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The oceanographical research in the Northeastern Pacific I

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Abstract

Oceanographical observation and biological research in the eastern North Pacific Ocean were carried out on the training ship "Keiten Maru" of Kagoshima University from December, 1974 to February, 1975.

The oceanic characteristics and the distribution of zooplankton observed during our research are described in this paper.

There exists a water mass of low temperature and low salinity (lower than 16°C in water temperature and 33.50‰ in salinity) on the surface of eastern waters in the eastern North Pacific Ocean and another water mass of high temperature and high salinity (more than 21°C and 35.20‰ respectively) in the western waters of the Ocean. A remarkable transition zone is observable around 129°W.

The thermocline becomes gradually shallower from the west to the east, and the existence of short time-scale upwelling is suspected. The meso-scale eddies are observed in the east-north-east area of Hawaiian Islands, 28°N, 140°W–150°W. The maximum flow speed in the eastern water and that of the western water are 0.3 kt and 1.0 kt, respectively. In this region, zooplanktons are far more abundant in the eastern cold waters than in the western warm waters. Of the planktons, Copepoda occupies more than 70% of the total individual number. *Ceratium*, radiolaria, and appendicularia occur widely, though the number of individuals is small.

1. Introduction

It has been well known that the upwelling area in the eastern North Pacific Ocean (especially off the coast of California) is fertile in marine productivity, and many works have been published concerning this region: Wooster and Reid[1], Reid[2], Reid, Roden and Wyllie[3], Tibby[4], Munk[5], Roden[6], Yoshida[7,8], Yoshida and Kidokoro[9].

As part of the university student training program, the "Keiten Maru" training ship set out for ocean navigation from Dec, 1974 to Feb, 1975, for the research of tuna fishing ground.

The author carried out oceanographical observation and biological research during the navigation and gained some information on sea conditions and the distribution of zooplankton. The results are reported here.

The author wish to express thier sincere thanks to Prof. Yoshida of Tokyo University for many helpful discussions and suggestions concerning this work and to the crew of the Keiten Maru for their skillful handling of the ship during our research.

2. Materials and Methods

The oceanographical observation was made on the Keiten Maru (G. T. 854.55 TONS), the fisheries training and research ship, Faculty of Fisheries, Kagoshima University, in the eastern boundary region of the North Pacific Ocean.

The first observation was made on the northeast area of Hawaiian Islands (Lat. 25°N–28°N, Long. 141°W–150°W) from Dec. 30, 1974 to Jan. 8, 1975 and the second one, off the coast of California (Lat. 30°N–32°N, Long. 123°W–132°W) from Jan. 24, 1975 to Feb. 6, 1975. The observation points are shown in Fig. 1.

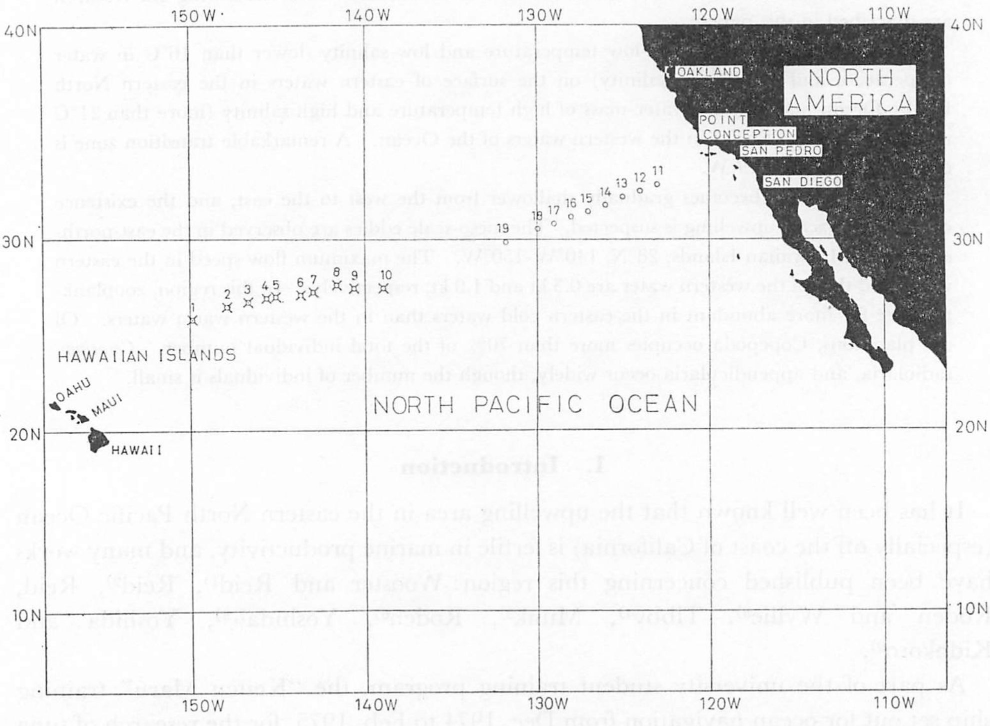

Fig. 1. Map showing the observation stations. Symbols of stations; circles, serial oceanographic observation by the S. T. D. system and collections of plankton; crosses, tuna fishing experiment.

The first observation region is here-in-after to be referred to as the western waters and the second region, as the eastern waters, respectively.

The oceanographic data were obtained by the S. T. D. (Plessy Model 9040). The observations were made from the surface to a depth of 1,500 m. The casting-speed of senser was 1.0 m/sec in the 0–300 m depth and 1.5 m/sec in the 300–1,500 m depth.

The traces for water-temperature and for salinity of the western waters in the eastern North Pacific Ocean are shown in Fig. 2-(a), (b), (c) and the traces of the eastern waters in Fig. 2-(a'), (b'), (c'). The values of temperature and salinity at selected depths read from the traces were summarized in Table 1 (The marked "Spike" phenomenon reported by Solomon[10] was not observable because of the difference created by the reduced scale).

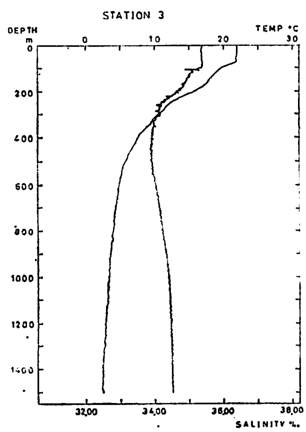

Fig. 2 (a)

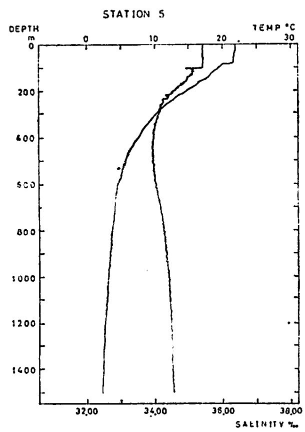

Fig. 2 (b)

