226 R^2 = 0.90679 Adjusted R^2 = 0.86951

$F_{(2,5)}$ = 24.322, p < 0.00265, SE of estimate: 4.3133

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-126.17	21.90	-5.760	0.002
Surface T (°C)	1.074	0.177	12.47	2.06	6.064	0.002
Horiz. ΔT °C	-0.214	0.177	-4.27	3.54	-1.207	0.282

Echinoderm larvae

R = 0.99065 R^2 = 0.98138 Adjusted R^2 = 0.97394

$F_{(2,5)}$ = 131.79, p < 0.00005, SE of estimate: 1.6212

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-15.03	3.28	-4.587	0.006
Horiz. ΔT °C	1.071	0.069	17.99	1.16	15.569	0.000

Gastropod veligers

R = 0.95562 R^2 = 0.91320 Adjusted R^2 = 0.87848

$F_{(2,5)}$ = 26.303, p < 0.00222, SE of estimate: 4.3339

	Beta	SE Beta	B	SE of B	t(6)	p-level
Intercept			-131.01	22.01	-5.953	0.002
Surface T (°C)	1.070	0.171	12.94	2.07	6.260	0.002
Horiz. ΔT °C	-0.199	0.171	-4.14	3.56	-1.164	0.297

Appendix B-1. Forward step-wise multiple linear regression detailed summary statistics for each significant holoplankton taxa, and sample volume, on August 23 and 24, 2000. Non-significant variables were omitted. All variables were regressed against (1) distance from shore, (2) surface temperature, (3) surface salinity, (4) surface density, (5) approximate thermocline depth, (6) temperature change in the upper 5 meters, (7) temperature change in the upper 12 meters, and (8) the natural log of 0.5 km horizontal change in surface temperature centered on each station.

Copepods

R = 0.69387 $R^2 = 0.48146$ Adjusted $R^2 = 0.37034$

$F_{(3,14)} = 4.3329$, $p < 0.02338$, SE of estimate: 129.61

	Beta	SE Beta	B	SE of B	t(14)	p-level
Intercept			399.79	109.47	3.652	0.003
Distance (km)	0.509	0.206	21.26	8.61	2.470	0.027
LN(Horiz. ΔT °C)	0.390	0.202	41.21	21.38	1.927	0.075
ΔT Depth (12 m)	-0.301	0.199	-54.77	36.25	-1.511	0.153

LN(Euphausiid eggs+1)

R = 0.85630 $R^2 = 0.73326$ Adjusted $R^2 = 0.67610$

$F_{(3,14)} = 12.828$, $p < 0.00026$, SE of estimate: 1.2345

	Beta	SE Beta	B	SE of B	t(14)	p-level
Intercept			49.89	8.17	6.103	0.000
Surface temp (°C)	-1.515	0.271	-3.82	0.68	-5.587	0.000
ΔT Depth (12 m)	0.943	0.269	2.28	0.65	3.501	0.004
LN(Horiz. ΔT °C)	0.164	0.151	0.23	0.21	1.089	0.294

Euphausiid juveniles

R = 0.73122 $R^2 = 0.53468$ Adjusted $R^2 = 0.39151$

$F_{(4,13)} = 3.7345$, $p < 0.03099$, SE of estimate: 12.698

	Beta	SE Beta	B	SE of B	t(13)	p-level
Intercept			-607.02	592.64	-1.024	0.324
Distance (km)	0.645	0.220	2.69	0.92	2.934	0.012
ΔT Depth (5 m)	0.513	0.233	10.89	4.94	2.205	0.046
LN(Horiz. ΔT °C)	0.382	0.199	4.03	2.10	1.918	0.077
Surface density (kg/m^3)	0.259	0.250	24.26	23.40	1.037	0.319

Hydromedusae

R = 0.62311 $R^2 = 0.38826$ Adjusted $R^2 = 0.30670$

$F_{(2,15)} = 4.7602$, $p < 0.02507$, SE of estimate: 1.4357

	Beta	SE Beta	B	SE of B	t(15)	p-level
Intercept			2.51	1.09	2.302	0.036
LN(Horiz. ΔT °C)	0.560	0.203	0.63	0.23	2.763	0.015
ΔT Depth (12 m)	0.326	0.203	0.63	0.39	1.607	0.129

Siphonophore fragments

R = 0.84003 $R^2 = 0.70565$ Adjusted $R^2 = 0.61509$

$F_{(4,13)} = 7.7914$, $p < 0.00197$, SE of estimate: 0.77402

	Beta	SE Beta	B	SE of B	t(13)	p-level
Intercept			9.90	4.17	2.374	0.034
Distance (km)	0.393	0.184	0.13	0.06	2.132	0.053
LN(Horiz. ΔT °C)	-0.280	0.158	-0.23	0.13	-1.769	0.100
Surface temp (°C)	-0.542	0.214	-0.79	0.31	-2.537	0.025
ΔT Depth (5 m)	0.308	0.188	0.50	0.31	1.637	0.126

***Oikopleura* sp.**

R = 0.74391 $R^2 = 0.55340$ Adjusted $R^2 = 0.49386$

$F_{(2,15)} = 9.2937$, $p < 0.00237$, SE of estimate: 9.4958

	Beta	SE Beta	B	SE of B	t(15)	p-level
Intercept			84.70	44.80	1.891	0.078
Distance (km)	0.457	0.206	1.56	0.70	2.221	0.042
Surface temp (°C)	-0.388	0.206	-6.03	3.19	-1.888	0.079

Sample volume (ml)

R = 0.52825 $R^2 = 0.27905$ Adjusted $R^2 = 0.23399$

$F_{(1,16)} = 6.1930$, $p < 0.02422$, SE of estimate: 5.1241

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			53.31	19.29	2.763	0.014
Surface temp (°C)	-0.53	0.212	-3.59	1.44	-2.489	0.024

Appendix B-2. Forward step-wise multiple linear regression detailed summary statistics for each significant meroplankton taxa, individuals per cubic meter, and total species, on August 23 and 24, 2000. Non-significant variables were omitted. All variables were regressed against (1) distance from shore, (2) surface temperature, (3) surface salinity, (4) surface density, (5) approximate thermocline depth, (6) temperature change in the upper 5 meters, (7) temperature change in the upper 12 meters, and (8) the natural log of 0.5 km horizontal change in surface temperature centered on each station.

***Magelona* sp.**

R = 0.91075 $R^2 = 0.82946$ Adjusted $R^2 = 0.79292$

$F_{(3,14)} = 22.698$, $p < 0.00001$, SE of estimate: 31.701

	Beta	SE Beta	B	SE of B	t(14)	p-level
Intercept			-13023.5	2470.57	-5.271	0.000
LN(Horiz. ΔT °C)	0.943	0.122	42.60	5.50	7.741	0.000
Surface density (kg/m^3)	1.283	0.241	514.40	96.42	5.335	0.000
ΔT Depth (12 m)	1.005	0.239	77.90	18.56	4.201	0.001

LN(Gastropod veliger+1)

R = 0.73032 $R^2 = 0.53336$ Adjusted $R^2 = 0.50420$

$F_{(1,16)} = 18.288$, $p < 0.00058$, SE of estimate: 1.0881

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			19.46	4.10	4.750	0.000
Surface temp (°C)	-0.73	0.171	-1.31	0.31	-4.276	0.001

Brachyura zoea

R = 0.49228 $R^2 = 0.24234$ Adjusted $R^2 = 0.19499$

$F_{(1,16)} = 5.1177$, $p < 0.03796$, SE of estimate: 10.133

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			18.83	5.19	3.631	0.002
LN(Horiz. ΔT °C)	0.492	0.218	3.60	1.59	2.262	0.038

Fish egg

R = 0.56584 $R^2 = 0.32018$ Adjusted $R^2 = 0.27769$

$F_{(1,16)} = 7.5356$, $p < 0.01438$, SE of estimate: 5.1269

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			-47.52	19.30	-2.461	0.026
Surface temp (°C)	0.566	0.206	3.97	1.44	2.745	0.014

Caridea zoea

R = 0.49261 $R^2 = 0.24267$ Adjusted $R^2 = 0.19534$

$F_{(1,16)} = 5.1268$, $p < 0.03781$, SE of estimate: 4.3205

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			-1.01	2.43	-0.417	0.683
Thermocline (m)	0.493	0.218	0.65	0.29	2.264	0.038

