LA JOLLA N.M.F.S. SOUTHWEST FISHERIES SCIENCE CENTER
file copy
JUL 09 1996
LIBRARY

NOAA Technical Memorandum NMFS

FEBRUARY 1995

SEASONAL, VERTICAL, AND HORIZONTAL DISTRIBUTION OF FOUR SPECIES OF COPEPODS AROUND OAHU, HAWAII: DATA REPORT

R. Patrick Hassett
George W. Boehlert

NOAA-TM-NMFS-SWFSC-215

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

NOAA Technical Memorandum NMFS

This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information. The TMs have not received complete formal review, editorial control, or detailed editing.

FEBRUARY 1995

SEASONAL, VERTICAL, AND HORIZONTAL DISTRIBUTION OF FOUR SPECIES OF COPEPODS AROUND OAHU, HAWAII: DATA REPORT

R. Patrick Hassett[1]
George W. Boehlert[2*]

[1]Department of Zoology
Arizona State University
Tempe, AZ 85287-1501

[2]Honolulu Laboratory,SWFSC
National Marine Fisheries Service, NOAA
2570 Dole Street
Honolulu, Hawaii 96822-2396

*Current address: NMFS Southwest Fisheries Science Center,
Pacific Fisheries Environmental Group, P.O. Box 831, Monterey, CA 93942

NOAA-TM-NMFS-SWFSC-215

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

Introduction

Distinct populations of planktonic and micronektonic marine organisms appear to be maintained around islands. These include populations of meso-pelagic fishes (Reid, et al. 1991), larval fishes (Leis and Miller, 1976; Leis, 1982; Boehlert, et al. 1992), and zooplankton (Leis, 1982). The relative importance of physical and biological processes in the maintainence of these populations is unclear. Detailed vertical distribution data for zooplankton around islands is lacking, so that the degree to which vertical distribution can affect the ability of zooplankton to be retained around islands cannot be assessed. To address this problem we have determined the vertical distribution of four species of copepods together with the physical structure of the water column for four seasonal transects off the leeward and windward coasts of the island of Oahu in the Hawaiian Archipelago. This data report is intended to provide a detailed data summary of station information and copepod abundances that will be used for future publication of the analyzed data set. A data report on larval fish distributions from the same seasonal cruises will also be issued (Boehlert and Mundy, in prep), and the distribution of tuna larvae has been discussed (Boehlert and Mundy, 1994).

For our analysis of copepod distributions we chose two neritic/nearshore species, the calanoid *Undinula vulgaris* (Dana) and the pontellid *Labidocera madurae* (Scott), and two oceanic species, both calanoids, *Cosmocalanus darwinii* (Lubbock) and *Scolecithrix danae* (Lubbock). *U. vulgaris* and *C. darwinii* are closely related, the latter species formerly having been classified in the genus *Undinula* . *C. darwinii* and *S. danae* are widespread species, but are strictly oceanic (Grice, 1961). *U. vulgaris* is also a widespread species found throughout warm, tropical waters (e.g., Wilson, 1950; Michel and Foyo, 1976), but it most commonly occurs in neritic waters, where it can be very abundant (Grice, 1961). *L. madurae* is little reported in the literature and appears to be associated with islands in the tropical Indo-Pacific (Scott, 1909). Leis (1982) found *U. vulgaris* to be most abundant at 0.5–1 km from shore off Kahe Point on the leeward Oahu coast, and *L. madurae* at 0.2 km. All four species are of similar sizes, ranging from 2.0-2.6 mm for females and 1.6-2.0 mm for males.

Methods

Day/night vertical series of plankton samples were collected during onshore/offshore transects on 6-15 September and 12-20 December, 1985, and 8-18 April and 24 June - 2 July, 1986. Stations were occupied at 1.8, 9.3, and 28 km off Kahe Point on the leeward Oahu coast (identified as L1, L5, and L15) and 3.7, 9.3, and 28 km off Kaneohe Bay on the windward side (W2, W5, W15) (see Figure 1 in Boehlert and Mundy, 1994). Tows were taken as nearly parallel to the coast as weather conditions would allow. The nearshore stations were occupied near the 100m depth contours, but, due to weather constraints and the steep bathymetry, some tows ended over deeper water. Sampling was done with a 1 m^2 MOCNESS multiple opening/closing net and environmental sensing system (Weibe et al. 1985), which provided measurements of depth, conductivity, temperature, and several characteristics of net performance (velocity, mouth angle, water volume filtered). MOCNESS samples were collected between 0-80 m at the nearshore stations (10 m intervals from 0-60m plus 60-80 m) and between 0-200 m at the offshore stations (20 m intervals from 0-120 m and 40 m intervals from 120-200m). Surface neuston samples were taken with a 0.49 m^2 modified Manta net, which sampled the 0-0.7 m (neuston) depth interval. Replicate night and day tows were taken at each site (identified as N1, N2 and D1, D2). Tows at several depth intervals within the thermocline were taken at some stations, and data from one such tow (TC8602 L5 thermocline) are reported here. A mechanical flowmeter attached to the MOCNESS frame above the nets provided filtration volume estimates (Wiebe et al. 1985) and densities of copepods were calculated as number of individuals per 1000 cubic meters. Water column abundance was calculated by multiplying density x 1000 x the depth range sampled within each stratum and summing the resultant values for all strata in a tow. Water column abundance is thus presented as total number of individuals/ m^2 sea surface area. For depth intervals where the measured end and start depths of successive strata were not identical, the midpoint between the end and start depths was used in calculations. Station and environmental data are presented in Table 1.

Identifications of adult females and males of *Undinula vulgaris* and *Cosmocalanus* (formerly *Undinula*) *darwinii* were from descriptions by Mori (1937), *Scolecithrix danae* from Rose (1933), and *Labidocera madurae* from the original description by Scott (1909). According to Leis (1978) the species identification of the *Labidocera* in nearshore Hawaiian waters is uncertain, but most closely resembles the description of Scott (1909) for *L. madurae.*

Preserved samples from cruises TC8504 and TC8602 were subsampled using a Folsom splitter. Later subsampling, for *Undinula vulgaris* alone, was done with a 10 ml Stempel pipet, drawing fractions from a known sample volume. Due to occasional large differences in abundance among species, different sized fractions were sometimes counted for the different species. For the first 18 samples, replicate subsamples of the Folsom splitter were counted to check for the accuracy of subsampling. After the first 6 samples had been counted, the splitting was modified by manually stirring the sample in the splitter with a plastic paddle as the split was being made. This modification increased the accuracy of the split from 83% (n=6) to 91% (n=12), where percent = the lower count of the two subsamples divided by the higher count x 100 (minimum of 100 individuals in each subsample). This was particularly necessary for *Scolecithrix danae*, which tended to be unevenly distributed in the sample due to the combination of a relatively high density compared to the other copepods and a tendency to collect air bubbles on its carapace. Successive splits did not introduce appreciable error into the counts, as the lower count of replicate splits averaged 90-94% of the larger over a range of 5 successive splits (n=12).

The samples that were counted from the four cruises are indicated in Table 1. Copepods from the nearshore stations (L1, W2) were counted over the entire depth range sampled (0-80m), while the offshore stations (L5, L15, W5, W15) were counted from the surface to depth until the target copepods were rare or absent (usually to 120 or 160 m maximum depth). For the September 1985 cruise, TC 8504, the four copepod species were counted in all vertical series except W2N2. In the latter series, *Undinula vulgaris* was so overwhelmingly dominant that counting for other species was impractical. For the other three cruises, selected samples and species were counted. Only for one replicate series, of the April 1986 leeward transect, were all four species counted. In the other transects, *U. vulgaris* was the only species counted from the MOCNESS series, with *Labidocera madurae* being counted from Manta Net samples of all transects. This strategy provided a complete vertical and horizontal distribution for all species during the leeward and windward September transects and the leeward April transect, as well as seasonal profiles for *U. vulgaris* and *L. madurae* during the other transects.

Results

Total water column abundances (Table 2) confirm the neritic/nearshore distribution of both *Undinula vulgaris* and *Labidocera madurae*, as the abundance of both species drops rapidly moving away from shore. Abundances of the oceanic species *Cosmocalanus*

darwinii and *Scolecithrix danae* show a corresponding decrease in abundance moving onshore. The relative decrease in abundance of the oceanic species in nearshore waters is far less than that of their nearshore counterparts in oceanic waters. Water column abundances of *U. vulgaris* and *L. madurae* decrease by 1-3 orders of magnitude moving offshore, while abundances of *C. darwinii* and *S. danae* decrease by a factor of only 2-5 moving onshore. However, it should be noted that comparing absolute abundances between windward and leeward sides, and between seasons, is complicated by the possibility that physical processes may be shifting the center or edges of a species' distribution nearer or further from the island.