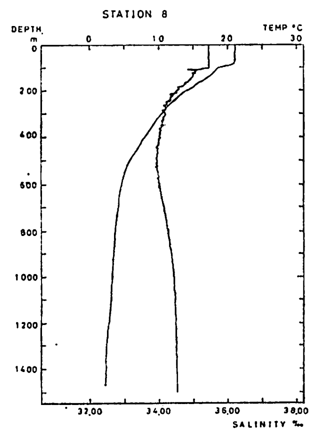

Fig. 2 (c)

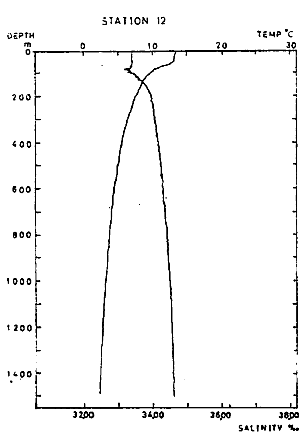

Fig. 2 (a')

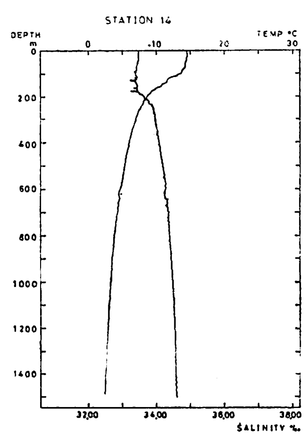

Fig. 2 (b')

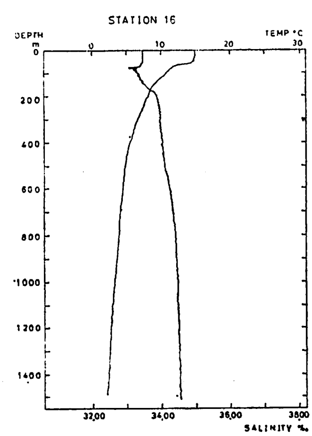

Fig. 2 (c')

Fig. 2. The S. T. D. traces for temperature and for salinity as example; (a), (b), (c) in the eastern waters and (a'), (b'), (c') in the western waters.

Using the data in Table 1, the geographical current was estimated by dynamic computation (in which the movement of water mass at the 1,500 m depth was assumed to be zero). The results are shown in Table 2.

Zooplankton were collected with the Kitahara's quanitative net (22.5 cm in mouth diameter, 100 cm in length, supplied with bolting silk net XX No. 13). After each collection, the samples were immediately fixed with a 5% formalin solution. The individual numbers of zooplankton were calculated in the laboratory and tabulated in Table 4.

3. Results and Discussions

(1) The vertical distribution of water temperature and salinity.

The vertical distribution of water temperature and salinity in the eastern and western waters of the eastern North Pacific Ocean are shown in Fig. 3. (a) (b) and in Fig 4. (a) (b), respectively.

It is indicated in Fig 3 that the water temperature of the surface layer in eastern waters becomes lower as the continental coast is approached from offshore. In the subsurface layer, the thermocline at the 200 m depth becomes shallower to about the 100 m depth facing in an easterly direction. This phenomenon is suggests the existence of a water mass moving toward the equator because of the geostrophic circulation.

Yoshida et al calculated the mean-annual-depth of thermocline in the North Pacific Ocean theoretically from the stress-distribution of wind (Fig. 5). The theoretical depths are somewhat smaller than those observed by the author. These differences may have resulted from the incompleteness of the theory (Yoshida).

The vertical gradient of the thermocline is 5°C/100 m, and the remarkable peak at the 100 m depth around 128°W, seems to be indicative of the existence of an upwelling. Reid et al, report that the coastal upwelling off the coast of California, occurs frequently in spring and summer, but, actually it seems to occur in all the seasons. Roden (1969) also reported the upwelling phenomenon in these waters.

Besides the phenomenon which continues for several months, there occurs also an upwelling continuing only several days, appearing and disappearing alternately within several days or weeks. Yoshida stated that, under suitable wind conditions, these short time scale upwellings may occur anytime and anywhere, irrespective of the season.

During the observation period, the winds were predominantly from the north or northeast. It was not clear that the upwelling phenomenon around 128°W was due to these winds; but since the observation was made in winter, the phenomenon may be supposed to be the above-mentioned short time scale upwelling.

Regarding the distribution of salinity (Fig. 3, (b)), an area of the surface water with a salinity lower than 33.80‰ extends from the east to the west like a tongue. On the western sides, an area of surface water with a salinity higher than 34.00‰ extends toward the east, forming a remarkable transition zone of salinity around 129°W. In the vertical distribution of salinity in the report by Roden (1969), this zone was also described at the same position. Isohalines rises from offshore toward

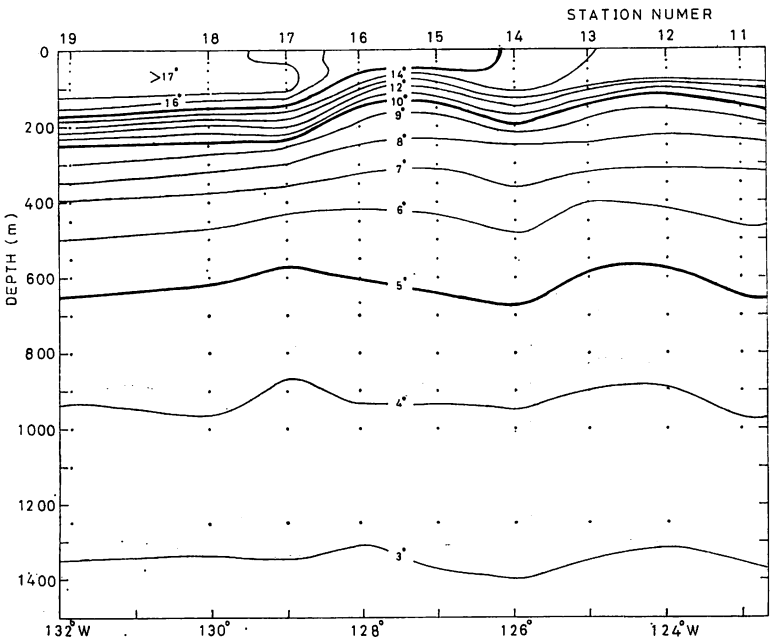

Fig. 3 (a)

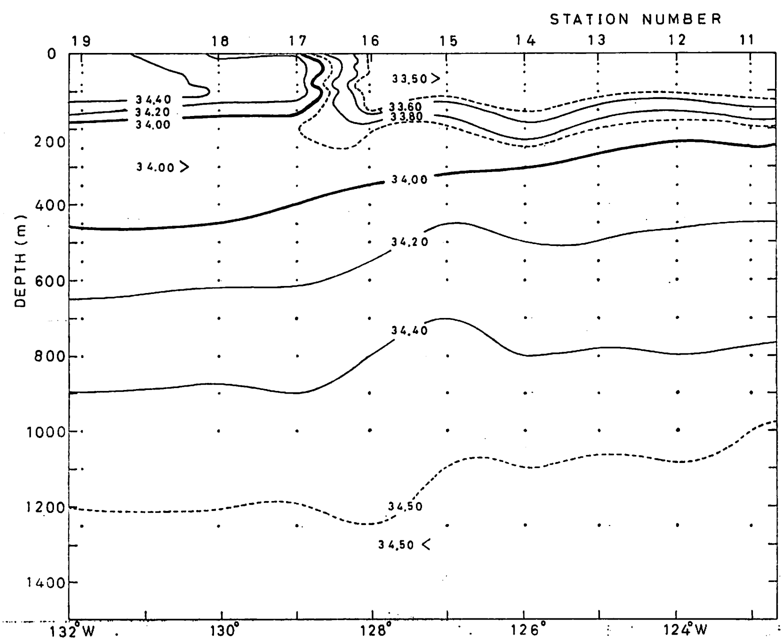

Fig. 3 (b)

Fig. 3. Vertical distributions of temperature and the salinity along the latitude 30°N–32°N, between from 123°W to 132°W.