Polynoidae

R = 0.54977 $R^2 = 0.30224$ Adjusted $R^2 = 0.25863$

$F_{(1,16)} = 6.9306$, $p < 0.01810$, SE of estimate: 2.1616

	Beta	SE Beta	B	SE of B	t(16)	p-level
Intercept			5.73	1.39	4.129	0.001
ΔT Depth (12 m)	-0.550	0.209	-1.54	0.58	-2.633	0.018

Individuals per m^3

R = 0.79238 $R^2 = 0.62787$ Adjusted $R^2 = 0.47282$

$F_{(5,12)} = 4.0494$, $p < 0.02192$, SE of estimate: 311.71

	Beta	SE Beta	B	SE of B	t(12)	p-level
Intercept			5339.7	1694.62	3.151	0.008
Surface temp (°C)	-0.85	0.261	-421.92	129.95	-3.247	0.007
LN(Horiz. ΔT °C)	0.250	0.201	69.44	55.81	1.244	0.237
ΔT Depth (5 m)	0.726	0.404	406.36	226.10	1.797	0.097
Distance (km)	0.441	0.279	48.39	30.61	1.581	0.140
Thermocline (m)	0.457	0.390	53.83	45.98	1.171	0.264

Total species

R = 0.84573 $R^2 = 0.71526$ Adjusted $R^2 = 0.62765$

$F_{(4,13)} = 8.1640$, $p < 0.00161$, SE of estimate: 4.0398

	Beta	SE Beta	B	SE of B	t(13)	p-level
Intercept			235.36	46.98	5.010	0.000
Surface temp (°C)	-2.364	0.577	-18.19	4.44	-4.094	0.001
Distance (km)	-0.678	0.206	-1.15	0.35	-3.291	0.006
ΔT Depth (12 m)	1.670	0.638	12.31	4.70	2.616	0.021
Thermocline (m)	0.637	0.343	1.16	0.62	1.857	0.086

Appendix C. Pearson correlation results for significant MLR taxa collected on April 24, 2000. N=8, with a case-wise deletion of missing data, with red marked correlations significant at $p<0.050$.

	Copepoda	Euphausiid juveniles	*Sagitta* sp.	Siphonophora frag.	*Oikopleura* sp.	*Pleurobrachia bachei*	*Muggiaea* sp.	Medusae	Thaliacea	*Evadne* sp.	*Sphaeronectes* sp.	Amphipoda	Brachyura zoea	Fish eggs	Caridea zoea	*Magelona* sp.	Polychaeta (other)	Cirripedia nauplii	Brachyura megalopa	Paguridae zoea	Gastropod veliger	Fish larvae	Echinoderm larvae	Porcellanidae zoea	Plankton ml per m^3
Copepoda	R=1.0 p= --																								
Euphausiid juveniles	R=0.796 p=0.018	R=1.0 p= ---																							
Sagitta sp.	R=0.795 p=0.018	R=0.685 p=0.061	R=1.0 p= --																						
Siphonophora frag.	R=0.419 p=0.301	R=0.376 p=0.358	R=0.451 p=0.262	R=1.0 p= ---																					
Oikopleura sp.	R=0.848 p=0.008	R=0.626 p=0.097	R=0.876 p=0.004	R=0.449 p=0.264	R=1.0 p= --																				
Pleurobrachia bachei	R=0.896 p=0.003	R=0.902 p=0.002	R=0.871 p=0.005	R=0.446 p=0.267	R=0.885 p=0.003	R=1.0 p= ---																			
Muggiaea sp.	R=0.276 p=0.508	R=-0.034 p=0.936	R=0.258 p=0.536	R=-0.146 p=0.729	R=0.384 p=0.347	R=0.130 p=0.758	R=1.0 p= --																		
Medusae	R=0.501 p=0.205	R=0.234 p=0.577	R=0.733 p=0.038	R=0.156 p=0.711	R=0.671 p=0.068	R=0.463 p=0.247	R=0.801 p=0.017	R=1.0 p= ---																	
Thaliacea	R=0.360 p=0.381	R=0.076 p=0.857	R=0.299 p=0.471	R=-0.037 p=0.930	R=0.343 p=0.405	R=0.121 p=0.774	R=0.628 p=0.095	R=0.613 p=0.106	R=1.0 p= --																
Evadne sp.	R=0.417 p=0.304	R=-0.083 p=0.845	R=0.266 p=0.524	R=-0.271 p=0.516	R=0.358 p=0.383	R=0.112 p=0.791	R=0.388 p=0.341	R=0.392 p=0.336	R=0.666 p=0.071	R=1.0 p= --															
Sphaeronectes sp.	R=0.762 p=0.028	R=0.668 p=0.070	R=0.905 p=0.002	R=0.344 p=0.403	R=0.846 p=0.008	R=0.83 p=0.011	R=0.563 p=0.146	R=0.852 p=0.007	R=0.342 p=0.407	R=0.163 p=0.700	R=1.0 p= --														
Amphipoda	R=0.774 p=0.024	R=0.722 p=0.043	R=0.837 p=0.009	R=0.603 p=0.113	R=0.793 p=0.019	R=0.875 p=0.004	R=0.205 p=0.626	R=0.53 p=0.169	R=-0.079 p=0.852	R=-0.073 p=0.862	R=0.857 p=0.007	R=1.0 p= --													
Brachyura zoea	R=0.662 p=0.073	R=0.724 p=0.042	R=0.740 p=0.036	R=0.128 p=0.762	R=0.758 p=0.029	R=0.774 p=0.024	R=0.279 p=0.503	R=0.549 p=0.158	R=0.532 p=0.174	R=0.279 p=0.502	R=0.710 p=0.048	R=0.457 p=0.254	R=1.0 p= ---												
Fish eggs	R=0.897 p=0.002	R=0.632 p=0.092	R=0.889 p=0.003	R=0.317 p=0.443	R=0.963 p=0.000	R=0.858 p=0.006	R=0.436 p=0.280	R=0.719 p=0.044	R=0.504 p=0.202	R=0.540 p=0.167	R=0.844 p=0.008	R=0.713 p=0.047	R=0.803 p=0.016	R=1.0 p= --											
Caridea zoea	R=-0.099 p=0.814	R=0.136 p=0.748	R=-0.166 p=0.694	R=-0.087 p=0.836	R=-0.225 p=0.592	R=-0.139 p=0.742	R=-0.147 p=0.728	R=-0.164 p=0.696	R=0.526 p=0.180	R=0.040 p=0.924	R=-0.233 p=0.578	R=-0.476 p=0.233	R=0.354 p=0.389	R=-0.109 p=0.796	R=1.0 p= ---										
Magelona sp.	R=0.719 p=0.044	R=0.863 p=0.006	R=0.887 p=0.003	R=0.563 p=0.146	R=0.766 p=0.027	R=0.914 p=0.001	R=0.082 p=0.847	R=0.515 p=0.191	R=0.068 p=0.871	R=-0.151 p=0.721	R=0.850 p=0.007	R=0.878 p=0.004	R=0.731 p=0.039	R=0.713 p=0.047	R=-0.062 p=0.883	R=1.0 p= --									
Polychaeta (other)	R=0.475 p=0.234	R=0.496 p=0.210	R=0.639 p=0.088	R=0.699 p=0.053	R=0.527 p=0.179	R=0.51 p=0.189	R=-0.124 p=0.768	R=0.328 p=0.427	R=0.424 p=0.295	R=0.076 p=0.858	R=0.418 p=0.302	R=0.383 p=0.348	R=0.611 p=0.107	R=0.528 p=0.178	R=0.444 p=0.269	R=0.643 p=0.085	R=1.0 p= ---								
Cirripedia nauplii	R=0.541 p=0.166	R=0.250 p=0.549	R=0.415 p=0.307	R=-0.061 p=0.884	R=0.733 p=0.038	R=0.484 p=0.223	R=0.712 p=0.047	R=0.602 p=0.114	R=0.565 p=0.144	R=0.524 p=0.183	R=0.566 p=0.143	R=0.303 p=0.465	R=0.63 p=0.088	R=0.736 p=0.037	R=-0.067 p=0.874	R=0.265 p=0.525	R=0.089 p=0.833	R=1.0 p= --							
Brachyura megalopa	R=0.470 p=0.240	R=0.029 p=0.945	R=0.630 p=0.093	R=0.153 p=0.717	R=0.680 p=0.063	R=0.341 p=0.408	R=0.522 p=0.184	R=0.762 p=0.028	R=0.722 p=0.043	R=0.751 p=0.031	R=0.531 p=0.176	R=0.257 p=0.539	R=0.534 p=0.172	R=0.754 p=0.030	R=-0.007 p=0.986	R=0.264 p=0.526	R=0.487 p=0.221	R=0.637 p=0.089	R=1.0 p= ---						
Paguridae zoea	R=0.489 p=0.218	R=0.018 p=0.965	R=0.519 p=0.187	R=-0.138 p=0.744	R=0.553 p=0.155	R=0.275 p=0.509	R=0.812 p=0.014	R=0.849 p=0.008	R=0.709 p=0.049	R=0.783 p=0.021	R=0.603 p=0.113	R=0.273 p=0.513	R=0.388 p=0.342	R=0.681 p=0.063	R=-0.188 p=0.654	R=0.148 p=0.726	R=0.074 p=0.860	R=0.678 p=0.064	R=0.830 p=0.011	R=1.0 p= --					
Gastropod veliger	R=0.500 p=0.219	R=0.028 p=0.949	R=0.528 p=0.189	R=-0.134 p=0.7619	R=0.563 p=0.1637	R=-0.287 p=0.509	R=0.805 p=0.013	R=0.847 p=0.005	R=0.706 p=0.049	R=0.788 p=0.017	R=0.607 p=0.115	R=0.280 p=0.519	R=0.388 p=0.360	R=0.691 p=0.057	R=-0.192 p=0.664	R=0.156 p=0.725	R=0.080 p=0.858	R=0.682 p=0.062	R=0.833 p=0.007	R=0.674 p=0.067	R=1.0 p= --				
Fish larvae	R=0.144 p=0.733	R=0.252 p=0.547	R=0.436 p=0.280	R=0.57 p=0.133	R=0.278 p=0.504	R=0.224 p=0.593	R=0.206 p=0.624	R=0.498 p=0.209	R=0.476 p=0.232	R=-0.194 p=0.644	R=0.427 p=0.291	R=0.247 p=0.554	R=0.439 p=0.276	R=0.257 p=0.538	R=0.454 p=0.258	R=0.509 p=0.198	R=0.790 p=0.020	R=0.039 p=0.925	R=0.353 p=0.391	R=0.104 p=0.806	R=0.099 p=0.824	R=1.0 p= ---			
Echinoderm larvae	R=0.895 p=0.003	R=0.857 p=0.006	R=0.814 p=0.014	R=0.355 p=0.388	R=0.881 p=0.004	R=0.981 p=0.000	R=0.100 p=0.812	R=0.388 p=0.342	R=0.071 p=0.867	R=0.194 p=0.645	R=0.762 p=0.028	R=0.831 p=0.011	R=0.733 p=0.038	R=0.857 p=0.007	R=-0.210 p=0.617	R=0.827 p=0.011	R=0.409 p=0.314	R=0.530 p=0.176	R=0.335 p=0.417	R=0.283 p=0.496	R=0.296 p=0.494	R=0.049 p=0.907	R=1.0 p= --		
Porcellanidae zoea	R=0.157 p=0.709	R=0.017 p=0.967	R=0.040 p=0.923	R=-0.410 p=0.312	R=0.061 p=0.885	R=0.074 p=0.860	R=-0.386 p=0.344	R=-0.277 p=0.505	R=0.020 p=0.962	R=0.614 p=0.105	R=-0.242 p=0.562	R=-0.226 p=0.589	R=0.148 p=0.726	R=0.187 p=0.657	R=0.072 p=0.864	R=-0.184 p=0.661	R=-0.042 p=0.921	R=0.058 p=0.890	R=0.212 p=0.613	R=0.099 p=0.814	R=0.110 p=0.803	R=-0.556 p=0.152	R=0.212 p=0.614	R=1.0 p= ---	
Plankton ml per m^3	R=0.738 p=0.036	R=0.920 p=0.001	R=0.729 p=0.040	R=0.529 p=0.177	R=0.677 p=0.065	R=0.923 p=0.001	R=-0.171 p=0.684	R=0.184 p=0.662	R=-0.200 p=0.633	R=-0.212 p=0.614	R=0.660 p=0.075	R=0.856 p=0.007	R=0.584 p=0.128	R=0.605 p=0.112	R=-0.160 p=0.704	R=0.906 p=0.002	R=0.472 p=0.238	R=0.162 p=0.701	R=0.007 p=0.986	R=-0.081 p=0.847	R=-0.070 p=0.875	R=0.182 p=0.666	R=0.893 p=0.003	R=0.00 p=1.00	R=1.0 p= ---