The estimates of total water column abundance of *Undinula vulgaris*, *Cosmocalanus darwinii*, and *Scolecithrix danae* (Table 2) at the nearshore leeward and windward stations (L1, W2) are minimum estimates because the entire vertical range of these species was not sampled there. Virtually all of the vertical range of these three species was covered by our sampling in offshore waters (Table 3), but these species sometimes were abundant at depths of 80-100m, which exceeds the maximum sampling depth at the L1 and W2 stations (maximum sampling depth of 80 m over a nominal bottom depth of 100 m). In the nearshore stations the densities of *U. vulgaris*, *C. darwinii*, and *S. danae* frequently were high in the deepest 60-80m stratum. Thus, while peak densities were generally in shallower stratum, a potentially significant fraction of the population sometimes may have been present below our sampling range at the nearshore stations. This problem does not apply to *Labidocera madurae*, because of its shallow vertical distribution.

Vertical distributions of the four copepod species in numbers per 1000 cubic meters, broken down into male, female, and total adult, are given in Tables 3-6. *Undinula vulgaris* was the most abundant species in nearshore samples, both windward and leeward of Oahu, occurring in densities of up to 800 adults/cubic meter (Table 3: TC8504 W2N2, 45-50 m depth stratum). During TC8504 (September) *Labidocera madurae* was largely limited to the upper 1 m of the water column, except for one series that had higher abundances in the 1-10m sample (L1N2). During the leeward transect of TC8602 (April), *L. madurae* was distributed throughout the water column at the 1.8 and 9.3 km stations, but only in the surface layer at the 28 km station. *Scolecithrix danae* demonstrated the most pronounced and consistent day/night differences in vertical distribution, with a depth range of approximately 60-100 m during the day and 0-40 m at night. A variable degree of apparent migratory behavior was exhibited by *U. vulgaris* and *Cosmocalanus darwinii*. Variable patterns are evident here over relatively short distances. For instance, during TC8504 (September) all three species had pronounced differences in day and night distributions at the 27.8 km leeward station, but relatively little difference at the 9.3 km station.

Abundances of *Labidocera madurae* in Manta net samples are given in Table 7 and include additional stations not shown in Tables 3-6. *L. madurae* distributions show a trend toward higher abundances on the leeward side. It is likely that this is due to the leeward station being 1.8 km from shore vs. 3.7 km on the windward side, as *L. madurae*'s peak abundance in Leis (1982) was at 0.2 km from shore. *L. madurae* also tended to be more abundant at the offshore stations on the leeward side compared to windward, in particular being consistently very rare or absent at the windward 28 km stations. The April cruise showed an unusual pattern in *L. madurae* distribution, in that the copepod was distributed throughout the upper 100 m at the leeward 1.8 and 9.3 km stations, and was also uncharacteristically abundant at the 9.3 km station (Table 5). At other stations *L. madurae* was found only in surface waters. The windward transects in April also displayed unusual patterns in that the abundance of *Undinula vulgaris* was very low nearshore. Though the oceanic indicator species were not counted in these samples, it was noted that they and other typically oceanic species (e.g., *Neocalanus gracilis*, *Haloptilus longicornis*) were present in the nearshore windward (W2) samples.

General features of the distribution of these copepod species around Oahu conform to earlier characterizations as insular or oceanic taxa. Detailed interpretation of the distributional patterns of copepods is beyond the scope of this data report. Analysis of the physical structure of the water column during sampling is not presented here. A detailed discussion of the effects of water column structure and other influences on the distribution of copepods near Oahu will be the subject of further analysis based on the data tabulated here.

Acknowledgments

We would like to thank Bruce Mundy for his assistance in coordinating the data gathering and Ron Yoshimoto for assistance in counting samples. We also thank the crew of the NOAA vessel Townsend Cromwell for their work during the cruises collecting these data. We thank Bruce Mundy and H. Geoffrey Moser for reviews of an earlier draft of this data report. This research was conducted while the senior author held a National Research Council Postdoctoral Research Associateship at the NMFS Honolulu Laboratory. Their support is gratefully acknowledged.

References

Boehlert, G. W., and B. C. Mundy. 1994. Vertical and onshore-offshore distributional patterns of tuna larvae in relation to physical habitat features. Mar. Ecol. Prog. Ser. 107: 1-13.

Boehlert, G. W., W. Watson, and L. C. Sun. 1992. Horizontal and vertical distributions of larval fishes around an isolated oceanic island in the tropical Pacific. Deep-Sea Res. 39: 439-466.

Grice, G. D. 1961. Calanoid copepods from the equatorial waters of the Pacific Ocean. Fishery Bulletin 186, 61: 171-246.

Leis, J. M. 1978. Distributional ecology of ichthyoplankton and invertebrate macrozooplankton in the vicinity of a Hawaiian coastal power plant. 317 pp. PhD dissertation, University of Hawaii, Honolulu.

Leis, J. M. 1982. Nearshore distributional gradients of larval fish (15 taxa) and planktonic crustaceans (6 taxa) in Hawaii. Mar. Biol. 72: 89-97.

Leis, J. M., and J. M. Miller, 1976. Offshore distributional patterns of Hawaiian fish larvae. Mar. Biol. 36: 359-367.

Michel, H. B., and M. Foyo. 1968. Caribbean zooplankton. Part I - Siphonophora, Heteropoda, Copepoda, Euphausiacea, Chaetognatha and Salpidae. Office of Naval Research. 549 pp.

Mori, T. 1937. The pelagic Copepoda from the neighboring waters of Japan. Tokyo: The Soya Co. Inc. 150 pp, 80 pls.

Reid, S. B., J. Hirota, R. E. Young, and L. E. Hallacher. 1991. Mesopelagic-boundary community in Hawaii: micronekton at the interface between neritic and oceanic ecosystems. Mar. Biol. 109: 427-440.

Rose, M. 1933. Copepodes pelagiques. Faune de France 26: 1-374.

Scott, A. 1909. The Copepoda of the Siboga expedition. Siboga Exped. 29: 1-323.

Wiebe, P. H., A. W. Morton, A. M. Bradley, R. H. Backus, J. E. Craddock, V. Barber, T. J. Cowles, and R. G. Flierl. 1985. New developments in MOCNESS, an apparatus for sampling zooplankton and micronekton. Mar. Biol. 87: 313-323.

Wilson, C. B. 1950. Copepods gathered by the United States fisheries steamer "Albatross" from 1887 to 1909, chiefly in the Pacific Ocean. Bull. U.S. Natl. Mus. 100. 14: 141-441.

Table 1. Station and environmental data for 1985-86 cruises. Start time is time of first CTD reading of MOCNESS deployment. Maximum temperature is maximum in °C recorded during deployment. Cloud cover is from ship's logs and gives fractional cover of sky. Also given are depths and species counted from the MOCNESS and Manta net deployments.

U = *Undinula vulgaris* C = *Cosmocalanus darwinii*
S = *Scolecithrix danae* L = *Labidocera madurae*