(a) Temperature (b) Salinity

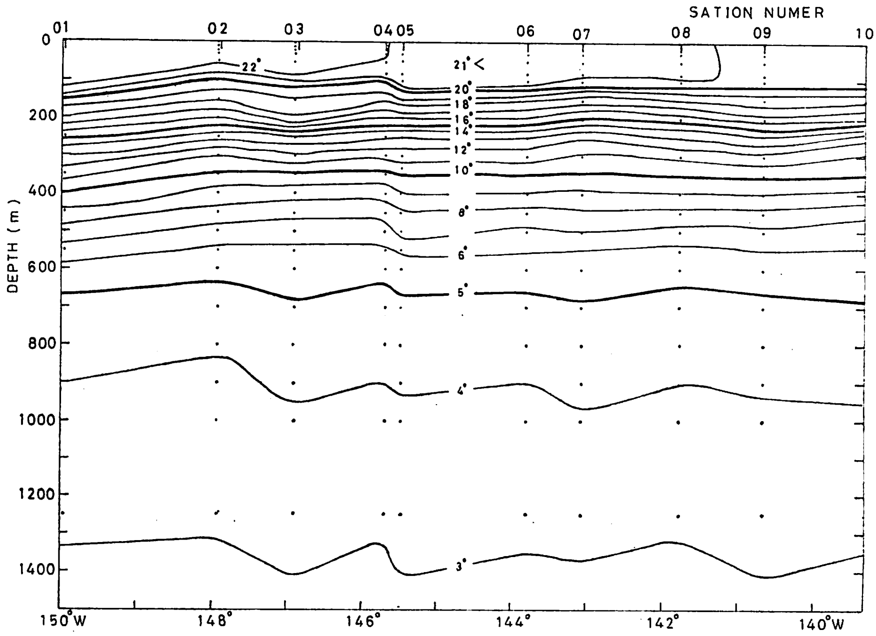

Fig. 4 (a)

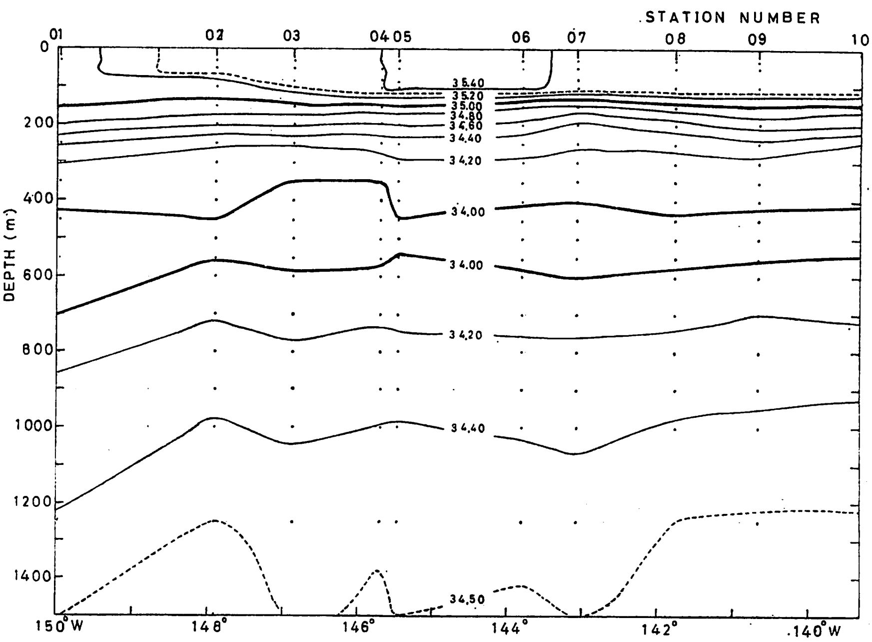

Fig. 4 (b)

Fig. 4. Vertical distributions of temperature and the salinity along the latitude of 25°N–28°N, between from 141°W to 150°W.

(a) Temperature (b) Salinity

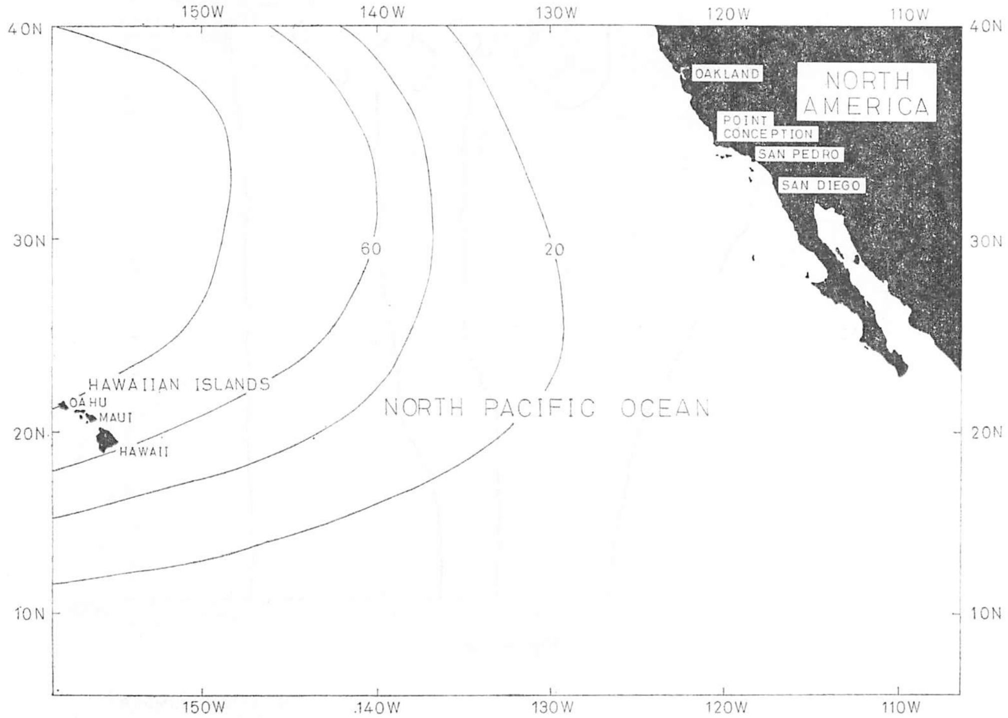

Fig. 5. Contours of thermocline depths in the eastern North Pacific, calculated from the wind-stress-distribution (Annual mean).

coast and, at a depth deeper than 600 m a dome-like isohalines were formed around 127°W. The isohaline corresponds almost exactly to the abovementioned upwelling.