Pearson correlation results for significant MLR taxa collected on August 23-24, 2000. N=18, with a case-wise deletion of missing data, with red marked correlations significant at p<0.050.

	Copepods	LN (Euphausiid eggs +1)	*Magelona* sp.	LN(Gastropod veliger +1)	Euphausiid juveniles	*Oikopleura* sp.	Brachyura zoea	*Sagitta* sp.	Fish eggs	Caridea zoea	Polynoidae	Cirripedia nauplii	Medusae	Siphonophore frag.	Ostracoda	Individuals per m^3	Total species	Diversity (H')	Plankton volume (ml)	Plankton ml per m^3
Copepoda	R=1.0 p= ---																			
LN (Euphausiid eggs +1)	R=0.439 p=0.068	R=1.0 p= ---																		
Magelona sp.	R=0.456 p=0.057	R=0.523 p=0.026	R=1.0 p= ---																	
LN(Gastropod veliger +1)	R=0.585 p=0.011	R=0.801 p=0.000	R=0.440 p=0.067	R=1.0 p= ---																
Euphausiid juveniles	R=0.623 p=0.006	R=0.454 p=0.058	R=0.511 p=0.030	R=0.326 p=0.186	R=1.0 p= ---															
Oikopleura sp.	R=0.470 p=0.049	R=0.787 p=0.000	R=0.187 p=0.456	R=0.767 p=0.000	R=0.284 p=0.253	R=1.0 p= ---														
Brachyura zoea	R=0.503 p=0.033	R=0.086 p=0.733	R=0.504 p=0.033	R=-0.038 p=0.879	R=0.477 p=0.045	R=-0.170 p=0.500	R=1.0 p= ---													
Sagitta sp.	R=0.253 p=0.310	R=0.114 p=0.650	R=0.017 p=0.946	R=0.197 p=0.433	R=0.566 p=0.014	R=0.077 p=0.759	R=0.009 p=0.969	R=1.0 p= ---												
Fish eggs	R=-0.277 p=0.265	R=-0.198 p=0.430	R=0.072 p=0.774	R=-0.45 p=0.055	R=-0.025 p=0.921	R=-0.469 p=0.049	R=0.447 p=0.063	R=-0.247 p=0.322	R=1.0 p= ---											
Caridea zoea	R=0.289 p=0.245	R=-0.107 p=0.671	R=0.208 p=0.407	R=-0.143 p=0.571	R=0.133 p=0.598	R=-0.292 p=0.239	R=0.649 p=0.004	R=-0.075 p=0.765	R=0.486 p=0.041	R=1.0 p= ---										
Polynoidae	R=0.479 p=0.044	R=0.511 p=0.030	R=0.346 p=0.160	R=0.851 p=0.000	R=0.220 p=0.380	R=0.487 p=0.040	R=-0.097 p=0.702	R=0.268 p=0.282	R=-0.384 p=0.115	R=0.021 p=0.933	R=1.0 p= ---									
Cirripedia nauplii	R=0.228 p=0.361	R=-0.287 p=0.248	R=0.046 p=0.854	R=-0.226 p=0.367	R=0.075 p=0.766	R=-0.297 p=0.231	R=0.376 p=0.123	R=-0.027 p=0.914	R=0.046 p=0.856	R=0.775 p=0.000	R=-0.088 p=0.728	R=1.0 p= ---								
Medusae	R=0.373 p=0.127	R=-0.059 p=0.814	R=0.413 p=0.088	R=-0.073 p=0.771	R=0.252 p=0.312	R=-0.179 p=0.476	R=0.783 p=0.000	R=-0.101 p=0.689	R=0.469 p=0.050	R=0.427 p=0.077	R=-0.074 p=0.768	R=0.167 p=0.507	R=1.0 p= ---							
Siphonophore frag.	R=0.313 p=0.206	R=0.702 p=0.001	R=0.003 p=0.990	R=0.64 p=0.004	R=0.333 p=0.176	R=0.731 p=0.001	R=-0.241 p=0.335	R=0.418 p=0.084	R=-0.510 p=0.030	R=-0.3553 p=0.148	R=0.367 p=0.133	R=-0.237 p=0.343	R=-0.298 p=0.229	R=1.0 p= ---						
Ostracoda	R=0.303 p=0.220	R=0.250 p=0.316	R=0.359 p=0.143	R=0.552 p=0.018	R=-0.165 p=0.512	R=0.302 p=0.222	R=-0.020 p=0.937	R=-0.208 p=0.407	R=-0.242 p=0.333	R=0.369 p=0.131	R=0.701 p=0.001	R=0.306 p=0.216	R=-0.029 p=0.906	R=-0.040 p=0.875	R=1.0 p= ---					
Individuals per m^3	R=0.633 p=0.005	R=0.873 p=0.000	R=0.640 p=0.004	R=0.877 p=0.000	R=0.461 p=0.054	R=0.749 p=0.000	R=0.262 p=0.292	R=0.130 p=0.605	R=-0.254 p=0.309	R=0.096 p=0.703	R=0.730 p=0.001	R=-0.079 p=0.754	R=0.169 p=0.501	R=0.575 p=0.012	R=0.532 p=0.023	R=1.0 p= ---				
Total species	R=0.260 p=0.297	R=0.581 p=0.011	R=0.413 p=0.088	R=0.4526 p=0.059	R=0.060 p=0.810	R=0.372 p=0.128	R=0.196 p=0.434	R=-0.279 p=0.262	R=-0.050 p=0.842	R=0.378 p=0.121	R=0.254 p=0.307	R=0.383 p=0.117	R=-0.052 p=0.836	R=0.316 p=0.200	R=0.490 p=0.039	R=0.571 p=0.013	R=1.0 p= ---			
Diversity (H')	R=-0.044 p=0.860	R=0.299 p=0.227	R=0.131 p=0.603	R=0.323 p=0.191	R=-0.044 p=0.861	R=0.308 p=0.213	R=-0.324 p=0.188	R=-0.181 p=0.472	R=-0.458 p=0.055	R=-0.392 p=0.108	R=0.196 p=0.434	R=-0.255 p=0.307	R=-0.456 p=0.057	R=0.205 p=0.414	R=0.203 p=0.419	R=0.176 p=0.485	R=0.049 p=0.845	R=1.0 p= ---		
Plankton volume (ml)	R=0.297 p=0.230	R=0.630 p=0.005	R=0.234 p=0.349	R=0.584 p=0.011	R=0.230 p=0.357	R=0.749 p=0.000	R=0.028 p=0.909	R=0.154 p=0.541	R=-0.264 p=0.289	R=-0.137 p=0.587	R=0.313 p=0.206	R=-0.139 p=0.582	R=0.013 p=0.958	R=0.533 p=0.023	R=0.198 p=0.430	R=0.621 p=0.006	R=0.388 p=0.111	R=-0.029 p=0.907	R=1.0 p= ---	
Plankton ml per m^3	R=0.309 p=0.211	R=0.545 p=0.019	R=0.249 p=0.318	R=0.481 p=0.043	R=0.258 p=0.300	R=0.667 p=0.002	R=0.158 p=0.529	R=0.132 p=0.599	R=-0.197 p=0.431	R=-0.012 p=0.960	R=0.223 p=0.374	R=0.008 p=0.972	R=0.140 p=0.578	R=0.457 p=0.056	R=0.175 p=0.487	R=0.581 p=0.011	R=0.395 p=0.104	R=-0.105 p=0.676	R=0.977 p=0.000	R=1.0 p= ---