Cruise	Location	Station	Date	Start Time	Maximum Temperature	Cloud Cover	Depth Range Counted	MOCNESS Species Counted	Manta Net Species Counted
TC-8504	L1D1	29	9/11/85	11:33	27.19	4/8	0-80	U,C,S,L	U,C,S,L
TC-8504	L1D2	30,31	9/11/85	14:55	27.37	6/8	0-80	U,C,S,L	U,C,S,L
TC-8504	L1N1	32	9/11/85	20:12	26.93	2/8	0-80	U,C,S,L	U,C,S,L
TC-8504	L1N2	34	9/13/85	00:20	26.99	clear	0-80	U,C,S,L	U,C,S,L
TC-8504	L5D1	25	9/10/85	15:54	27.09	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	L5D2	28	9/11/85	08:06	26.96	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	L5N1	26	9/10/85	20:10	26.58	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	L5N2	27	9/11/85	00:47	26.66	2/8	0-120	U,C,S,L	U,C,S,L
TC-8504	L15D1	35	9/12/85	12:55	27.52	3/8	0-160	U,C,S,L	U,C,S,L
TC-8504	L15D2	36	9/12/85	15:21	26.96	2/8	0-160	U,C,S,L	U,C,S,L
TC-8504	L15N1	37	9/12/85	21:02	26.77	6/8	0-120	U,C,S,L	U,C,S,L
TC-8504	L15N2	38	9/12/85	00:03	26.59	1/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W2D1	7	9/7/85	13:38	26.18	7/8	0-80	U,C,S,L	U,C,S,L
TC-8504	W2D2	8	9/7/85	16:21	26.36	7/8	0-80	U,C,S,L	U,C,S,L
TC-8504	W2N1	9	9/7/85	20:31	26.16	6/8	0-80	U,C,S,L	U,C,S,L
TC-8504	W2N2	10	9/7/85	23:10	26.18	4/8	0-80	U	U,C,S,L
TC-8504	W5D1	2	9/6/85	15:50	28.70	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W5D2	5	9/7/85	08:29	26.38	7/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W5N1	3	9/6/85	20:20	26.54	4/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W5N2	4	9/7/85	03:05	25.97	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W15D1	11	9/8/85	08:19	26.59	3/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W15D2	13	9/8/85	14:15	27.20	6/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W15N1	14	9/8/85	20:21	26.74	4/8	0-120	U,C,S,L	U,C,S,L
TC-8504	W15N2	15	9/8/85	01:10	26.78	4/8	0-120	U,C,S,L	U,C,S,L
TC-8505	L1D1	21	12/16/85	08:30	24.77	2/8	0-120	U	U,L
TC-8505	L1D2	22	12/16/85	11:19	24.70	7/8	0-1		L
TC-8505	L1N1	24	12/16/85	19:54	24.60	1/8	0-80	U	U,L
TC-8505	L1N2	25	12/16/85	22:10	24.47	1/8	0-80	U	U,L
TC-8505	L5D1	23	12/16/85	13:46	24.71	4/8	0-120	U	U,L
TC-8505	L5D2	28	12/17/85	09:14	24.63	5/8	0-1		L
TC-8505	L5N1	26	12/17/85	00:56	24.51	1/8	0-100	U	U,L
TC-8505	L5N2	27	12/17/85	03:26	24.70	1/8	0-100	U	U,L

Table 1 (cont).

Cruise	Location	Station	Date	Start Time	Maximum Temperature	Cloud Cover	Depth Range Counted	MOCNESS Species Counted	Manta Net Species Counted
TC-8505	L15D1	29	12/17/85	12:28	24.81	5/8	0-120	U	U,L
TC-8505	L15D2	30	12/17/85	15:10	24.96	6/8	0-1		L
TC-8505	L15N1	32	12/17/85	22:02	24.89	8/8	0-100	U	U,L
TC-8505	L15N2	33	12/18/85	00:52	24.89	5/8	0-100	U	U,L
TC-8505	W2D1	5	12/13/85	10:47	24.80	2/8	0-1		L
TC-8505	W2D2	6	12/13/85	13:28	24.96	3/8			
TC-8505	W2N1	7	12/13/85	20:13	24.59	5/8	0-80	U	U,L
TC-8505	W2N2	8	12/13/85	22:39	24.53	3/8	0-80	U	
TC-8505	W5D1	1	12/12/85	15:01	24.74	4/8	0-1		L
TC-8505	W5D2	4	12/13/85	07:55	24.38	4/8			
TC-8505	W5N1	2	12/12/85	20:14	24.46	3/8	0-100	U	U,L
TC-8505	W5N2	3	12/13/85	00:42	24.39	3/8	0-100	U	
TC-8505	W15D1	10	12/14/85	08:05	24.42	2/8	0-1		L
TC-8505	W15D2	11	12/14/85	10:58	25.20	1/8			
TC-8505	W15N1	14	12/14/85	20:18	24.39	4/8	0-100	U	U,L
TC-8505	W15N2	15	12/14/85	22:48	24.44	1/8	1-100	U	
TC-8602	L1D1	6	4/9/86	11:56	24.16	7/8	0-80	U,C,S,L	U,C,S,L
TC-8602	L1D2	7,8	4/9/86	14:39	24.17	8/8	0-80	U	U,L
TC-8602	L1N1	9	4/9/86	20:22	24.08	4/8	0-80	U,C,S,L	U,C,S,L
TC-8602	L1N2	10	4/9/86	23:09	24.09	6/8	0-80	U	U,L
TC-8602	L5D1	1	4/8/86	14:03	24.26	6/8	0-1	L	L
TC-8602	L5D2	5	4/9/86	08:19	24.13	5/8	0-120	U,C,S,L	U,C,S,L
TC-8602	L5N1	3	4/8/86	21:12	24.24	5/8	0-160	U,C,S,L	U,C,S,L
TC-8602	L5N2	4	4/9/86	00:56	24.10	5/8	0-1		L
TC-8602	L5	11	4/10/86	02:50	----	7/8	49-105	L	
TC-8602	L15D1	12	4/10/86	08:35	24.16	8/8	0-1		L
TC-8602	L15D2	18,19	4/11/86	11:13	24.18	7/8	0-120	U,C,S,L	U,C,S,L
TC-8602	L15N1	20	4/11/86	20:47	24.10	6/8	0-120	U,C,S,L	U,C,S,L
TC-8602	L15N2	21	4/11/86	23:56	23.99	8/8	0-1		L
TC-8602	W2D1	38	4/15/86	09:15	23.34	8/8	0-80	U	U,L
TC-8602	W2D2	39	4/15/86	12:22	23.31	8/8	0-80	U	U,L
TC-8602	W2N1	42	4/15/86	21:52	23.37	4/8	1-80	U	
TC-8602	W2N2	43	4/16/86	00:17	23.27	8/8	1-80	U	
TC-8602	W5D1	31	4/14/86	09:11	23.34	6/8	0-120	U	U,L
TC-8602	W5D2	32	4/14/86	13:34	23.32	6/8	0-1		L
TC-8602	W5N1	34	4/14/86	20:19	23.19	7/8	1-100	U	
TC-8602	W5N2	35	4/15/86	01:16	23.28	6/8	1-100	U	
TC-8602	W15D1	45	4/16/86	08:21	23.21	4/8	0-1		L

Table 1 (cont).

Cruise	Location	Station	Date	Start Time	Maximum Temperature	Cloud Cover	Depth Range Counted	MOCNESS Species Counted	Manta Net Species Counted
TC-8602	W15D2	46	4/16/86	12:06	----	3/8	0-1		L
TC-8602	W15N1	47	4/16/86	20:42	23.44	4/8	1-100	U	
TC-8602	W15N2	49	4/17/86	00:32	23.39	7/8	1-100	U	
TC-8604	L1D1	6	6/25/86	14:21	26.07	3/8	0-80	U	U,L
TC-8604	L1D2	7	6/25/86	16:39	25.91	3/8	0-1		L
TC-8604	L1N1	8	6/25/86	20:41	25.86	4/8	1-80	U	
TC-8604	L5N1	2	6/24/86	23:14	25.95	5/8	1-100	U	
TC-8604	L5N2	3	6/25/86	02:31	25.94	7/8	1-100	U	
TC-8604	L15D1	12	6/26/86	08:24	26.41	2/8	0-120	U	U,L
TC-8604	L15D2	13,14	6/26/86	11:02	27.32	1/8	0-1		L
TC-8604	L15N1	16	6/26/86	20:53	26.26	6/8	1-100	U	
TC-8604	L15N2	17	6/26/86	23:33	----	2/8	1-100	U	
TC-8604	W2D1	32	6/29/86	13:51	25.57	5/8	0-1		L
TC-8604	W2D2	33	6/29/86	16:14	25.53	8/8	0-1		L
TC-8604	W2N1	35	6/29/86	23:17	25.38	7/8	1-80	U	
TC-8604	W2N2	36,37	6/30/86	04:35	25.39	7/8	1-80	U	
TC-8604	W5D1	30	6/29/86	08:30	25.39	7/8	0-1		L
TC-8604	W5D2	31	6/29/86	11:10	25.51	5/8	0-1		L
TC-8604	W5N1	29	6/29/86	02:19	25.39	4/8	1-100	U	
TC-8604	W5N2	34	6/29/86	20:47	25.48	8/8	1-100	U	
TC-8604	W15D1	39	6/30/86	08:32	25.33	7/8	0-1		L
TC-8604	W15D2	41	6/30/86	12:20	25.52	4/8	0-1		L
TC-8604	W15N1	45	6/30/86	20:50	25.43	6/8	1-100	U	
TC-8604	W15N2	46	6/30/86	23:14	----	2/8	1-100	U	

Table 2. Total number of adult copepods per square meter of sea surface area, average of n replicate vertical series. Day series were not used when maximum abundances were at the deepest depth sampled, which occurred at several of the 1 and 2 mile (nearshore) stations with *Undinula vulgaris*.