In the western waters, (Fig. 4), the mixing surface water of high temperature and high salinity (higher than 20°C in temperature and 35.00‰ in salinity) is shown around the surface. The thermocline under the surface is also observable, but not as clear as in the case of eastern waters and its gradient is only 15°C/600 m.

In the salinity distribution, there are waters of high salinity at the surface around 144°W. In the 100–300 m depth, a rather obscure halocline seems to occur which is not noticeable in the western waters.

(2) The circulation of water mass

The distributions for the south-north components of geostrophic current referred to the 1,500 m depth are shown in Fig. 6, (a), (b) and their transport volumes are listed in Table 3.

In the eastern waters, the southward flow is the California Current and the northward one is the countercurrent.

The west-wind-drift-current flowing in an easterly direction in the North Pacific Ocean is blocked by the North America Continent, causing a portion of the current

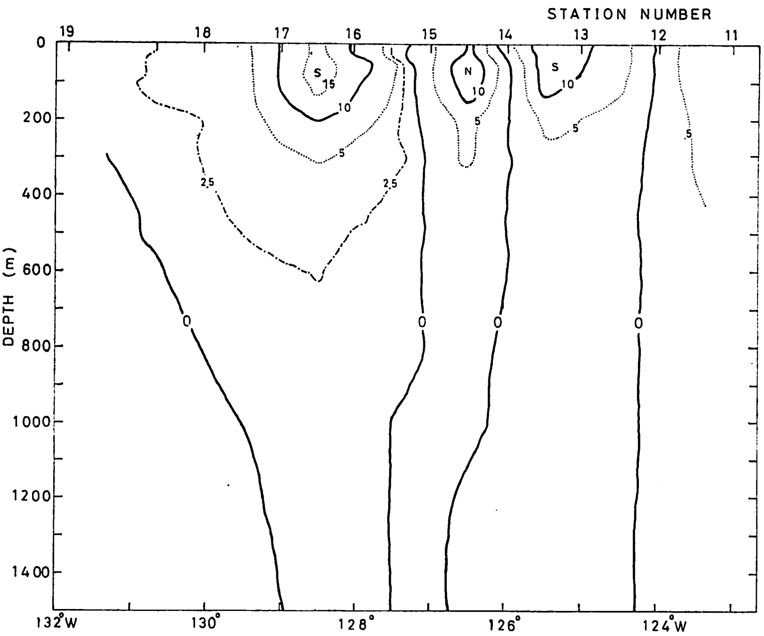

Fig. 6 (a)

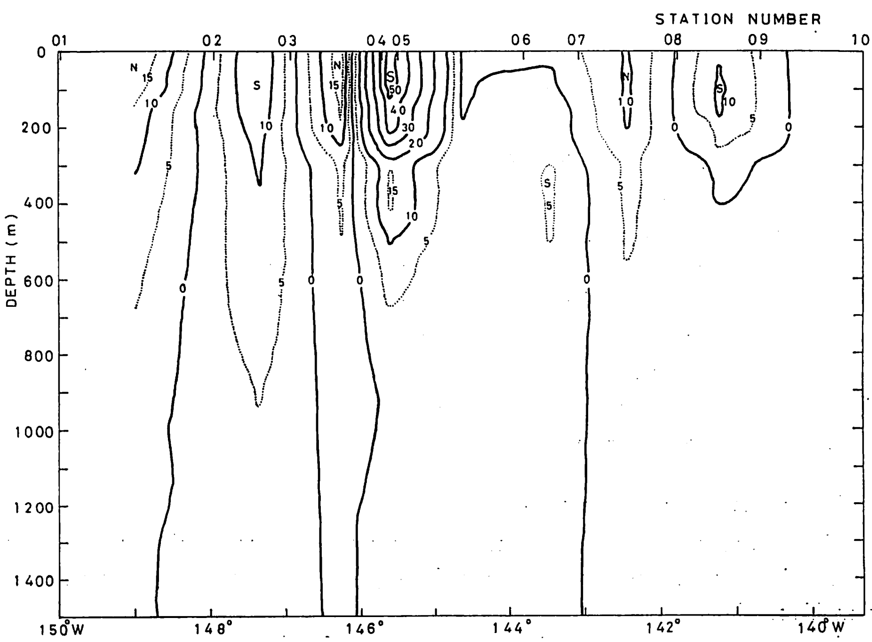

Fig. 6 (b)

Fig. 6. The north-south component (cm/sec) of calculated relative current velocity refferred to 1,500m; (a) along the latitude of 30°N—32°N, between from 123°W to 132°W, (b) along the latitude of 25°N —28°N, between from 141°W to 150°W.

Table 3. Values of the current velocity and the transport of component of geostrophic current in the eastern boundary current.

	Position of current axis (Long. W)	South-North component	Current velocity (cm/sec)	Transport (10^5 m^3/sec)
Eastern Waters	128°-30′	South	18	42.9
	126°-30′	North	15	44.7
	125°-20′	South	14	3.5
Western Waters	146°-41′	South	17	104.6
	146°-11′	North	19	28.1
	145°-36′	South	56	214.6
	142°-25′	North	11	1.3
	141°-13′	South	11	20.9

to turn south and flow toward the equator from a relatively high latitude along the west coast of the North America Continent.

On the other hand, the counter-current near the coast facing the surface pole is indicated, and this is considered to be one of the compensatory movements related to the upwelling phenomenon. According to Wooster and Reid, this counter-current appears from the tip of California to 45°N along the North America coast during winter.

Though Reid et al (1958) described the presence of an undercurrent throughout the year off the coast of California, it could not be found during our research. The relation between this undercurrent and the coastal upwelling was discussed by Yoshida and his collaborators.

In the western waters, the components of the directions of the current show the alternate distribution of the south and north components. This is considered to correspond with the meso-scale eddies and to occur widely at all times, though the scale and position of them are not constant. In a comparison of Fig. 2 (b) and, Fig. 3 (b), it is noticeable that the eddies cover the area of maximum temperature and salinity. It has not been established whether these eddies are the wind-spun vortex accompanied with the subtropical gyre or those from the topographical effect of Hawaiian Islands or those due to baroclinic instability.

The main current axis was around 129°W in the eastern waters and around 140°W in the western waters. The maximum speed of the southward flow is far slower in the eastern waters than in the western waters, i.e. the maximum speed of the southward flow is about 1.0 kt in the western waters, while only 0.3 kt in the eastern waters.

The total amounts of transport across both waters were calculated and the results are shown in Table 4. The southward transport across the western waters is far larger than the one across eastern waters and; on the other hand, the northward transport across the western waters is smaller than the one across the eastern waters.