Appendix D-2. Pearson correlation results for significant MLR taxa collected on August 23-24, 2000. N=18, with a case-wise deletion of missing data, with red marked correlations significant at $p<0.050$. Data from transect 2 were not included.

	Copepods	LN (Euphausiid eggs +1)	*Magelona* sp.	LN(Gastropod veliger +1)	Euphausiid juveniles	*Oikopleura* sp.	Brachyura zoea	*Sagitta* sp.	Fish eggs	Caridea zoea	Polynoidae	Cirripedia nauplii	Medusae	Siphonophore frag.	Ostracoda	Individuals per m^3	Total species	Diversity (H')	Plankton volume (ml)	Plankton ml per m^3
Copepoda	R=1.0 p= ---																			
LN (Euphausiid eggs +1)	R=0.805 p=0.001	R=1.0 p= ---																		
Magelona sp.	R=0.698 p=0.010	R=0.614 p=0.032	R=1.0 p= ---																	
LN(Gastropod veliger +1)	R=0.701 p=0.009	R=0.809 p=0.001	R=0.574 p=0.050	R=1.0 p= ---																
Euphausiid juveniles	R=0.672 p=0.015	R=0.473 p=0.123	R=0.475 p=0.121	R=0.304 p=0.346	R=1.0 p= ---															
Oikopleura sp.	R=0.688 p=0.011	R=0.827 p=0.000	R=0.412 p=0.189	R=0.736 p=0.005	R=0.357 p=0.262	R=1.0 p= ---														
Brachyura zoea	R=0.498 p=0.101	R=0.191 p=0.563	R=0.579 p=0.048	R=-0.018 p=0.957	R=0.455 p=0.141	R=-0.152 p=0.645	R=1.0 p= ---													
Sagitta sp.	R=0.234 p=0.474	R=0.087 p=0.794	R=0.041 p=0.901	R=0.185 p=0.575	R=0.574 p=0.050	R=0.047 p=0.889	R=-0.005 p=0.989	R=1.0 p= ---												
Fish eggs	R=-0.338 p=0.291	R=-0.181 p=0.583	R=-0.039 p=0.906	R=-0.469 p=0.127	R=-0.041 p=0.901	R=-0.491 p=0.107	R=0.439 p=0.157	R=-0.233 p=0.476	R=1.0 p= ---											
Caridea zoea	R=0.162 p=0.624	R=0.036 p=0.913	R=0.343 p=0.283	R=-0.12 p=0.717	R=0.101 p=0.762	R=-0.329 p=0.306	R=0.639 p=0.023	R=-0.126 p=0.705	R=0.522 p=0.082	R=1.0 p= ---										
Polynoidae	R=0.494 p=0.105	R=0.63 p=0.026	R=0.622 p=0.029	R=0.898 p=0.000	R=0.247 p=0.450	R=0.519 p=0.085	R=-0.08 p=0.810	R=0.255 p=0.434	R=-0.377 p=0.235	R=0.018 p=0.958	R=1.0 p= ---									
Cirripedia nauplii	R=0.132 p=0.690	R=-0.216 p=0.510	R=0.095 p=0.775	R=-0.206 p=0.530	R=0.068 p=0.838	R=-0.286 p=0.378	R=0.348 p=0.276	R=-0.048 p=0.886	R=0.021 p=0.949	R=0.761 p=0.003	R=-0.108 p=0.745	R=1.0 p= ---								
Medusae	R=0.285 p=0.380	R=0.056 p=0.867	R=0.547 p=0.065	R=-0.069 p=0.835	R=0.244 p=0.455	R=-0.169 p=0.609	R=0.786 p=0.0027	R=-0.122 p=0.714	R=0.478 p=0.119	R=0.386 p=0.222	R=-0.107 p=0.748	R=0.094 p=0.777	R=1.0 p= ---							
Siphonophore frag.	R=0.544 p=0.068	R=0.526 p=0.080	R=-0.048 p=0.887	R=0.573 p=0.051	R=0.376 p=0.236	R=0.676 p=0.014	R=-0.251 p=0.443	R=0.486 p=0.111	R=-0.575 p=0.049	R=-0.417 p=0.183	R=0.293 p=0.366	R=-0.182 p=0.581	R=-0.292 p=0.367	R=1.0 p= ---						
Ostracoda	R=0.221 p=0.501	R=0.306 p=0.343	R=0.511 p=0.091	R=0.557 p=0.059	R=-0.235 p=0.472	R=0.25 p=0.444	R=-0.054 p=0.872	R=-0.244 p=0.455	R=-0.236 p=0.470	R=0.371 p=0.242	R=0.729 p=0.006	R=0.324 p=0.313	R=-0.085 p=0.798	R=-0.133 p=0.689	R=1.0 p= ---					
Individuals per m^3	R=0.85 p=0.000	R=0.85 p=0.000	R=0.899 p=0.000	R=0.836 p=0.000	R=0.472 p=0.124	R=0.683 p=0.012	R=0.401 p=0.203	R=0.086 p=0.796	R=-0.217 p=0.509	R=0.227 p=0.488	R=0.78 p=0.002	R=0.015 p=0.965	R=0.305 p=0.345	R=0.288 p=0.374	R=0.581 p=0.046	R=1.0 p= ---				
Total species	R=0.529 p=0.077	R=0.426 p=0.172	R=0.55 p=0.064	R=0.243 p=0.456	R=0.313 p=0.332	R=-0.008 p=0.981	R=0.762 p=0.003	R=-0.05 p=0.880	R=0.427 p=0.171	R=0.832 p=0.000	R=0.254 p=0.437	R=0.454 p=0.142	R=0.513 p=0.089	R=-0.165 p=0.617	R=0.349 p=0.275	R=0.555 p=0.061	R=1.0 p= ---			
Diversity (H')	R=0.079 p=0.812	R=0.48 p=0.117	R=0.208 p=0.527	R=0.416 p=0.184	R=0.194 p=0.556	R=0.251 p=0.442	R=-0.138 p=0.678	R=0.194 p=0.557	R=0.056 p=0.867	R=-0.032 p=0.923	R=0.448 p=0.148	R=-0.307 p=0.341	R=-0.283 p=0.382	R=0.19 p=0.563	R=0.135 p=0.685	R=0.285 p=0.379	R=-0.028 p=0.934	R=1.0 p= ---		
Plankton volume (ml)	R=0.861 p=0.000	R=0.708 p=0.008	R=0.637 p=0.024	R=0.61 p=0.033	R=0.64 p=0.023	R=0.564 p=0.055	R=0.348 p=0.275	R=0.498 p=0.101	R=-0.435 p=0.162	R=0.022 p=0.948	R=0.473 p=0.123	R=0.018 p=0.956	R=0.222 p=0.497	R=0.579 p=0.048	R=0.094 p=0.778	R=0.721 p=0.006	R=0.320 p=0.319	R=0.227 p=0.488	R=1.0 p= ---	
Plankton ml per m^3	R=0.757 p=0.003	R=0.395 p=0.210	R=0.652 p=0.020	R=0.262 p=0.421	R=0.649 p=0.020	R=0.24 p=0.464	R=0.636 p=0.024	R=0.379 p=0.231	R=-0.206 p=0.531	R=0.331 p=0.302	R=0.174 p=0.598	R=0.39 p=0.217	R=0.518 p=0.085	R=0.287 p=0.376	R=0.019 p=0.955	R=0.562 p=0.057	R=0.444 p=0.153	R=-0.036 p=0.915	R=0.849 p=0.000	R=1.0 p= ---