			Undinula vulgaris		*Cosmocalanus darwinii*		*Scolecithrix danae*	*Labidocera madurae*
Cruise	Location	Maximum Temperature	n	#/m2	n	#/m2	#/m2	#/m2
TC-8504	L1	27.12	2	1572	4	134	5	3.71
TC-8504	L5	26.82	4	25	4	501	27	0.015
TC-8504	L15	26.96	4	71	4	364	23	0.056
TC-8504	W2	26.22	4	12453	4	105	9	0.157
TC-8504	W5	26.90	4	491	4	85	24	0.025
TC-8504	W15	26.83	4	14	4	200	26	0.002
TC-8505	L1	24.61	2	3602				
TC-8505	L5	24.64	3	1406				
TC-8505	L15	24.86	3	334				
TC-8505	W2	24.56	2	858				
TC-8505	W5	24.43	2	441				
TC-8505	W15	24.42	2	85				
TC-8602	L1	24.13	3	6206	2	163	15	12.40
TC-8602	L5	24.19	2	669	2	303	23	3.75
TC-8602	L15	24.14	2	203	2	621	13	0.25
TC-8602	W2	23.32	4	75				
TC-8602	W5	23.27	3	165				
TC-8602	W15	23.35	3	63				
TC-8604	L1	25.91	2	4585				
TC-8604	L5	25.91	3	922				
TC-8604	L15	26.34	3	144				
TC-8604	W2	25.39	2	7700				
TC-8604	W5	25.44	2	681				
TC-8604	W15	25.43	2	80				

Table 3. Cruise TC-8504, September 1985. Vertical distributions of copepods in numbers/1000 cubic meters. F = female, M = male, Σ = total.

Nominal Depth	Mean Depth	*Undinula vulgaris*			*Cosmocalanus darwinii*			*Scolecithrix danae*			*Labidocera madurae*		
		F	M	Σ	F	M	Σ	F	M	Σ	F	M	Σ
L1D1													
0-1 m	0.5	5	29	34	56	16	72	3	0	3	27	500	527
1-10 m	5.5	7	8	15	188	167	355	12	22	34	2	10	12
10-20 m	14.5	1240	410	1650	2206	926	3132	36	59	95	0	0	0
20-30 m	24.0	455	317	772	598	189	787	63	29	92	2	2	4
30-40 m	33.5	53	23	76	325	77	402	40	13	53	0	0	0
40-50 m	42.5	3770	2381	6151	6524	2425	8949	63	19	82	13	6	19
50-60 m	54.0	1220	849	2069	549	243	792	0	32	32	6	6	12
60-80 m	69.5	2038	2340	4378	409	105	514	91	10	101	3	0	3
L1D2													
0-1 m	0.5	3	3	6	61	29	90	0	0	0	35	227	262
1-10 m	5.5	11	2	13	159	66	225	6	0	6	3	3	6
10-20 m	15.0	3	6	9	402	142	544	10	14	24	0	0	0
20-30 m	25.5	6	3	9	780	494	1274	19	41	60	0	3	3
30-40 m	34.5	310	401	711	472	182	654	0	0	0	0	0	0
40-50 m	44.0	312	243	555	458	204	662	28	0	28	0	0	0
50-60 m	52.5	74	25	99	564	167	731	13	6	19	0	0	0
60-80 m	67.5	1292	733	2025	827	112	939	101	74	175	0	0	0
L1N1													
0-1 m	0.5	17426	10209	27635	1597	453	2050	0	0	0	13	138	151
1-10 m	6.0	845	404	1249	10645	4830	15475	51	6	57	0	0	0
10-20 m	11.5	692	270	962	3616	1247	4863	38	28	66	0	0	0
20-30 m	23.0	1344	857	2201	643	142	785	32	52	84	0	0	0
30-40 m	32.0	12287	7135	19422	357	14	371	71	29	100	0	0	0
40-50 m	43.0	16168	10894	27062	170	26	196	7	13	20	0	13	13
50-60 m	51.5	46680	36633	83313	131	26	157	0	0	0	0	0	0
60-80 m	68.5	21724	19713	41437	58	32	90	6	0	6	0	0	0
L1N2													
0-1 m	0.5	552	138	690	6407	2217	8624	117	11	128	0	138	138
1-10 m	6.0	32063	22768	54831	1097	522	1619	0	0	0	888	522	1410
10-20 m	13.0	16600	12810	29410	696	336	1032	24	24	48	120	0	120
20-30 m	24.0	3843	3251	7094	669	508	1177	0	25	25	0	37	37
30-40 m	33.0	5690	5703	11393	560	100	660	12	25	37	0	0	0
40-50 m	41.5	1296	1258	2554	1005	216	1221	64	51	115	0	13	13
50-60 m	54.5	3063	2749	5812	2737	1494	4231	50	63	113	0	0	0
60-80 m	69.0	775	762	1537	1437	781	2218	49	43	92	0	0	0
L5D1													
0-1 m	0.5	4	0	4	8	0	8	0	0	0	0	0	0
1-20 m	11.0	19	17	36	572	90	662	9	5	14	0	0	0
20-40 m	29.5	58	13	71	14132	4834	18966	84	45	129	0	0	0
40-60 m	48.5	574	444	1018	9017	2831	11848	130	104	234	0	0	0
60-80 m	70.0	31	15	46	155	21	176	148	89	237	0	0	0
80-100 m	88.5	47	30	77	8	2	10	239	101	340	0	0	0
100-120 m	110.0	3	3	6	6	2	8	6	0	6	0	0	0

Table 3 (cont.)

Nominal	Mean	*Undinula vulgaris*			*Cosmocalanus darwinii*			*Scolecithrix danae*			*Labidocera madurae*		
Depth	Depth	F	M	Σ	F	M	Σ	F	M	Σ	F	M	Σ
L5D2													
0-1 m	0.5	0	0	0	32	39	71	5	0	5	3	3	6
1-20 m	10.0	23	13	36	104	47	151	7	0	7	0	0	0
20-40 m	29.0	6	12	18	1111	169	1280	6	0	6	0	0	0
40-60 m	48.5	513	269	782	9043	6952	15995	154	64	218	0	0	0
60-80 m	68.0	0	7	7	1440	1032	2472	263	204	467	0	0	0
80-100 m	88.5	0	2	2	10	5	15	2	3	5	0	0	0
100-120 m	109.0	0	0	0	5	0	5	2	0	2	0	0	0
L5N1													
0-1 m	0.5	29	45	74	2920	1324	4244	3	0	3	3	3	6
1-20 m	11.0	50	110	160	3238	971	4209	585	632	1217	0	0	0
20-40 m	28.5	306	177	483	6067	1850	7917	316	350	666	0	0	0
40-60 m	48.0	295	461	756	3138	1153	4291	222	117	339	0	0	0
60-80 m	67.5	0	2	2	791	376	1167	28	0	28	0	0	0
80-100 m	86.0	0	0	0	28	0	28	3	0	3	0	0	0
100-120 m	108.0	0	0	0	2	0	2	0	0	0	0	0	0
L5N2													
0-1 m	0.5	0	32	32	5762	2327	8089	24	0	24	16	32	48
1-20 m	10.0	116	71	187	5539	2992	8531	640	379	1019	0	0	0
20-40 m	29.5	656	554	1210	2522	1166	3688	183	168	351	0	0	0
40-60 m	50.5	66	60	126	4694	2630	7324	163	109	272	0	0	0
60-80 m	69.5	26	0	26	7481	4656	12137	26	116	142	0	0	0
80-100 m	89.0	0	0	0	1626	455	2081	20	3	23	0	0	0
100-120 m	109.0	2	2	4	24	2	26	3	0	3	0	0	0
L15D1													
0-1 m	0.5	2	2	4	102	10	112	0	0	0	1	3	4
1-20 m	10.5	6	8	14	45	11	56	0	0	0	2	2	4
20-40 m	28.5	103	59	162	167	28	195	0	0	0	0	0	0
40-60 m	47.5	411	303	714	1276	273	1549	5	4	9	0	0	0
60-80 m	67.0	143	88	231	2525	909	3434	6	0	6	0	0	0
80-100 m	90.0	1390	1522	2912	8663	4864	13527	182	271	453	0	0	0
100-120 m	110.5	33	38	71	71	29	100	181	386	567	0	0	0
120-160 m	139.0	4	11	15	17	4	21	1	4	5	0	0	0
L15D2													
0-1 m	0.5	1	1	2	90	19	109	0	1	1	14	20	34
1-20 m	11.5	3	3	6	601	71	672	1	0	1	0	0	0
20-40 m	31.0	0	3	3	818	224	1042	0	0	0	0	0	0
40-60 m	50.5	171	126	297	1595	373	1968	6	6	12	0	0	0
60-80 m	68.5	1176	1493	2669	2882	1268	4150	13	40	53	0	0	0
80-100 m	88.0	111	70	181	2134	755	2889	126	277	403	0	0	0
100-120 m	110.0	0	2	2	15	2	17	126	101	227	0	0	0
120-160 m	140.0	1	0	1	0	1	1	5	1	6	0	0	0
L15N1													
0-1 m	0.5	373	73	446	4751	888	5639	0	4	4	4	27	31
1-20 m	10.5	936	1148	2084	1810	462	2272	574	225	799	0	0	0
20-40 m	28.5	588	248	836	712	365	1077	274	189	463	0	0	0
40-60 m	49.5	45	19	64	1520	683	2203	217	109	326	0	0	0
60-80 m	69.5	0	10	10	2425	1373	3798	52	26	78	0	0	0
80-100 m	89.5	2	0	2	640	254	894	2	3	5	0	0	0
100-120 m	111.5	0	0	0	3	0	3	2	0	2	0	0	0