According to Reid (1962), the width of the California Current was observed to be 40 miles, with a maximum speed of about 0.44 kt near the center. The maximum speed of the California Current observed in the present research therefore, cor-

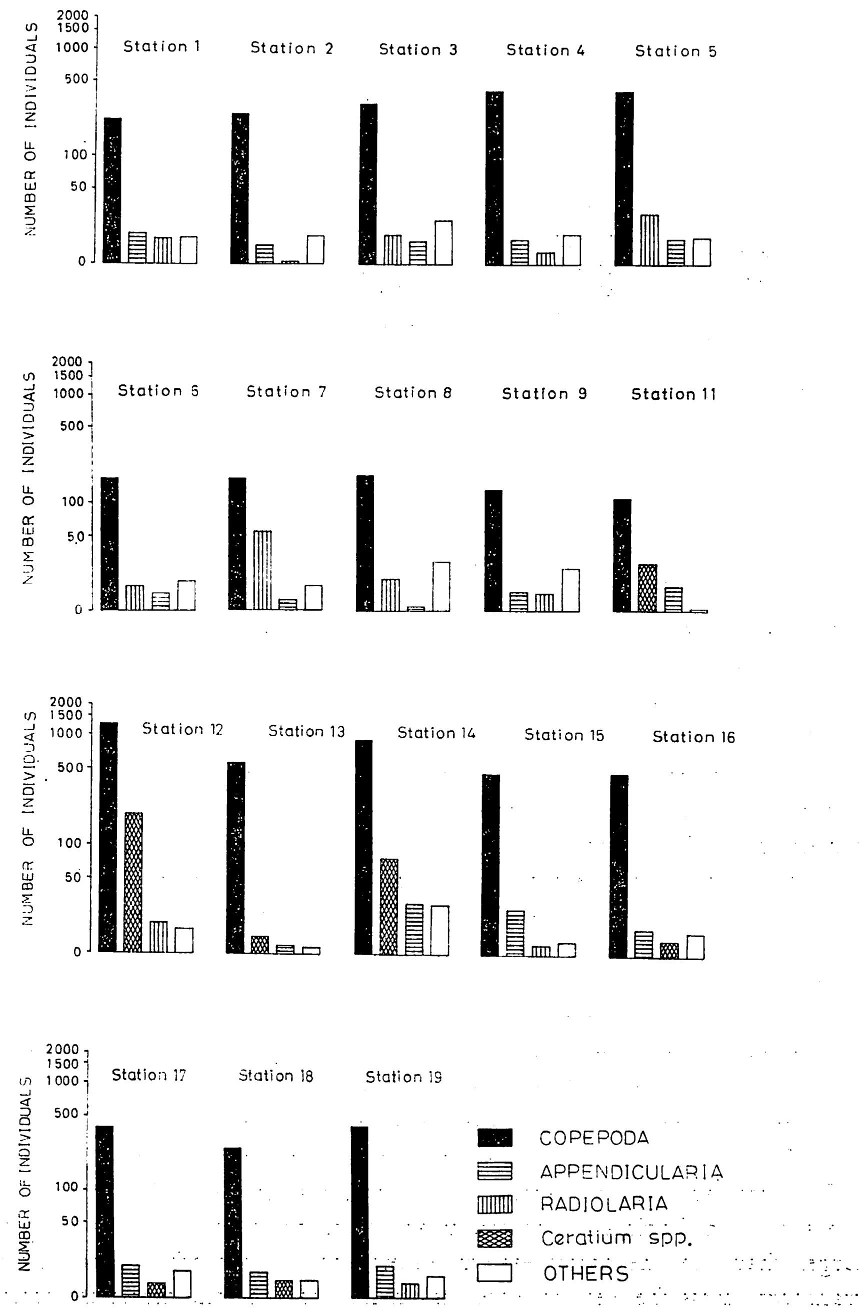

Fig. 7. Occurrence of the estimated number of zooplankton organisms per cubic meter of sea water at each station.

responds approximately to that observed by Reid, but the amount of the transport of the Current was quite small, compared with that presented by Wooster and Reid. The difference may be due to the calculation in this work, where the amount of transport for the east sides from station 11 was not included. The transport volume of the California Current and that of the poleward countercurrent is almost equivalent and, in the western waters, the transport volume of southward flow is greater than that of northward one.

In general, the width of the current in the eastern waters is relatively broad and its thickness is smaller than that in the western waters, though both the width and the thickness of the current varies considerably from time to time.

(3) Zooplankton

Fig. 7 shows the distribution of zooplankton in the eastern North Pacific Ocean. The zooplankton communities in this region are representative of Copepoda, radiolaria, *Ceratium,* appendicularia. Chaetognatha, polychaeta, ostracoda, thaliacea are found locally, but the number of individuals is very small. Copepoda occupies more than 70% of total individual number in each station. *Ceratium,* radiolaria and appendicularia occur very widely, though the numbers of individuals are small.

The total number of zooplankton varied from 500 to 10,400 per cubic meter. There is a distribution of maximum abundance in the eastern waters between 124°W and 126°W. The individual number of zooplankton, therefore, is far higher in the eastern waters than that in the western waters. The chart for the distribution of zooplankton in the Pacific Ocean (NORPAC committee, 1960) shows similar features in the regions of the California Current.

Generally, it has been ascertained that the occurrence of plankton organisms is related to physical and chemical conditions such as nutrient-salts, water temperature, salinity, and transparency in the sea and, that they are more abundant in colder sea than in warmer sea.

On the other hand, upwelling is of great importance to the sea productivity because it brings nutrients-salts into the euphotic zone, which is the socalled production-layer.

Phytoplankton is abundant in this layer and many zooplankton are swarming in and around this layer. Therefore, the favorite fishing grounds, abundant with such species as California sardine and Peruvian anchovy are formed with short-food-chains.

4. Summary

The oceanographical research in the eastern North Pacific Ocean was carried out in winter season from Dec, 1974 to Feb, 1975. The results obtained are summarized as follows:

1) Near the surface layer, there occurs a water mass of low temperature and low salinity in the eastern waters and one of high temperature and high salinity, in the

western waters. The remarkable transition zone of both waters is observed around 129°W.

2) In the subsurface layer, the thermoline is observable, and it becomes gradually shallower in an easterly direction, and the temperature gradient is also greater in eastern waters than in western waters.

3) The appearance of a short-time-scale-upwelling around 128°W is suspected.

4) The intermediate water of 5.7°C in water temperature and 34.60‰ in salinity occurs at the 500–600 m depth.

5) The undercurrent under the California Current was not observable. In western waters, the meso-scale eddies the origin of which was not clear were found.

6) The-main-current-axis was situated around 129°W in the eastern waters and around 146°W in the western waters and the maximum-flow-speeds were 0.3 kt and 1.0 kt, respectively.

7) The individual number of zooplankton was far higher in the eastern waters than in the western waters. Copepoda occupied more than 70% of total number at each station and *ceratium,* radiolaria and appendicular occurred very widely, though the number of individuals was small. Chaetognata, polychaeta, ostracoda and thaliacea were found only locally, and their number was also very small.

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Table 1. S. T. D. data at each observing station.