Appendix E. Species list and numbers of individuals per cubic meter by station. April 24, 2000.

	Station									Percent
Species	1A	1B	2A	2B	3A	3B	4A	4B	Total	Total
Cnidaria										
Hydromedusae - *Aquorea* sp.	-	6.0	9.7	-	-	-	-	-	15.6	0.02
Hydromedusae - *Bougainvillia* sp.	-	-	-	-	-	8.0	-	-	8.0	0.01
Hydromedusae - *Calycopsis* sp.	-	-	9.7	-	-	-	-	-	9.7	0.01
Hydromedusae - *Clytia gregaria*	47.9	47.9	106.2	9.7	-	12.1	3.9	3.9	231.5	0.32
Hydromedusae - *Cunina* sp.	-	42.0	9.7	-	-	-	3.9	-	55.5	0.08
Hydromedusae - *Euphysa* sp.	-	-	-	4.8	-	-	-	-	4.8	0.01
Hydromedusae - *Euphysa tentaculata*	-	-	-	9.7	-	-	-	-	9.7	0.01
Hydromedusae - *Halitholus* sp. 1	-	-	19.3	-	-	-	-	-	19.3	0.03
Hydromedusae - *Halitholus* sp. 2	-	-	-	-	-	4.0	-	3.9	7.9	0.01
Hydromedusae - *Leukartiara* sp.	-	24.0	48.3	-	-	12.1	-	-	84.3	0.12
Hydromedusae - *Mitrocoma* sp.	-	24.0	-	9.7	-	-	-	-	33.6	0.05
Hydromedusae - *Rathkea* sp.	-	6.0	9.7	4.8	-	-	-	-	20.5	0.03
Hydromedusae - *Sarsia princeps*	-	-	-	4.8	-	-	-	-	4.8	0.01
Hydromedusae - *Sarsia* sp.	6.0	6.0	-	4.8	-	-	-	-	16.8	0.02
Hydromedusae - *Stomatoca atra*	18.0	6.0	-	-	-	-	-	-	24.0	0.03
Hydromedusae - unknown	-	30.0	19.3	4.8	-	4.0	-	7.7	65.8	0.09
Scyphomedusae - *Aurelia* sp. ephyra	-	6.0	-	-	-	4.0	-	-	10.0	0.01
Scyphomedusae - *Chrysaora* sp. ephyra	42.0	42.0	-	-	-	4.0	-	7.7	95.6	0.13
Scyphomedusae various fragments	-	-	-	-	205.3	-	-	-	205.3	0.28
Siphonophora - *Muggiaea* sp.	71.9	227.7	125.5	86.9	24.1	92.6	61.7	57.9	748.3	1.03
Siphonophora - *Sphaeronectes* sp.	-	18.0	38.6	19.3	-	4.0	3.9	-	83.8	0.12
Siphonophora - various fragments	347.6	155.8	646.7	371.6	116.7	438.7	451.3	567.1	3095.5	4.27
Ctenophora										
Pleurobrachia bachei	-	18.0	415.1	395.8	16.1	64.4	34.7	15.4	959.4	1.32
Annelida										
Polychaeta - *Magelona* sp.	30.0	47.9	241.3	144.8	76.5	88.5	73.3	65.6	767.9	1.06
Polychaeta - Polynoidae I	18.0	-	9.7	9.7	28.2	64.4	23.1	34.7	187.7	0.26
Polychaeta - Polynoidae II	-	-	-	38.6	4.0	12.1	-	19.3	74.0	0.10
Polychaeta - Spionidae	-	-	19.3	-	-	-	-	-	19.3	0.03
Polychaeta - *Typhloscolex* sp.	71.9	-	115.8	9.7	-	28.2	-	7.7	233.3	0.32
Polychaeta - unidentified trochophore	-	-	9.7	-	-	8.0	-	-	17.7	0.02
Arthropoda										
Amphipoda - Gammaridea	-	6.0	9.7	4.8	-	-	7.7	7.7	35.9	0.05
Amphipoda - Hyperiidae	-	-	19.3	14.5	-	-	-	-	33.8	0.05
Amphipoda - Unidentified	-	-	-	-	-	-	3.9	-	3.9	0.01
Anomura - *Emerita analoga* (Stage 1) zoea	18.0	6.0	-	-	-	4.0	-	-	28.0	0.04
Anomura - *Emerita analoga* (Stage 2-5) zoea	-	-	-	-	-	-	7.7	-	7.7	0.01
Anomura - *Lepidopa myops* zoea	-	-	-	-	-	4.0	-	-	4.0	0.01
Anomura - Paguridae zoea 1	24.0	30.0	9.7	9.7	-	-	-	-	73.2	0.10
Anomura - Paguridae zoea 2	-	-	9.7	4.8	-	4.0	3.9	-	22.4	0.03
Anomura - Porcellanidae zoea	6.0	-	-	4.8	4.0	-	-	-	14.8	0.02
Brachyura - Cancridae megalopa	77.9	59.9	77.2	43.4	16.1	20.1	-	34.7	329.4	0.45
Brachyura - Cancridae zoea	119.9	155.8	376.4	318.5	277.7	426.6	-	119.6	1794.5	2.48
Brachyura - Grapsidae megalopa	-	-	-	-	-	12.1	-	-	12.1	0.02
Brachyura - Grapsidae zoea	-	12.0	-	-	-	-	-	-	12.0	0.02
Brachyura - Majidae zoea	-	-	-	-	4.0	-	-	-	4.0	0.01
Brachyura - Pinnotheridae zoea	227.7	263.7	501.9	424.7	161.0	193.2	-	69.4	1841.7	2.54
Brachyura - Portunidae zoea	-	-	-	4.8	4.0	-	-	-	8.9	0.01
Brachyura - Xanthidae zoea	12.0	6.0	-	14.5	-	20.1	-	-	52.6	0.07
Caridea - Alpheidae zoea	-	-	-	-	4.0	4.0	-	-	8.0	0.01
Caridea - Crangonidae zoea	12.0	-	19.3	9.7	20.1	28.2	7.7	-	97.0	0.13
Caridea - Hippolytidae zoea	89.9	47.9	48.3	29.0	84.5	197.2	23.1	27.0	546.9	0.75
Caridea - *Pandalus* sp. zoea 1	12.0	-	-	9.7	8.0	16.1	-	-	45.8	0.06
Caridea - *Pandalus* sp. zoea 2	6.0	-	-	4.8	-	8.0	-	-	18.9	0.03
Caridea - *Pandalus* sp. zoea 3	6.0	-	-	-	-	4.0	-	-	10.0	0.01
Caridea - *Pandalus* sp. zoea 4	-	-	-	4.8	8.0	-	-	-	12.9	0.02

Appendix E. (Continued).