Table 3 (cont.)

Nominal Depth	Mean Depth	*Undinula vulgaris* F	M	Σ	*Cosmocalanus darwinii* F	M	Σ	*Scolecithrix danae* F	M	Σ	*Labidocera madurae* F	M	Σ
L15N2													
0-1 m	0.5	275	123	398	8018	6072	14090	6	0	6	29	53	82
1-20 m	10.5	1983	1786	3769	6137	2970	9107	366	249	615	0	0	0
20-40 m	27.0	400	317	717	2958	1111	4069	203	158	361	0	0	0
40-60 m	47.5	76	57	133	5704	1823	7527	108	152	260	0	0	0
60-80 m	69.5	13	13	26	4177	2297	6474	7	7	14	0	0	0
80-100 m	88.5	0	7	7	2305	1434	3739	0	0	0	0	0	0
100-120 m	111.0	0	0	0	152	39	191	0	0	0	0	0	0
120-160 m	138.5	2	0	2		0	0	0	0	0	0	0	0
W2D1													
0-1 m	0.5	70	81	151	34	9	43	0	0	0	195	28	223
1-10 m	4.5	17896	18679	36575	671	280	951	168	336	504	56	0	56
10-20 m	14.5	183285	123388	306673	2396	2396	4792	0	0	0	0	0	0
20-30 m	24.0	180750	100140	280890	2909	2076	4985	831	0	831	0	0	0
30-40 m	28.5	118321	84455	202776	732	105	837	0	209	209	0	0	0
40-50 m	40.5	37619	19769	57388	0	96	96	96	96	192	0	0	0
50-60 m	55.0	93021	71444	164465	2757	839	3596	0	0	0	0	0	0
60-80 m	69.5	60503	47377	107880	2666	1231	3897	103	103	206	0	0	0
W2D2													
0-1 m	0.5	101	77	178	311	59	370	2	5	7	2	2	4
1-10 m	4.0	210	315	525	1707	473	2180	26	0	26	0	0	0
10-20 m	12.0	2535	3689	6224	929	394	1323	28	28	56	0	0	0
20-30 m	22.5	219891	204153	424044	729	874	1603	0	291	291	0	0	0
30-40 m	34.5	48683	44450	93133	770	192	962	0	0	0	0	0	0
40-50 m	42.5	39375	23277	62652	290	218	508	0	0	0	0	0	0
50-60 m	52.5	17606	9744	27350	498	111	609	55	0	55	0	0	0
60-80 m	69.5	52826	50759	103585	1225	536	1761	230	77	307	0	0	0
W2N1													
0-1 m	0.5	22013	36168	58181	1672	892	2564	0	0	0	0	0	0
1-10 m	5.0	73181	100513	173694	1543	771	2314	0	110	110	0	0	0
10-20 m	15.5	52204	76849	129053	1792	112	1904	0	0	0	0	0	0
20-30 m	25.5	24383	26799	51182	659	330	989	55	0	55	0	0	0
30-40 m	35.0	69751	75871	145622	211	211	422	0	0	0	0	0	0
40-50 m	45.5	---	---	---	---	---	---	---	---	---	---	---	---
50-60 m	55.5	61697	36578	98275	55	0	55	0	55	55	0	0	0
60-80 m	72.5	120996	91774	212770	0	0	0	60	0	60	0	0	0
W2N2													
0-1 m	0.5	4082	5302	9384	469	217	686	12	6	18	5	5	10
1-10 m	5.5	62593	58602	121195	2205	1785	3990	0	105	105	0	0	0
10-20 m	14.5	64791	50952	115743	---	---	---	---	---	---	---	---	---
20-30 m	25.5	45625	60333	105958	---	---	---	---	---	---	---	---	---
30-35 m	31.0	153988	138728	292716	---	---	---	---	---	---	---	---	---
35-45 m	40.0	315367	259330	574697	---	---	---	---	---	---	---	---	---
45-50 m	48.0	428990	367126	796116	---	---	---	---	---	---	---	---	---
50-60 m	54.0	93950	80271	174221	---	---	---	---	---	---	---	---	---
60-80 m	70.5	36468	43263	79731	151	0	151	0	0	0	0	0	0

Table 3 (cont.)

Nominal Depth	Mean Depth	*Undinula vulgaris* F	M	Σ	*Cosmocalanus darwinii* F	M	Σ	*Scolecithrix danae* F	M	Σ	*Labidocera madurae* F	M	Σ
W5D1													
0-1 m	0.5	42	12	54	17	8	25	0	0	0	2	4	6
1-20 m	9.0	111	86	197	861	363	1224	18	80	98	0	0	0
20-40 m	28.5	8172	5683	13855	615	288	903	92	183	275	0	0	0
40-60 m	48.0	10101	10299	20400	555	272	827	124	124	248	0	0	0
60-80 m	66.0	17006	13660	30666	1761	755	2516	830	201	1031	0	0	0
80-100 m	87.5	7163	3755	10918	1505	720	2225	257	180	437	0	0	0
100-120 m	111.5	94	38	132	7	2	9	12	9	21	0	0	0
W5D2													
0-1 m	0.5	14	10	24	2	0	2	0	0	0	27	8	35
1-20 m	9.0	62	34	96	520	116	636	75	34	109	0	0	0
20-40 m	29.0	463	180	643	1338	644	1982	438	335	773	0	0	0
40-60 m	49.5	425	250	675	889	265	1154	88	96	184	0	0	0
60-80 m	69.0	1320	733	2053	168	35	203	28	14	42	0	0	0
80-100 m	88.0	5	7	12	7	2	9	4	2	6	0	0	0
100-120 m	108.0	4	0	4	6	0	6	0	0	0	0	0	0
W5N1													
0-1 m	0.5	292	120	412	418	178	596	2	2	4	29	2	31
1-20 m	10.5	220	48	268	500	220	720	80	108	188	0	0	0
20-40 m	31.5	705	352	1057	338	85	423	127	113	240	0	0	0
40-60 m	49.5	3499	1982	5481	314	177	491	68	82	150	0	0	0
60-80 m	67.5	139	57	196	130	147	277	49	33	82	0	0	0
80-100 m	88.5	48	42	90	6	12	18	12	12	24	0	0	0
100-120 m	107.0	2	2	4	0	0	0	2	2	4	0	0	0
W5N2													
0-1 m	0.5	16	23	39	90	20	110	13	0	13	21	7	28
1-20 m	10.5	1934	1464	3398	916	204	1120	164	180	344	0	0	0
20-40 m	28.0	2420	1021	3441	406	112	518	154	84	238	0	0	0
40-60 m	49.5	2401	791	3192	532	205	737	82	82	164	0	0	0
60-80 m	68.0	1484	600	2084	188	127	315	14	31	45	0	0	0
80-100 m	86.5	1072	289	1361	315	244	559	58	26	84	0	0	0
100-120 m	108.5	0	0	0	0	0	0	14	3	17	0	0	0
W15D1													
0-1 m	0.5	4	4	8	0	22	22	4	4	8	0	0	0
1-20 m	11.0	35	53	88	71	14	85	50	18	68	0	0	0
20-40 m	31.0	136	68	204	34	7	41	48	27	75	0	0	0
40-60 m	48.5	86	43	129	1867	969	2836	150	135	285	0	0	0
60-80 m	67.5	106	213	319	4923	1639	6562	240	80	320	0	0	0
80-100 m	88.5	22	15	37	242	11	253	30	4	34	0	0	0
100-120 m	107.5	10	3	13	7	3	10	7	0	7	0	0	0
W15D2													
0-1 m	0.5	1	5	6	16	10	26	1	1	2	0	0	0
1-20 m	10.0	36	33	69	33	0	33	117	36	153	0	0	0
20-40 m	27.5	108	59	167	3	10	13	121	20	141	0	0	0
40-60 m	48.5	8	0	8	23	8	31	116	46	162	0	0	0
60-80 m	68.5	198	184	382	3953	922	4875	290	458	748	0	0	0
80-100 m	90.0	28	28	56	3809	1090	4899	414	124	538	0	0	0
100-120 m	111.0	4	4	8	15	0	15	19	0	19	0	0	0