Depth	Station 1 Lat. 25°–54′.0N Long. 149°–58′.8W Dec. 30, 1974 Temp. (°C)	Salinity (‰)	Station 2 Lat. 26°–25′.0N Long. 147°–55′.6W Dec. 31, 1974 Temp. (°C)	Salinity (‰)	Station 3 Lat. 26°–48′.8N Long. 146°–53′.1W Jan. 1, 1975 Temp. (°C)	Salinity (‰)
0	23.2	35.13	22.4	35.41	22.1	35.37
10	23.2	35.13	22.4	35.41	22.1	35.37
20	23.2	35.13	22.3	35.41	22.2	35.37
30	23.2	35.14	22.3	35.41	22.2	35.36
50	23.2	35.14	22.2	35.40	22.1	35.36
75	23.2	35.14	20.9	35.18	22.0	35.38
100	23.2	35.14	19.8	35.11	20.9	35.28
150	19.9	35.01	18.1	34.91	18.7	34.92
200	17.8	34.81	16.2	34.60	17.9	34.64
250	15.2	34.43	13.2	34.22	13.6	34.21
300	12.9	34.22	10.9	34.10	11.7	34.12
350	11.4	34.08	9.8	34.07	9.8	33.98
400	10.0	34.03	8.6	34.02	8.3	33.93
450	8.8	33.97	7.6	34.00	7.3	33.91
500	7.6	33.90	6.6	33.98	6.6	33.93
550	6.6	33.89	5.8	34.00	5.8	33.95
600	5.7	33.91	5.2	34.05	5.4	34.02
700	4.7	34.01	4.6	34.18	4.9	34.13
800	4.4	34.15	4.1	34.30	4.6	34.23
900	4.0	34.24	3.8	34.37	4.1	34.33
1000	3.8	34.33	3.6	34.41	3.9	34.39
1250	3.2	34.41	3.1	34.50	3.2	34.45
1500			2.7	34.55	2.9	34.48

Depth	Station 4 Lat. 27°–03′.2N Long. 145°–28′.5W Jan. 2, 1975 Temp. (°C)	Salinity (‰)	Station 5 Lat. 26°–59′.8N Long. 145°–42′.9W Jan. 3, 1975 Temp. (°C)	Salinity (‰)	Station 6 Lat. 26°–55′.5N Long. 143°–48′.0W Jan. 4, 1975 Temp. (°C)	Salinity (‰)
0	21.7	35.43	22.1	35.40	21.7	35.42
10	21.8	35.43	22.1	35.40	21.7	35.42
20	21.8	35.43	22.1	35.40	21.7	35.42
30	21.8	35.43	22.1	35.40	21.7	35.42
50	21.8	35.42	21.9	35.39	21.7	35.42
75	21.7	35.43	21.8	35.40	21.7	35.42
100	21.7	35.42	20.1	35.40	21.8	35.42
150	18.7	34.97	18.4	34.92	17.9	34.81
200	16.1	34.60	15.8	34.54	15.8	34.56
250	12.9	34.30	13.2	34.25	12.9	34.26
300	11.4	34.17	11.2	34.11	11.4	34.18
350	10.0	34.12	9.6	34.00	10.1	34.09
400	8.9	35.05	8.4	33.97	8.8	34.01
450	7.9	33.99	7.2	33.95	7.6	33.95
500	7.4	33.97	6.4	33.94	6.7	33.95
550	6.2	34.01	5.8	33.98	6.1	33.98
600	5.6	34.05	5.2	34.03	5.4	34.02
700	4.8	34.15	4.6	34.18	4.7	34.14
800	4.3	34.26	4.2	34.25	4.3	34.24
900	4.1	34.35	4.0	34.32	4.0	34.32
1000	3.8	34.41	3.7	34.40	3.8	34.39
1250	3.2	35.49	3.1	34.47	3.2	34.48
1500	2.9	34.50	2.7	34.53	2.7	34.51

Table 1. (Continued)

Depth	Station 7 Lat. 27°–19′.5N Long. 143°–04′.7W Jan. 5, 1975		Station 8 Lat. 27°–36′.7N Long. 141°–45′.5W Jan. 6, 1975		Station 9 Lat. 27°–29′.2N Long. 140°–41′.0W Jan. 7, 1975	
	Temp. (°C)	Salinity (‰)	Temp. (°C)	Salinity (‰)	Temp. (°C)	Salinity (‰)
0	21.0	35.37	21.1	35.41	20.6	35.38
10	21.0	35.38	21.1	35.41	20.6	35.38
20	21.0	35.38	21.2	35.42	20.6	35.38
30	21.0	35.38	21.2	35.42	20.6	35.38
50	21.0	35.38	21.2	35.42	20.6	35.39
75	21.1	35.37	21.2	35.42	20.6	35.39
100	20.7	35.34	20.8	35.42	20.6	35.39
150	17.2	34.70	17.8	34.86	18.6	34.97
200	14.8	34.30	15.2	34.50	16.7	34.69
250	12.0	34.21	12.8	34.22	13.8	34.32
300	10.8	34.16	11.2	34.17	11.6	34.15
350	10.0	34.05	10.0	34.09	10.2	34.08
400	8.7	34.00	8.8	34.03	8.9	34.02
450	7.9	33.98	7.7	33.98	7.7	33.97
500	6.9	33.91	6.6	33.95	6.7	33.98
550	5.9	33.92	5.7	33.98	6.0	34.00
600	5.5	33.00	5.2	34.02	5.5	34.05
700	4.9	34.13	4.7	34.15	4.7	34.20
800	4.6	34.24	4.2	34.26	4.4	34.28
900	4.2	34.35	4.0	35.36	4.1	34.37
1000	3.9	34.38	3.8	34.42	3.8	34.43
1250	3.2	34.45	3.1	34.50	3.2	34.51
1500	2.8	34.50	2.7	34.53	2.9	34.55

DeOth	Station 10 Lat. 27°–29′.0N Long. 139°–13′.0W Jan. 8, 1975		Station 11 Lat. 32°–37′.0N Long. 122°–59′.8W Jan. 24, 1974		Station 12 Lat. 32°–18′.0N Long. 123°–58′.2W Jan. 24, 1975	
	Temp. (°C)	Salinity (‰)	Temp. (°C)	Salinity (‰)	Temp. (°C)	Salinity (‰)
0	20.6	35.40	13.6	33.40	13.8	33.42
10	20.6	35.41	13.6	33.40	13.8	33.42
20	20.6	35.41	13.6	33.40	13.8	33.42
30	20.6	35.41	13.6	33.40	13.7	33.41
50	20.7	35.41	13.5	33.40	13.6	33.43
75	20.7	35.41	13.1	33.35	13.0	33.37
100	20.6	35.41	11.9	33.39	10.7	33.43
150	18.4	34.92	9.7	33.63	9.1	33.79
200	15.8	34.59	8.5	33.92	8.3	33.97
250	12.3	34.14	7.8	34.01	7.6	34.02
300	10.9	34.12	7.2	34.08	7.1	34.06
350	10.0	34.08	6.6	34.10	6.6	34.11
400	8.7	34.01	6.3	34.15	6.1	34.15
450	7.2	33.97	6.1	34.20	5.8	34.19
500	6.5	33.97	5.7	34.25	5.5	34.22
550	5.9	34.01	5.4	34.25	5.3	34.27
600	5.4	34.06	5.2	34.29	4.8	34.29
700	4.9	34.18	4.8	34.36	4.6	34.34
800	4.4	34.29	4.6	34.42	4.3	34.40
900	4.1	34.39	4.2	34.48	4.0	34.43
1000	3.9	34.44	3.9	34.50	3.7	34.48
1250	3.2	34.51	3.3	34.53	3.1	34.54
1500	2.7	34.55	2.6	34.55	2.7	34.59