	Station									
Species	1A	1B	2A	2B	3A	3B	4A	4B	Total	Percent Total
Arthropoda (continued)										
Caridea - Sergestidae zoea	-	-	-	4.8	-	-	3.9	-	8.7	0.01
Caridea - unknown zoea	-	-	9.7	-	-	20.1	-	-	29.8	0.04
Cirripedia - unidentified cyprid	-	-	9.7	-	-	-	-	-	9.7	0.01
Cirripedia - balanomorphan nauplii	47.9	101.9	57.9	86.9	16.1	48.3	-	46.3	405.3	0.56
Cirripedia - lepadomorphan nauplii	-	-	-	14.5	4.0	8.0	-	3.9	30.4	0.04
Cladocera - *Evadne* sp.	77.9	47.9	29.0	43.4	8.0	16.1	3.9	-	226.3	0.31
Copepoda - *Acartia* sp.	1929.7	1989.7	2886.1	3185.3	1867.4	949.8	1778.3	1481.3	16067.7	22.18
Copepoda - *Calanus* sp.	1294.5	1378.4	1660.2	1558.9	478.9	499.0	721.4	667.4	8258.7	11.40
Copepoda - *Clausocalanus* spp.	347.6	191.8	550.2	627.4	177.1	1935.8	740.7	462.9	5033.4	6.95
Copepoda - *Corycaeus* sp.	119.9	12.0	38.6	57.9	24.1	32.2	88.7	34.7	408.2	0.56
Copepoda - *Epilabidocera longipedata*	-	-	9.7	-	-	-	-	-	9.7	0.01
Copepoda - *Eucalanus californica*	-	6.0	29.0	57.9	16.1	4.0	42.4	7.7	163.1	0.23
Copepoda - Harpacticoidea	6.0	-	-	-	-	-	-	-	6.0	0.01
Copepoda - *Labidocera trispinosa*	-	6.0	38.6	4.8	-	8.0	23.1	-	80.6	0.11
Copepoda - *Rhincalanus nasutus*	53.9	53.9	183.4	217.2	24.1	96.6	119.6	81.0	829.8	1.15
Copepoda - *Tortanus discaudatus*	341.6	83.9	86.9	106.2	24.1	326.0	374.2	235.3	1578.2	2.18
Copepoda - Unidentified	-	12.0	29.0	9.7	24.1	4.0	-	19.3	98.1	0.14
Euphausiacea - calyptopis (*E. pacifica, T. spinifera*)	347.6	473.4	1660.2	1785.7	491.0	817.0	929.7	77.2	6581.8	9.09
Euphausiacea - furcilia (*E. pacifica* , *T. spinifera*)	479.4	455.5	3233.6	3267.4	1593.7	2410.7	1597.0	644.2	13681.5	18.88
Ostracoda - *Conchoecia* sp.	-	-	9.7	-	-	-	-	-	9.7	0.01
Ostracoda - *Cypridina* sp.	-	-	9.7	-	-	-	-	-	9.7	0.01
Panaeoidea - *Penaeus* sp. zoea	83.9	-	19.3	24.1	28.2	52.3	3.9	-	211.7	0.29
Mollusca										
Cephalopoda - *Loligo opalescens* paralarvae	-	-	-	-	-	4.0	-	-	4.0	0.01
Gastropoda - veliger unidentified	18.0	24.0	-	14.5	-	4.0	3.9	-	64.3	0.09
Phoronida										
Unidentified actinotroch	12.0	-	-	-	-	8.0	-	-	20.0	0.03
Echinodermata										
Asteroidea - *Pycnopodia helianthoides* brachiolaria	-	-	-	4.8	-	-	-	-	4.8	0.01
Echinoidea - Unknown echinopluteus	-	-	-	4.8	-	-	-	-	4.8	0.01
Ophiuroidea - Ophiothrix sp. ophiopluteus	-	-	19.3	14.5	-	-	-	-	33.8	0.05
Chaetognatha										
Sagitta sp.	431.5	341.6	1283.8	685.3	245.5	205.3	196.7	189.0	3578.7	4.94
Chordata										
Appendicularia - *Fritillaria* sp.	-	-	19.3	4.8	-	-	3.9	-	28.0	0.04
Appendicularia - *Oikopleura* spp.	125.9	143.8	279.9	251.0	48.3	96.6	46.3	131.2	1122.9	1.55
Fish - *Engraulis mordax* post-flexon	-	6.0	-	-	-	12.1	-	-	18.1	0.02
Fish - Gobiidae post-flexon	-	-	9.7	-	-	-	-	-	9.7	0.01
Fish - Pleuronectidae post-flexon	-	-	-	-	-	-	3.9	-	3.9	0.01
Fish - unidentified post-flexon I	-	-	-	-	-	4.0	-	-	4.0	0.01
Fish - unidentified post-flexon II	6.0	-	9.7	-	4.0	-	-	7.7	27.4	0.04
Fish egg - *Engraulis mordax*	161.8	125.9	231.7	135.1	28.2	52.3	15.4	57.9	808.2	1.12
Fish egg unidentified Type I	-	6.0	29.0	48.3	-	4.0	-	-	87.2	0.12
Fish egg unidentified Type II	12.0	-	29.0	19.3	-	-	-	11.6	71.8	0.10
Fish egg unidentified Type III	-	-	29.0	9.7	-	20.1	-	-	58.7	0.08
Fish egg unidentified Type IV	-	12.0	19.3	33.8	-	-	-	-	65.1	0.09
Fish egg unidentified Type V	6.0	30.0	9.7	14.5	-	4.0	7.7	-	71.8	0.10
Fish egg unidentified Type VI	-	-	-	9.7	-	4.0	-	-	13.7	0.02
Fish egg unidentified Type VII	-	-	-	24.1	-	12.1	-	-	36.2	0.05
Fish egg unidentified Type VIII	-	-	-	14.5	-	8.0	-	-	22.5	0.03
Thaliacea - Salpida unidentified	95.9	95.9	77.2	43.4	4.0	104.6	-	-	421.1	0.58
Number of individuals	7264	6892	15521	14416	6170	9562	7414	5208	72447	
Number of species	42	47	58	64	37	61	34	33	99	
Diversity (H')	2.39	2.16	2.26	2.23	2.00	2.30	1.99	2.07	2.31	
Sampling Depth (m)	27.2	27.2	33.6	33.6	39.9	39.9	39.7	39.7		
Water volume sampled (m^3)	5.340	5.340	6.630	6.630	7.951	7.951	8.295	8.295		

Appendix F. Species list and numbers of individuals per cubic meter by station. August 23-24, 2000.