Table 3 (cont.)

Nominal Depth	Mean Depth	*Undinula vulgaris* F	M	Σ	*Cosmocalanus darwinii* F	M	Σ	*Scolecithrix danae* F	M	Σ	*Labidocera madurae* F	M	Σ
W15N1													
0-1 m	0.5	12	6	18	1729	787	2516	0	0	0	0	0	0
1-20 m	11.0	163	176	339	1058	665	1723	326	380	706	0	0	0
20-40 m	30.5	120	93	213	587	200	787	233	127	360	0	0	0
40-60 m	50.5	7	0	7	1052	228	1280	201	69	270	0	0	0
60-80 m	68.5	0	3	3	1583	391	1974	47	3	50	0	0	0
80-100 m	89.0	0	0	0	271	45	316	9	2	11	0	0	0
100-120 m	108.0	0	0	0	10	0	10	7	0	7	0	0	0
W15N2													
0-1 m	0.5	31	31	62	940	171	1111	24	0	24	0	6	6
1-20 m	9.5	199	265	464	2599	1551	4150	199	93	292	0	0	0
20-40 m	31.0	177	163	340	3045	1006	4051	299	116	415	0	0	0
40-60 m	50.0	0	0	0	1699	710	2409	258	165	423	0	0	0
60-80 m	69.5	0	0	0	1445	578	2023	33	50	83	0	0	0
80-100 m	91.0	0	4	4	484	63	547	4	7	11	0	0	0
100-120 m	110.5	0	0	0	71	4	75	0	0	0	0	0	0

Table 4. Cruise TC-8505, December, 1985. Vertical distribution of copepods in numbers / 1000 cubic meter. F = female, M = male, Σ = total

Nominal Depth	Mean Depth	*Undinula vulgaris* F	M	Σ	Mean Depth	*Undinula vulgaris* F	M	Σ	Mean Depth	*Undinula vulgaris* F	M	Σ
	L1D1				**L1N1**				**L1N2**			
0-1 m	1	32	22	54	1	950	900	1850	1	199	368	567
1-10 m	6	79	40	119	5	13141	19406	32547	5	1906	2052	3958
10-20 m	15	0	0	0	14	17887	36105	53992	15	2185	3902	6087
20-30 m	25	0	37	37	25	23897	48777	72674	24	10783	19714	30497
30-40 m	35	38	0	38	35	70826	103128	173954	33	4664	4198	8862
40-50 m	45	38	0	38	46	104031	93298	197329	43	8047	7886	15933
50-60 m	55	0	38	38	55	6227	6555	12782	55	7582	4285	11867
60-80 m	70	8614	2940	11554	68	24627	11594	36221	71	10594	7594	18188
	L5D1				**L5N1**				**L5N2**			
0-1 m	1	11	19	30	1	428	257	685	1	192	170	362
1-20 m	11	63	188	251	10	2706	2939	5645	11	10959	12359	23318
20-40 m	30	4591	10330	14920	30	5939	5860	11799	29	1464	1772	3236
40-60 m	50	11269	15277	26546	50	7123	7042	14165	50	14197	14045	28242
60-80 m	70	75	150	225	71	8267	7644	15911	71	29869	26955	56824
80-100 m	90	72	72	143	90	787	350	1137	93	3656	3656	7312
100-120 m	110	39	0	39								
	L15D1				**L15N1**				**L15N2**			
0-1 m	1	16	20	36	1	219	76	295	1	320	272	592
1-20 m	11	66	33	98	10	479	958	1437	11	493	2217	2710
20-40 m	30	108	108	215	29	247	824	1071	31	1554	2418	3972
40-60 m	50	387	669	1056	50	977	1244	2221	47	977	977	1954
60-80 m	70	6336	8390	14726	70	6604	5284	11888	71	187	654	841
80-100 m	90	2928	5362	8291	88	459	734	1193	91	0	87	87
100-120 m	110	1	100	101								
	W2N1				**W2N2**							
0-1 m	1	3086	4050	7136	1	---	---	---				
1-10 m	5	15424	20005	35429	6	783	2661	3444				
10-20 m	16	17759	18676	36435	16	598	2479	3077				
20-30 m	24	1444	2247	3691	25	323	969	1292				
30-40 m	35	1032	602	1634	34	771	943	1714				
40-50 m	46	1995	332	2327	45	2205	678	2883				
50-60 m	55	3325	1247	4572	56	5923	1220	7143				
60-80 m	71	8845	2437	11282	71	17539	3490	21029				
	W5N1				**W5N2**							
0-1 m	1	619	450	1069	1	---	---	---				
1-20 m	11	4699	4938	9637	10	84	923	1007				
20-40 m	31	1885	1799	3684	29	167	335	502				
40-60 m	52	563	724	1287	48	3556	1474	5030				
60-80 m	69	663	745	1408	69	4106	3320	7426				
80-100 m	89	0	83	83	89	5799	7405	13204				
	W15N1				**W15N2**							
0-1 m	1	25	15	40	1	---	---	---				
1-20 m	11	77	697	774	10	250	583	833				
20-40 m	30	151	227	378	29	825	247	1072				
40-60 m	50	79	1420	1499	51	167	669	836				
60-80 m	70	0	711	711	70	83	667	750				
80-100 m	93	250	583	833	88	83	579	662				

Table 5. Cruise TC-8602, April, 1986. Vertical distribution of copepods in numbers / 1000 cubic meter. F = female, M = male, Σ = total