Table 1. (Continued)

Depth	Station 13 Lat. 31°-57'.2N Long. 125°-01'.6W Jan. 24, 1975 Temp. (°C)	Salinity (‰)	Station 14 Lat. 31°-37'.0N Long. 125°-58'.5W Jan. 25, 1975 Temp. (°C)	Salinity (‰)	Station 15 Lat. 31°-18'.4N Long. 127°-00'.0W Jan. 25, 1975 Temp. (°C)	Salinity (‰)
0	14.0	33.42	14.9	33.50	15.4	33.54
10	14.0	33.42	14.9	33.50	15.4	33.54
20	14.0	33.42	14.9	33.50	15.3	33.50
30	14.0	33.41	14.9	33.50	15.3	33.50
50	13.8	33.40	14.9	33.49	15.2	33.40
75	13.6	33.40	14.7	33.45	12.9	33.45
100	12.6	33.42	14.4	33.43	12.1	33.47
150	9.7	33.66	12.1	33.47	9.2	33.70
200	8.6	33.92	9.7	33.66	8.6	33.95
250	7.9	33.99	8.0	33.92	7.7	33.98
300	7.2	34.02	7.7	33.99	7.2	33.99
350	6.7	34.05	7.1	34.05	6.4	34.01
400	6.0	34.06	6.7	34.09	6.2	34.13
450	5.4	34.10	6.2	34.14	5.9	34.20
500	5.6	34.20	5.9	34.20	5.7	34.26
550	5.3	34.25	5.7	34.25	5.4	34.29
600	4.9	34.28	5.4	34.29	5.2	34.34
700	4.7	34.36	4.9	34.35	4.7	34.40
800	4.3	34.41	4.4	34.39	4.4	34.42
900	4.0	34.44	4.1	34.43	4.1	34.45
1000	3.7	34.49	3.9	34.48	3.8	34.48
1250	3.2	34.53	3.3	34.53	3.2	34.53
1500	2.7	34.58	2.8	34.58	2.8	34.54

Depth	Station 16 Lat. 31°-00'.5N Long. 128°-02'.0W Jan. 25, 1975 Temp. (°C)	Salinity (‰)	Station 17 Lat. 30°-43'.4N Long. 129°-00'.0W Jan. 25, 1975 Temp. (°C)	Salinity (‰)	Station 18 Lat. 30°-23'.2N Long. 130°-02'.0W Jan. 25, 1975 Temp. (°C)	Salinity (‰)
0	15.3	33.49	16.7	33.98	17.2	34.17
10	15.3	33.49	16.8	33.98	17.2	34.17
20	15.2	33.49	16.8	34.27	17.2	34.17
30	15.2	33.49	16.9	34.28	17.5	34.30
50	15.1	33.48	17.3	34.33	17.6	34.35
75	14.4	33.25	17.4	34.31	17.6	34.34
100	11.7	33.35	17.6	34.39	17.6	34.39
150	9.9	33.55	14.4	34.04	14.8	34.09
200	8.7	33.89	12.2	33.90	11.7	33.81
250	7.9	33.95	9.2	33.81	9.4	33.91
300	7.3	33.98	7.9	33.93	8.4	33.98
350	6.7	34.00	7.1	33.98	7.4	33.97
400	6.2	34.03	6.4	34.00	6.6	33.98
450	5.6	34.07	5.8	34.02	6.2	34.00
500	5.4	34.10	5.3	34.07	5.6	34.08
550	5.1	34.19	5.1	34.12	5.3	34.11
600	5.0	34.25	4.9	34.18	5.1	34.08
700	4.6	34.33	4.5	34.28	4.7	34.29
800	4.4	34.40	4.2	34.35	4.4	34.35
900	4.1	34.44	3.9	34.40	4.2	34.42
1000	3.8	34.47	3.7	34.44	3.9	34.45
1250	3.1	34.50	3.2	34.52	3.2	34.51
1500	2.7	34.53	2.7	34.58	2.8	34.55

Depth	Station 19 Lat. 29°–49′.7N Long. 131°–51′.3W Jan. 26, 1975 Temp. (°C)	Salinity (‰)
0	17.9	34.52
10	17.9	34.52
20	17.9	34.52
30	17.9	34.52
50	17.9	34.52
75	17.9	34.52
100	17.9	34.52
150	16.0	34.30
200	12.9	33.82
250	10.0	33.80
300	9.0	33.99
350	8.0	33.97
400	7.1	33.97
450	6.3	33.99
500	6.0	34.05
550	5.6	34.10
600	5.3	34.15
700	4.7	34.25
800	4.4	34.34
900	4.1	34.40
1000	3.8	34.45
1250	3.2	34.51
1500	2.7	34.57

Table 2. Current velocities (cm/sec) referred to 1,500 m depth in the eastern and western waters of the eastern North Pacific Ocean.

Depth	St. 1–2	St. 2–3	St. 3–4	St. 4–5	St. 5–6	St. 6–7
0	−20.9	16.5	−18.5	52.8	−0.4	−1.1
10	−20.7	16.6	−18.5	53.4	−0.4	−0.9
20	−20.3	16.6	−18.4	54.0	−0.4	−0.6
30	−20.0	16.6	−18.3	54.5	−0.4	−0.3
50	−19.4	16.6	−18.2	55.3	−0.3	0.2
75	−18.3	16.3	−17.9	55.9	−0.2	0.8
100	−16.9	15.8	−17.2	52.6	−0.3	1.6
150	−13.2	14.7	−16.0	45.2	−0.2	3.0
200	−12.2	12.9	−14.4	44.3	0.1	3.5
250	−11.3	11.4	− 9.7	29.2	0.1	4.2
300	−10.3	10.8	− 6.0	14.7	0.0	5.2
350	− 9.3	10.1	− 5.7	15.4	−0.0	5.5
400	− 8.4	9.8	− 5.5	15.6	−0.1	5.4
450	− 7.6	9.7	− 5.2	13.9	−0.2	5.3
500	− 6.8	9.4	− 4.9	10.4	0.0	5.0
550	− 6.2	9.1	− 4.6	7.8	0.2	4.8
600	− 5.5	8.8	− 4.5	7.0	0.2	4.4
700	− 4.3	7.9	− 3.8	4.2	0.2	3.8
800	− 3.2	6.5	− 2.8	1.9	0.2	3.0
900	− 2.2	5.3	− 2.2	0.8	0.2	2.6
1000	− 1.5	4.5	− 1.9	0.8	0.1	2.0
1250	0	3.0	− 1.1	2.5	−0.2	0.7
1500		0	0	0	0	0