Phylum	Station																			Percent
Species	T1-1	T1-2	T1-3	T1-4	T1-5	T1-6	T1-7	T2-1	T2-2	T2-3	T2-4	T2-5	T2-6	T3-1	T3-2	T3-3	T3-4	T3-5	Total	Total*
Cnidaria																				
Hydromedusae - *Aquorea* sp.	-	-	0.4	0.5	-	-	-	0.4	-	0.5	0.1	-	-	-	-	0.4	0.2	-	2.5	0.02
Hydromedusae - *Calycopsis nematophora*	-	0.2	0.2	0.7	-	-	-	0.4	-	0.4	-	-	-	-	-	0.1	-	-	2.0	0.02
Hydromedusae - *Clytia gregaria*	-	-	-	0.2	-	-	-	-	-	0.2	-	0.2	-	-	-	0.1	0.1	-	0.8	0.01
Hydromedusae - *Leukartiara* sp.	-	-	0.2	0.2	-	-	-	-	-	0.1	-	-	-	-	1.9	0.2	-	-	2.6	0.02
Hydromedusae - *Sarsia* sp.	-	0.7	0.6	-	-	-	-	0.2	0.2	0.1	-	-	-	-	-	-	-	-	1.9	0.02
Hydromedusae - Unidentified	1.9	3.9	2.2	5.1	1.2	0.8	0.1	-	1.8	1.1	0.7	-	-	0.2	-	1.7	1.3	0.8	22.7	0.22
Scyphomedusae - *Aurelia* sp. ephyra	-	-	-	-	-	-	-	-	-	0.1	-	-	-	0.5	-	0.2	0.5	-	1.3	0.01
Scyphomedusae - *Chrysaora* sp. ephyra	-	-	0.4	0.5	-	-	-	-	-	0.1	0.2	0.6	1.6	-	-	0.1	-	-	3.5	0.03
Siphonophora - Diphyidae	-	-	-	-	-	-	-	-	-	-	0.2	0.3	-	-	-	-	0.1	-	0.7	0.01
Siphonophora - *Muggiaea* sp.	-	-	-	1.2	-	2.7	0.4	-	-	0.7	1.7	4.0	3.1	0.7	-	0.9	2.8	2.3	20.4	0.20
Siphonophora - *Rhizophysa* sp.	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	0.1	0.00
Siphonophora - *Sphaeronectes* sp.	-	-	-	-	-	-	-	-	-	0.1	1.4	0.7	-	-	-	-	0.8	-	3.0	0.03
Siphonophora - various fragments	-	-	-	-	-	-	-	-	-	0.2	0.1	-	0.5	0.9	0.3	1.6	0.1	-	3.7	0.04
Ctenophora																				
Pleurobrachia bachei	-	-	-	-	-	-	-	-	-	1.0	0.5	0.4	0.1	-	-	0.3	0.3	0.4	2.9	0.03
Nemertea																				
Unidentified adult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	0.2	0.00
Unidentified pilidii	-	-	-	0.3	-	-	-	-	-	0.4	2.9	4.1	7.9	-	-	0.5	0.1	-	16.1	0.16
Nemata																				
Unidentified nematode	-	0.2	-	3.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.6	0.04
Sipunculida																				
Sipunculida - pelagosphaerae	-	0.7	-	0.5	-	-	-	-	-	3.2	-	-	-	-	-	-	-	-	4.4	0.04
Annelida																				
Polychaeta - *Magelona* sp.	0.8	0.2	35.1	149.9	36.2	10.8	18.4	0.6	2.8	235.7	79.1	47.3	29.4	0.7	1.9	173.8	1.9	3.7	828.4	8.03
Polychaeta - Phyllodocidae metatrochophore	-	-	-	0.3	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	4.3	0.04
Polychaeta - Polynoidae	-	0.2	0.4	1.7	2.5	4.8	2.4	-	2.6	1.5	0.4	4.1	4.0	1.8	1.4	10.3	3.7	0.2	42.0	0.41
Polychaeta - *Tomopteris* sp.	-	0.7	0.8	2.0	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	3.7	0.04
Polychaeta - *Typhoscolex* sp.	3.1	-	0.2	2.7	4.7	-	-	-	1.3	-	1.0	-	1.8	-	-	0.1	-	-	14.9	0.14
Polychaeta - unidentified prototrochophore	-	0.7	1.8	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.4	0.06
Polychaete - unidentified trochophore	-	1.7	3.2	6.2	3.2	1.3	1.7	1.3	0.4	2.7	0.5	0.2	3.8	5.5	0.2	0.6	0.3	1.2	34.0	0.33
Arthropoda																				
Amphipoda - Hyperiidae	-	0.5	0.4	1.5	-	0.1	-	-	-	0.7	-	-	-	-	-	0.1	-	-	3.3	0.03
Anomura - *Blepharipoda occidentalis* zoea	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	0.2	0.6	0.01
Anomura - *Emerita emerita* (Stage 1) zoea	-	1.9	1.4	-	-	-	-	0.4	0.1	1.7	-	-	-	0.5	2.2	1.5	-	-	9.7	0.09
Arthropoda (continued)																				
Anomura - *Lepidopa myops* zoea	-	-	0.2	-	-	-	-	-	-	-	-	0.1	0.1	-	-	-	-	-	0.4	0.00

Appendix F. (Continued).

Phylum Species	Station																		Total	Percent Total*
	T1-1	T1-2	T1-3	T1-4	T1-5	T1-6	T1-7	T2-1	T2-2	T2-3	T2-4	T2-5	T2-6	T3-1	T3-2	T3-3	T3-4	T3-5		
Anomura - Paguridae zoea	-	-	0.2	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-	-	0.9	0.01
Anomura - Porcellanidae zoea	0.8	0.2	0.4	-	-	-	-	0.9	-	-	-	-	-	5.3	-	-	-	-	7.6	0.07
Brachyura - Cancridae megalopa	-	0.2	-	0.3	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	0.9	0.01
Brachyura - Cancridae zoea	-	3.1	18.4	26.0	4.6	1.6	1.0	3.9	1.5	10.4	5.5	0.6	0.5	0.7	14.5	7.5	0.9	-	100.5	0.97
Brachyura - Grapsidae zoea	-	-	3.6	2.0	-	-	-	-	0.5	0.5	0.7	-	0.4	0.5	0.8	1.0	0.8	-	10.6	0.10
Brachyura - Pinnotheridae zoea	-	0.7	7.1	13.2	0.3	-	-	-	1.2	2.9	1.3	-	-	0.7	1.7	1.5	-	-	30.6	0.30
Brachyura - Portunidae megalopa	-	-	5.1	1.0	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	6.4	0.06
Brachyura - Xanthidae megalopa	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	0.3	0.00
Brachyura - Xanthidae zoea	-	-	1.2	0.3	-	-	-	-	-	1.0	0.8	1.7	2.0	0.2	0.8	0.6	0.9	-	9.6	0.09
Caridea - Crangonidae zoea	-	0.5	1.6	1.5	-	-	-	-	-	1.1	0.5	-	-	5.3	0.3	-	-	-	10.8	0.10
Caridea - Hippolytidae zoea	-	2.4	12.8	6.9	-	-	-	0.2	0.5	1.8	1.0	0.2	0.1	6.7	3.5	-	-	0.2	36.3	0.35
Caridea - Pandalidae zoea	-	-	2.0	1.3	1.6	2.6	1.9	1.5	0.6	0.2	0.4	0.7	1.0	1.8	1.3	7.6	-	-	24.4	0.24
Cirripedia - balanomorphan nauplii	-	0.2	5.3	7.1	3.4	1.2	0.1	1.3	2.5	2.4	0.6	0.5	0.4	16.1	4.7	1.3	-	-	47.0	0.46
Cirripedia - lepadomorphan nauplii	-	-	3.0	0.8	0.9	1.0	0.4	0.2	-	0.2	-	-	0.2	-	0.2	0.3	-	-	7.2	0.07
Cladocera - *Evadne* sp.	-	-	-	0.5	-	-	-	-	-	0.2	-	-	0.2	0.2	0.2	1.1	-	0.3	2.7	0.03
Cladocera - *Podon* sp.	-	0.7	0.2	1.0	-	-	-	-	-	-	-	0.3	-	-	-	-	0.1	-	2.4	0.02
Copepoda - *Acartia* sp.	3.1	95.6	272.4	617.7	354.3	234.7	128.1	41.0	132.7	182.5	35.2	46.5	105.8	183.9	236.1	280.8	124.1	106.0	3180.6	30.83
Copepoda - *Calanus* sp.	-	-	1.2	2.0	37.6	44.8	43.9	0.2	13.9	41.2	43.5	10.6	79.3	0.9	11.9	65.1	58.5	52.8	507.4	4.92
Copepoda - *Clausocalanus* sp. 1	-	-	0.4	-	-	-	0.4	-	-	0.6	-	-	1.6	-	-	1.9	0.9	-	5.8	0.06
Copepoda - *Clausocalanus* sp. 2	-	-	1.2	-	-	0.1	0.1	-	-	0.6	-	-	3.5	-	-	4.2	2.2	-	11.8	0.11
Copepoda - *Corycaeus* sp.	-	-	0.6	-	4.7	2.7	1.8	-	-	3.3	-	-	3.6	-	0.5	4.8	3.2	0.4	25.5	0.25
Copepoda - *Eucalanus californica*	-	-	0.4	1.9	0.4	0.2	-	-	-	0.2	-	0.3	-	0.5	0.6	0.1	4.0	0.1	8.8	0.09
Copepoda - Harpacticoida	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	0.7	-	-	1.1	0.01
Copepoda - *Labidocera trispinosa*	-	-	-	-	-	0.3	0.1	-	-	0.2	-	0.1	0.4	-	-	0.8	-	0.3	2.2	0.02
Copepoda - *Lucicutia* sp.	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	0.1	0.2	-	0.4	0.00
Copepoda - *Oithona helgolandica*	-	-	-	-	3.0	3.0	0.1	-	-	1.9	-	-	2.3	-	-	1.1	2.6	1.2	15.1	0.15
Copepoda - *Rhincalanus nasuta*	-	-	-	0.8	1.5	1.6	0.2	-	0.5	-	-	0.8	2.3	-	0.3	3.7	3.9	2.1	17.7	0.17
Copepoda - *Tortanus discaudatus*	-	1.9	2.2	5.7	18.3	53.5	70.3	0.6	2.5	62.3	56.8	94.8	94.8	33.6	54.2	145.3	213.0	232.6	1142.6	11.08
Copepoda - Unidentified	-	-	-	-	0.1	-	0.3	-	0.7	0.4	0.1	0.9	-	5.3	-	0.9	-	3.1	11.8	0.11
Euphausiacea - eggs	-	0.7	29.8	38.8	28.0	15.1	15.2	1.1	5.9	146.7	314.8	797.7	683.1	1.6	1.7	464.9	77.9	96.2	2719.2	26.36
Euphausiacea - calyptopis (*E. pac., T. spin.*)	-	4.1	25.7	48.1	51.7	38.9	23.1	4.1	7.2	32.6	29.2	21.4	15.6	2.5	7.4	20.8	16.7	7.6	356.7	3.46
Euphausiacea - furcilia (*E. pac.*, *T. spin.*)																				
Ostracod - *Conchoecia* sp.	-	-	-	1.0	-	-	-	-	-	0.2	0.1	-	0.5	0.9	0.3	0.2	0.1	-	3.4	0.03
Panaeoidea - *Penaeus* sp. zoea	-	-	-	4.4	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	4.9	0.05
Thalassinidea - *Neotrypaea* sp. zoea	-	-	0.4	4.0	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-	4.9	0.05
Mollusca																				
Gastropoda - veliger unidentified	-	-	0.8	5.7	7.2	14.4	2.2	0.2	2.7	10.3	6.8	21.6	70.0	1.2	3.5	281.0	53.5	4.9	486.1	4.71
Thecosomata - *Corolla calceola*	-	-	-	0.2	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	0.4	0.00