Nominal Depth	Mean Depth	*Undinula vulgaris*			*Cosmocalanus darwinii*			*Scolecithrix danae*			*Labidocera madurae*		
		F	M	Σ	F	M	Σ	F	M	Σ	F	M	Σ
L1D1													
0-1 m	1	19	26	45	3	0	3	0	0	0	186	29	215
1-10 m	7	14	7	21	196	46	242	4	0	4	49	14	63
10-20 m	16	7	10	17	1464	939	2403	7	3	10	14	3	17
20-30 m	26	319	525	844	1000	362	1362	0	7	7	14	14	28
30-40 m	34	28	28	56	1470	728	2198	21	0	21	28	98	126
40-50 m	45	28	55	83	934	422	1356	14	35	49	35	28	63
50-60 m	57	318	622	940	405	123	528	14	14	28	0	65	65
60-80 m	72	4373	7107	11480	719	216	935	43	43	86	43	129	172
L1N1													
0-1 m	1	640	466	1106	844	146	990	0	0	0	10	354	364
1-10 m	5	641	321	962	2698	2244	4942	107	27	134	0	0	0
10-20 m	14	326	815	1141	3712	1630	5342	181	272	453	0	91	91
20-30 m	26	3195	6391	9586	3373	1953	5326	178	355	533	0	118	118
30-40 m	35	8177	9485	17662	4407	1033	5440	138	69	207	344	69	413
40-50 m	46	39098	48428	87526	1155	355	1510	0	0	0	533	89	622
50-60 m	54	15061	10973	26034	215	215	430	0	72	72	72	0	72
60-80 m	68	1001	1206	2207	76	46	122	23	8	31	129	46	175
L5D2													
0-1 m	1	6	13	19	9	0	9	0	0	0	0	3	3
1-20 m	11	69	88	157	2355	631	2986	61	41	102	7	27	34
20-40 m	30	1524	1524	3048	1850	599	2449	408	463	871	11	16	27
40-60 m	47	524	396	920	2149	1014	3163	369	262	631	0	13	13
60-80 m	67	12960	20525	33485	1933	1126	3059	167	139	306	11	44	55
80-100 m	89	1271	1749	3020	93	21	114	42	3	45	0	0	0
100-120 m	111	60	74	134	3	3	6	7	3	10	0	0	0
L5N1													
0-1 m	1	889	234	1123	1327	409	1736	0	6	6	30	87	117
1-20 m	10	3969	3274	7243	3423	1340	4763	165	66	231	17	17	34
20-40 m	31	3245	2979	6224	4159	1504	5663	103	125	228	7	7	14
40-60 m	51	2282	1963	4245	4906	2257	7163	25	18	43	37	12	49
60-80 m	69	1010	946	1956	1048	626	1674	4	4	8	17	64	81
80-100 m	90	434	475	909	32	20	52	9	0	9	6	29	35
100-120 m	109	512	602	1114	27	17	44	3	0	3	13	17	30
120-160 m	138	2	0	2	0	0	0	0	0	0	2	0	2
L15D2													
0-1 m	1	6	3	9	9	9	18	1	0	1	0	1	1
1-20 m	11	3731	1837	5568	9779	8875	18654	85	113	198	0	0	0
20-40 m	29	4286	4560	8846	6538	8791	15329	110	0	110	0	0	0
40-60 m	50	2053	1509	3562	3481	1591	5072	27	0	27	0	0	0
60-80 m	70	42	21	63	633	111	744	28	7	35	0	0	0
80-100 m	85	4	0	4	11	4	15	44	0	44	0	0	0
100-120 m	107	0	4	4	11	4	15	4	0	4	0	0	0
L15N1													
0-1 m	1	56	80	136	4104	1267	5371	6	0	6	0	0	0
1-20 m	9	942	609	1551	10111	6842	16953	194	499	693	28	0	28
20-40 m	29	202	121	323	3066	1896	4962	54	40	94	0	0	0
40-60 m	49	396	354	750	1827	1005	2832	85	42	127	0	0	0
60-80 m	68	22	7	29	375	88	463	37	22	59	0	0	0
80-100 m	88	15	7	22	110	11	121	15	7	22	0	0	0
100-120 m	110	0	0	0	10	0	10	6	0	6	0	0	0

Table 5 (cont). *Undinula vulgaris*

Nominal Depth	Mean Depth	F	M	Σ	Mean Depth	F	M	Σ	Mean Depth	F	M	Σ
	L1D2				**L1N2**				**W2D1**			
0-1 m	1	60	41	101	1	2090	900	2990	1	4	0	4
1-10 m	6	0	786	786	6	11260	11557	22817	6	0	172	172
10-20 m	15	87258	117798	205056	15	19380	19759	39139	15	0	172	172
20-30 m	25	0	1311	1311	25	30680	37534	68214	25	0	349	349
30-40 m	35	0	338	338	34	56230	55912	112142	35	183	0	183
40-50 m	45	475	633	1108	45	57342	69466	126808	43	0	375	375
50-60 m	53	1236	530	1766	54	93952	97214	191166	54	929	558	1487
60-80 m	71	1320	2805	4125	69	206144	261598	467742	73	584	1168	1752
	W2D2				**W2N1**				**W2N2**			
0-1 m	1	5	3	8	1	---	---	---	1	---	---	---
1-10 m	5	217	0	217	5	184	551	735	6	183	734	917
10-20 m	12	37	74	111	14	1304	1211	2515	15	2717	2264	4981
20-30 m	22	0	106	106	24	366	183	549	24	157	315	472
30-40 m	32	73	146	219	35	557	372	929	35	274	91	365
40-50 m	41	0	0	0	46	183	0	183	45	83	0	83
50-60 m	52	0	74	74	57	544	363	907	55	96	192	288
60-80 m	66	39	160	199	71	297	396	693	70	266	622	888
	W5D1				**W5N1**				**W5N2**			
0-1 m	1	2	5	7	1	---	---	---	1	---	---	---
1-20 m	10	35	141	176	10	444	8356	8800	9	0	1272	1272
20-40 m	31	74	111	184	30	178	533	711	28	1274	2888	4162
40-60 m	51	649	649	1299	50	433	260	693	47	1002	1639	2641
60-80 m	71	0	248	248	70	375	375	750	71	344	2664	3008
80-100 m	91	76	38	114	90	187	747	934	89	0	271	271
100-120 m	111	38	38	77								
	W15N1				**W15N2**							
0-1 m	1	---	---	---	1	---	---	---				
1-20 m	11	162	323	485	10	525	1050	1575				
20-40 m	29	414	414	828	29	351	175	526				
40-60 m	48	0	178	178	49	265	176	441				
60-80 m	70	100	502	602	68	92	92	184				
80-100 m	89	169	592	761	89	0	739	739				

Labidocera madurae

Sample Depth	Mean Depth	F	M	Σ
L5N thermocline				
94-89 m	92	41	10	51
105-95 m	100	20	9	29
89-67 m	78	7	0	7
90-49 m	70	17	0	17

Table 6. Cruise TC-8604, June, 1986. Vertical distribution of copepods in numbers / 1000 cubic meter. F = female, M = male, Σ = total

Nominal Depth	Mean Depth	*Undinula vulgaris* F	M	Σ	Mean Depth	*Undinula vulgaris* F	M	Σ	Mean Depth	*Undinula vulgaris* F	M	Σ
	L1D1				**L1N1**				**L1N2**			
0-1 m	1	---	---	---	1	---	---	---	1	---	---	---
1-10 m	5	0	0	0	6	9136	17713	26849	5	19304	31111	50415
10-20 m	15	0	0	0	15	21578	74577	96155	15	20864	46213	67077
20-30 m	25	0	0	0	25	20096	82279	102375	25	17124	43381	60505
30-40 m	35	0	0	0	34	10090	13828	23918	34	7222	15741	22963
40-50 m	45	0	0	0	42	16108	34490	50598	44	27569	41175	68744
50-60 m	54	0	0	0	53	5023	7953	12976	55	31648	44308	75956
60-80 m	70	289	1361	1650	69	24970	24385	49355	71	36677	49599	86276
	L5D1				**L5N1**				**L5N2**			
0-1 m	1	---	---	---	1	---	---	---	1	---	---	---
1-20 m	11	0	40	40	10	3274	4247	7521	11	2592	1758	4350
20-40 m	29	0	41	41	30	727	1183	1910	32	1228	1228	2456
40-60 m	48	75	0	75	52	1326	1419	2745	51	10083	13630	23713
60-80 m	67	42	84	126	69	1549	1452	3001	70	4855	4855	9710
80-100 m	85	33795	41594	75388	90	1925	1604	3529	90	409	204	613
100-120 m	106	2857	1633	4490								
	L15D1				**L15N1**				**L15N2**			
0-1 m	1	---	---	---	1	---	---	---	1	---	---	---
1-20 m	9	0	0	0	11	1637	2503	4140	10	388	679	1067
20-40 m	28	0	0	0	29	794	397	1191	29	3289	5083	8372
40-60 m	50	0	0	0	47	101	706	807	49	102	1021	1123
60-80 m	69	0	0	0	66	0	400	400	67	0	731	731
80-100 m	88	568	1095	1663	88	0	783	783	89	0	655	655
100-120 m	108	164	0	164								
	W2N1				**W2N2**							
0-1 m	1	---	---	---	1	---	---	---				
1-10 m	5	44853	130118	174971	6	0	12279	12279				
10-20 m	15	62958	74444	137402	15	1792	2588	4380				
20-30 m	24	53534	73768	127302	25	24460	24253	48713				
30-40 m	34	63708	95770	159478	35	50126	62458	112584				
40-50 m	42	40686	38589	79275	45	58040	57177	115217				
50-60 m	54	39069	29414	68483	56	62444	48474	110918				
60-80 m	70	44284	47560	91844	74	55476	62066	117542				
	W5N1				**W5N2**							
0-1 m	1	---	---	---	1	---	---	---				
1-20 m	11	2401	5202	7603	9	432	6041	6473				
20-40 m	28	8700	8893	17593	28	789	8283	9072				
40-60 m	46	372	2230	2602	47	2592	5783	8375				
60-80 m	65	1322	3005	4327	69	1102	5034	6136				
80-100 m	86	1988	6294	8282	89	577	1154	1731				
	W15N1				**W15N2**							
0-1 m	1	---	---	---	1	---	---	---				
1-20 m	10	0	103	103	8	110	2098	2208				
20-40 m	30	198	296	494	27	103	931	1034				
40-60 m	49	0	760	760	48	0	2380	2380				
60-80 m	70	0	833	833	67	0	720	720				
80-100 m	89	0	99	99	88	0	0	0				