Table 2. (Continued)

Depth	St. 7–8	St. 8–9	St. 9–11	St. 11–12	St. 12–13	St. 13–14
0	−10.6	0	−3.4	8.7	−7.3	−14.2
10	−10.6	9.7	−3.3	8.7	−7.3	−14.0
20	−10.6	9.8	−3.3	8.8	−7.2	−13.8
30	−10.6	9.9	−3.3	8.8	−7.2	−13.6
50	−10.6	10.2	−3.3	8.8	−7.0	−13.3
75	−10.6	10.7	−3.3	8.7	−6.7	−12.7
100	−10.5	10.9	−3.3	8.1	−6.0	−11.9
150	−10.5	10.6	−3.3	6.6	−4.3	− 9.1
200	−10.3	9.4	−2.9	5.8	−3.4	− 6.1
250	− 7.9	5.0	−2.2	5.5	−2.9	− 4.8
300	− 5.9	0.9	−1.5	5.4	−2.5	− 4.3
350	− 6.0	0.4	−1.1	5.1	−2.2	− 3.8
400	− 5.8	0.0	−0.9	4.7	−1.8	− 3.3
450	− 5.6	−0.1	−0.6	4.5	−1.5	− 2.9
500	− 5.4	−0.2	−0.3	4.3	−1.5	− 2.4
550	− 5.0	−0.2	−0.2	4.2	−1.6	− 1.8
600	− 4.6	−0.4	−0.1	4.0	−1.6	− 1.5
700	− 4.1	−0.2	−0.2	3.5	−1.3	− 1.1
800	− 3.4	0.1	−0.3	3.0	−1.1	− 0.8
900	− 2.9	0.1	−0.3	3.0	−1.1	− 0.7
1000	− 2.4	0.2	−0.3	3.1	−1.1	− 0.5
1250	− 0.9	0.4	−0.4	2.3	−0.6	− 0.2
1500	0	0	0	0	0	0

Table 2. (Continued)

Depth	St. 14–15	St. 15–16	St. 16–17	St. 17–18	St. 18–19
0	6.4	1.9	−16.3	−3.8	−2.0
10	10.6	−2.2	−16.4	−3.9	−2.0
20	10.7	−2.2	−16.5	−3.8	−2.1
30	8.0	0.6	−16.8	−3.6	−2.2
50	15.3	−6.4	−17.3	−3.4	−2.3
75	14.9	−5.9	−17.8	−3.3	−2.3
100	13.6	−5.1	−17.2	−3.3	−2.4
150	10.0	−4.4	−14.1	−3.1	−2.3
200	6.7	−3.5	−10.4	−2.9	−1.7
250	5.1	−3.0	− 7.1	−3.4	−1.0
300	5.9	−4.1	− 5.2	−3.7	−0.5
350	4.1	−2.7	− 4.5	−3.5	−0.1
400	3.5	−2.3	− 3.9	−3.2	0.2
450	2.9	−2.1	− 3.4	−2.9	0.4
500	2.4	−1.7	− 3.1	−2.5	0.6
550	2.0	−1.3	− 2.9	−2.3	0.8
600	1.6	−1.1	− 2.6	−1.7	0.8
700	0.9	−0.6	− 2.2	−0.8	0.7
800	0.4	−0.3	− 2.0	−0.5	0.9
900	0.3	−0.1	− 2.0	−0.2	0.9
1000	0.2	0	− 1.8	0	0.8
1250	−0.2	0	− 1.2	0.6	0.6
1500	0	0	0	0	0

Table 4. Occurrence of zooplankton at each collecting station.

Date	Dec. 30, 1974	Dec. 31, 1974	Jan. 1, 1975	Jan. 2, 1975	Jan. 3, 1975	Jan. 4, 1975
Station No.	1	2	3	4	5	6
Latitude	25°–54′.0N	26°–25′.0N	26°–48′.8N	27°–03′.2N	26°–59′.8N	26°–55′.5N
Longitude	149°–58′.8W	147°–55′.6W	146°–53′.1W	145°–28′.5W	145°–42′.9W	143°–48′.0W
Radiolaria	49	3	59	20	98	46
Ceratitum	10	10	39	3	7	13
Chaetognatha	7	7	3	3	23	3
Polychaeta	13	7	7	13	7	
Pteropoda						
Ostracoda	6	10	7	7	3	
Copepoda	726	814	1029	1330	1360	546
Decapoda larve			10	7		3
Nauplius						
Appendicularia	62	33	43	46	49	29
Thaliacea		16	3	26	3	7
larve						
The other larval form		3	10			
Unidentified Organisms	16	3	7		10	
Medusa						
Total	889	906	1217	1455	1560	647

Table 4. (Continued)

Date	Jan. 5, 1975	Jan. 6, 1975	Jan. 7, 1975	Jan. 24, 1975	Jan. 24, 1975	Jan. 24, 1975
Station No.	7	8	9	11	12	13
Latitude	27°–19′.5N	27°–36′.7N	27°–29′.2N	32°–37′.0N	32°–18′.0N	31°–57′.2N
Longitude	143°–04′.7W	141°–45′.5W	140°–41′.0W	122°–59′.8W	123°–58′.2W	125°–01′.6W
Radiolaria	177	65	29		124	20
Ceratium	20	33	33	92	1288	59
Chaetognatha	3	39			7	
Polychaeta	10		3		7	
Pteropoda						
Ostracoda	3				7	
Copepoda	569	592	435	360	8837	3915
Decapoda larve					7	
Nauplius						
Appendicularia	16	7	33	46	72	26
Thaliacea	3	3	13	3		
larve	3					
The other larval form						
Unidentified Organisms		20	33			
Medusa	3					
Total	807	759	579	501	10349	4020

Table 4. (Continued)

Date	Jan. 25, 1975	Jan. 25, 1975	Jan. 25, 1975	Jan. 25, 1975	Jan. 25, 1975	Jan. 26, 1975
Station No.	14	15	16	17	18	19
Latitude	31°–37′.0N	31°–18′.4N	31°–00′.5N	30°–43′.4N	30°–23′.2N	29°–49′.7N
Longitude	125°–58′.5W	127°–00′.0W	128°–02′.0W	129°–00′.0W	130°–02′.0W	131°–51′.3W
Radiolaria	111	33	23	20	10	23
Ceratium	516	13	26	23	29	16
Chaetognatha	13		10	7	3	10
Polychaeta		7	7		3	
Pteropoda						
Ostracoda	13	7	16	10	3	
Copepoda	6510	3235	1641	1333	860	1382
Decapoda larve						
Nauplius				3		
Appendicularia	196	177	52	65	49	65
Thaliacea	39	13	10	10	7	10
larve						
The other larval form		7		3	3	3
Unidentified Organisms		7		3	3	3
Medusa						
Total	7398	3492	1785	1474	967	1509