Appendix F. (Continued).

Phylum	Station																			Percent
Species	T1-1	T1-2	T1-3	T1-4	T1-5	T1-6	T1-7	T2-1	T2-2	T2-3	T2-4	T2-5	T2-6	T3-1	T3-2	T3-3	T3-4	T3-5	Total	Total*
Phoronida																				
Unidentified actinotroch	-	-	0.4	0.3	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	0.8	0.01
Ectoprocta																				
Cyphanautes larvae - Bryozoa	-	0.7	3.9	6.1	-	-	-	0.2	0.4	-	-	-	-	7.4	0.2	0.3	-	1.0	20.1	0.19
Echinodermata																				
Asteroidea - *Pycnopodia* sp. brachiolaria	-	-	-	0.3	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	1.0	0.01
Echinoidea - Unknwon echinopluteus	1.9	-	0.6	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	2.6	0.03
Ophiuroidea -*Ophiothrix* sp. ophiopluteus	-	-	0.2	-	-	-	-	-	-	-	-	0.2	0.4	-	-	-	-	-	0.8	0.01
Chaetognatha																				
Sagitta sp.	-	-	1.6	14.2	7.8	44.7	9.8	0.2	1.8	3.2	7.3	9.9	4.7	0.5	1.7	1.6	1.8	1.1	111.6	1.08
Chordata																				
Appendicularia - *Oikopleura* spp.	-	-	0.6	12.1	25.4	11.1	5.8	1.3	0.5	7.2	17.9	20.2	46.1	1.8	1.9	28.6	18.6	30.5	229.5	2.23
Ascidiacea - unidentified tornaria	-	0.2	0.8	-	-	-	-	-	-	4.4	-	-	-	-	-	-	-	-	5.4	0.05
Fish - Gobiidae post-flexon	0.4	-	1.2	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-	1.8	0.02
Fish Egg - *Engraulis mordax*	1.1	2.2	9.3	4.2	2.2	0.4	0.7	-	6.0	3.9	2.6	0.7	-	0.2	0.3	1.9	-	0.3	36.1	0.35
Fish Egg unidentified Type I	3.4	1.9	4.3	-	0.1	0.5	-	-	0.6	2.2	1.7	2.3	2.0	-	-	0.2	0.1	-	19.5	0.19
Fish Egg unidentified Type II	-	-	3.0	0.2	-	-	0.5	0.4	-	0.2	-	0.3	-	-	0.6	0.1	-	-	5.4	0.05
Fish Egg unidentified Type V	-	-	1.2	-	-	-	-	0.2	-	0.5	-	-	-	-	0.8	0.2	-	0.7	3.5	0.03
Fish Egg unidentified Type VI	3.1	2.7	3.2	-	-	0.1	-	-	-	-	-	-	-	0.9	-	-	-	-	9.9	0.10
Fish Egg unidentified Type VII	-	-	3.4	-	-	0.4	-	4.3	0.1	0.5	-	-	-	-	-	-	-	-	8.7	0.08
Fish Egg unidentified Type IX	-	-	0.4	-	-	-	0.5	0.4	0.1	0.8	-	-	-	0.5	0.6	-	0.4	-	3.8	0.04
Fish Egg unidentified Type X	-	6.3	0.8	-	-	-	-	0.9	-	1.5	-	-	-	-	0.2	-	-	-	9.5	0.09
Number of individuals	20	137	478	1011	601	493	329	68	192	780	616	1095	1177	292	359	1523	596	550	10315.2	
Number of species	9	26	49	41	24	26	25	25	26	43	25	27	31	32	33	40	26	23	64	
Diversity (H')	1.90	1.32	1.91	1.55	1.65	1.85	1.87	1.68	1.38	1.99	1.69	1.12	1.57	1.56	1.37	1.95	1.87	1.64	2.09	
Water depth sampled (m)	13.3	21.1	25.8	30.2	34.5	47.3	52.2	23.6	41.5	42	42.5	43.8	42.5	22.1	32.4	52.5	52.1	53		
Water volume sampled (m^3)	2.61	4.14	5.07	5.93	6.77	9.29	10.25	4.63	8.15	8.25	8.34	8.60	8.34	4.34	6.36	10.31	10.23	10.41		
Plankton sample volume (ml)	0.48	0.94	2.12	8.96	3.3	6.13	4.714	0.85	2.83	7.54	6.2	5.89	26.74	2.55	1.8	5.89	4.95	5.12		
Plankton ml m^{-3}	0.18	0.23	0.42	1.51	0.49	0.66	0.46	0.18	0.35	0.91	0.74	0.68	3.20	0.59	0.28	0.57	0.48	0.49		
Surface temperature (°C)	14.67	15.12	14.02	13.65	13.65	13.55	12.68	14.34	14.45	13.18	12.96	13.24	12.31	12.59	13.35	12.48	12.20	12.93		
Surface salinity (PSU)	33.71	33.70	33.78	33.71	33.70	33.71	33.70	33.70	33.79	33.71	33.84	33.76	33.69	33.80	33.72	33.77	33.69	33.58		
Surface density kg m^{-3}	25.05	24.94	25.24	25.27	25.26	25.28	25.45	25.11	25.16	25.35	25.51	25.39	25.51	25.54	25.33	25.55	25.54	25.31		
Approximate thermocline depth (m)	8	7	9	5	4	10	7	9	6	7	3	2	5	14	12	16	6	8		
ΔT (°C) vertical (5 m)	1.85	1.93	0.78	1.61	2.01	0.41	0.43	1.36	1.75	1.13	1.58	2.12	0.48	0.34	0.05	0.06	0.20	0.06		
ΔT (°C) vertical (12 m)	2.68	3.92	2.73	2.36	2.97	2.24	1.61	2.91	3.56	2.36	2.40	2.41	1.53	0.64	1.60	0.54	1.31	2.09		
ΔT (°C) horizontal (0.5 km)	0.05	0.12	0.02	1.11	0.01	0.05	0.11	0.11	0.03	1.02	0.02	0.01	0.01	0.04	0.1	0.62	0.01	0.02		

* 0.00 < 0.005

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