Table 7. Abundance of *Labidocera madurae* in surface layer (0-1 m) Manta net samples, in number of copepods/ 1000 cubic meters

Cruise	Location	Station	Date	Maximum Temperature	#/1000 m-3 Females	Males	Σ Adults
TC-8504	L1D1	29	9/11/85	27.19	27	500	527
TC-8504	L1D2	30,31	9/11/85	27.37	35	227	262
TC-8504	L1N1	32	9/11/85	26.93	13	138	151
TC-8504	L1N2	34	9/13/85	26.99	0	138	138
TC-8504	L5D1	25	9/10/85	27.09	0	0	0
TC-8504	L5D2	28	9/11/85	26.96	3	3	6
TC-8504	L5N1	26	9/10/85	26.58	3	3	6
TC-8504	L5N2	27	9/11/85	26.66	16	32	48
TC-8504	L15D1	35	9/12/85	27.52	1	3	4
TC-8504	L15D2	36	9/12/85	26.96	14	20	34
TC-8504	L15N1	37	9/12/85	26.77	4	27	31
TC-8504	L15N2	38	9/12/85	26.59	29	53	82
TC-8504	W2D1	7	9/7/85	26.18	195	28	223
TC-8504	W2D2	8	9/7/85	26.36	2	2	4
TC-8504	W2N1	9	9/7/85	26.16	0	0	0
TC-8504	W2N2	10	9/7/85	26.18	5	5	10
TC-8504	W5D1	2	9/6/85	28.70	2	4	6
TC-8504	W5D2	5	9/7/85	26.38	27	8	35
TC-8504	W5N1	3	9/6/85	26.54	29	2	31
TC-8504	W5N2	4	9/7/85	25.97	21	7	28
TC-8504	W15D1	11	9/8/85	26.59	0	0	0
TC-8504	W15D2	13	9/8/85	27.20	0	0	0
TC-8504	W15N1	14	9/8/85	26.74	0	0	0
TC-8504	W15N2	15	9/8/85	26.78	0	6	6
TC-8505	L1D1	21	12/16/85	24.77	0	4	4
TC-8505	L1D2	22	12/16/85	24.70	1	5	6
TC-8505	L1N1	24	12/16/85	24.60	3	27	30
TC-8505	L1N2	25	12/16/85	24.47	7	20	27
TC-8505	L5D1	23	12/16/85	24.71	0	3	3
TC-8505	L5D2	28	12/17/85	24.63	0	9	9
TC-8505	L5N1	26	12/17/85	24.51	8	4	12
TC-8505	L5N2	27	12/17/85	24.70	2	7	9
TC-8505	L15D1	29	12/17/85	24.81	3	49	52
TC-8505	L15D2	30	12/17/85	24.96	0	5	5
TC-8505	L15N1	32	12/17/85	24.89	5	11	16
TC-8505	L15N2	33	12/18/85	24.89	3	6	9
TC-8505	W2D1	5	12/13/85	24.80	9	0	9

Table 7 (cont).

Cruise	Location	Station	Date	Maximum Temperature	#/1000 m-3 Females	Males	Σ Adults
TC-8505	W2N1	7	12/13/85	24.59	0	0	0
TC-8505	W5D1	1	12/12/85	24.74	0	0	0
TC-8505	W5N1	2	12/12/85	24.46	0	0	0
TC-8505	W15D1	10	12/14/85	24.42	0	0	0
TC-8505	W15N1	14	12/14/85	24.39	0	0	0
TC-8602	L1D1	6	4/9/86	24.16	186	29	215
TC-8602	L1D2	7	4/9/86	24.17	541	231	772
TC-8602	L1N1	9	4/9/86	24.08	10	354	364
TC-8602	L1N2	10	4/9/86	24.09	13	170	183
TC-8602	L5D1	1	4/8/86	24.26	4	6	10
TC-8602	L5D2	5	4/9/86	24.13	0	3	3
TC-8602	L5N1	3	4/8/86	24.24	30	87	117
TC-8602	L5N2	4	4/9/86	24.10	37	421	458
TC-8602	L15D1	12	4/10/86	24.16	0	0	0
TC-8602	L15D2	18	4/11/86	24.18	0	1	1
TC-8602	L15N1	20	4/11/86	24.10	0	0	0
TC-8602	L15N2	21	4/11/86	23.99	4	14	18
TC-8602	W2D1	38	4/15/86	23.34	11	25	36
TC-8602	W2D2	39	4/15/86	23.31	6	6	12
TC-8602	W5D1	31	4/14/86	23.34	5	31	36
TC-8602	W5D2	32	4/14/86	23.32	13	42	55
TC-8602	W15D1	45	4/16/86	23.21	0	0	0
TC-8602	W15D2	46	4/16/86	n.a.	0	0	0
TC-8604	L1D1	6	6/25/86	26.07	33	3	36
TC-8604	L1D2	7	6/25/86	25.91	41	31	72
TC-8604	L5D1	4	6/25/86	25.84	0	0	0
TC-8604	L5D2	5	6/25/86	26.05	0	0	0
TC-8604	L15D1	12	6/26/86	26.41	0	0	0
TC-8604	L15D2	13	6/26/86	27.32	0	0	0
TC-8604	W2D1	32	6/29/86	25.57	0	1	1
TC-8604	W2D2	33	6/29/86	25.53	0	1	1
TC-8604	W5D1	30	6/29/86	25.39	0	0	0
TC-8604	W5D2	31	6/29/86	25.51	0	0	0
TC-8604	W15D1	39	6/30/86	25.33	0	0	0
TC-8604	W15D2	41	6/30/86	25.52	0	0	0

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167. Paper copies vary in price. Microfiche copies cost $9.00. Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC-205 An assessment of the 1994 status of harbor porpoise in California.
J. BARLOW and K. FORNEY
(June 1994)

206 The Hawaiian monk seal on Laysan Island, 1990.
K.B. LOMBARD, B.L. BECKER, M.P. CRAIG, G.C. SPENCER, and K. HAGUE-BECHARD
(June 1994)

207 The estimation of perpendicular sighting distance on SWFSC research vessel surveys for cetaceans: 1974 to 1991.
J. BARLOW and T. LEE
(August 1994)

208 The physical oceanography off the central California coast during February-March and May-June 1992: a summary of CTD data from pelagic young-of-the-year rockfish surveys.
K.M. SAKUMA, H.A. PARKER, S. RALSTON, F.B. SCHWING, D.M. HUSBY, and E.M. ARMSTRONG
(September 1994)

209 The physical oceanography off the central California coast during March and May-June, 1993: a summary of CTD data from pelagic young-of-the-year rockfish surveys.
K.M. SAKUMA, H.A. PARKER, S. RALSTON, F.B. SCHWING, D.M. HUSBY, and E.M. ARMSTRONG
(September 1994)

210 The Hawaiian monk seal at French Frigate Shoals, 1990-91.
M.P. CRAIG, J.L. MEGYESI, C.S. HALL, J.L. GLUECK, L.P. LANIAWE, E.A. DELANEY, S.S. KEEFER, M.A. McDERMOND, M. SCHULZ, G.L. NAKAI, B.L. BECKER, L.M. HIRUKI, and R.J. MORROW
(September 1994)

211 Report of cetacean sightings during a marine mammal survey in the eastern Pacific ocean and the gulf of California aboard the NOAA ships *McArthur* and *David Starr Jordan* July 28-November 6, 1993.
K.F. MANGELS, T. GERRODETTE
(October 1994)

212 An evaluation of oocyte size in multiple regressions predicting gonad weight from body weight: A test using Hawaiian ehu, *Etelis carbunculus*.
B.B. LAU and E.E. DeMARTINI
(Ocotober 1994)

213 The Hawaiian monk seal on Laysan Island, 1987 and 1989.
B.L. BECKER, P.A. CHING, L.M. HIRUKI, and S.A. ZUR
(October 1994)

214 The Hawaiian monk seal on Laysan Island, 1991.
B.L. BECKER, K.E. O'BRIEN, K.B. LOMBARD, and L.P. LANIAWE
(February 1995)