Mem. Fac. Fish., Kagoshima Univ.
Vol. 29 pp. 179~192 (1980)

The Oceanographical Research in the Southern Region of the Hawaiian Islands—III

Yasutaka YUWAKI* and Tomio HENMI*

Abstract

The oceanographical observations and biological researches in the southern region of the Hawaiian Islands were carried out on board the training ship the Keiten Maru of Kagoshima University during the summers of the successive three years, 1977–1979. As summarized in the following, some informations were gained on the oceanic characteristics and on the distribution of zooplankton from the synthetic discussions on the results obtained throughout the three years.

1) South of 09°N, the surface temperature in the three years were almost equal, decreasing gradually towards the north from 09°N. In 1979, a discontinuous distribution of the surface temperature was supposed to exist near 10°N.

2) The depth of the thermocline, centered at 19°C to 20°C, was in a layer at a depth of about 125 m near 15°N and about 90 m near 08°N, becoming gradually shallower towards the equator from the north. The thermocline, the center of which was shallowest, was situated near 11°N in 1977 and near 09°–30′N in 1978 and 1979. The vertical gradient of temperature in the thermocline was largest at the section where the depth of the thermocline was shallower, its numerical value being ca. 0.20°C/m.

3) Below the thermocline, the upwelling was suspected to have taken place near 12°N and 13°N.

4) South of 09°N, the surface salinity were almost equal throughout the three years, decreasing north of 10°N. The variation in the value of maximum and minimum surface salinity was largest in 1979, its numerical value being ca. 0.40‰.

5) A tonguelike protuberance with salinity higher than 35.00‰ extending from the north was found in a layer at a depth of about 150 m. The location of the high salinity was variable due to the shifting over the years.

6) The salinity water lower than 34.50‰ extending from the north was found near 15°N in a layer at a depth of about 250 m, the depth of the low salinity water becoming shallower gradually toward the south. The water with a salinity of 34.70‰ extending from the south, was found near 08°N, in a layer at a depth of about 250 m, the location of the water shifting somewhat southward from year to year.

7) The main axis of the eastward flow was situated 10°–30′N in 1977, near 08°–45′N in 1978, and 07°–15′N in 1979. The main axis of the westward flow was situated near 09°–30′N, and 11°–45′N in 1977, and near 09°–30′N in 1978 and 1979.

8) The maximum velocities of the eastward flow and of the westward flow were 23 cm/sec and 33 cm/sec, respectively. It was larger in 1978 than those in 1977 and 1979.

9) It was estimated that the boundary between the North Equatorial Current and the Equatorial Countercurrent was situated south of 07°N in 1977, and near 09°N in 1978 and 1979.

10) The zooplankton-communities were represented by the species of *Copepoda, Radiolaria, Appendicularia, Ceratium* and *Foraminifera. Copepoda* occupies the greater part of the zooplanton.

* Training ship Keiten Maru, Faculty of Fisheries, Kagoshima University

The numerical value of the zooplankton appearance per cubic meter throughout the three years was 545 individuals as maximum, and 37 individuals as minimum. The average of the individuals in 1977, 1978 and 1979 were 252, 270 and 229, respectively.

1. Introduction

It is a well known fact that the productivity of such species as tuna and skipjak is higher around the ridging and dome in the eastern Equatorial Current, because of the existence of the fertile water which is being brought up to the surface, supporting the greater production of plankton. For the successive three years since the summer of 1977, the Keiten Maru, training ship of Kagoshima University, has carried out the meridional oceanographical observations and biological reserches of the tuna fishing ground in the southern region of the Hawaiian Islands, concurrently with the training of cadets. On the general feature of the oceanic condition and the distribution of zooplankton some information was gained from synthetic discussions on the results obtained during the summer season of the successive three years, 1977–1979.

2. Materials and Methods

In the southern region of the Hawaiian Islands the oceanographical observations and biological researches were carried out on board the Keiten Maru (G.T 860 ton) first along the meridian of 158°W from 15°N to 07°N in May of 1977, second along the meridian of 158°W from 15°N to 08°N in June of 1978 and third along the meridian of 156°W from 15°N to 07°N in May of 1979. The observation stations are shown in Fig. 1. The methods of observation and of zooplankton sampling are quite similar to those reported in the previous paper (Henmi, 1976). The values of temperature and salinity obtained in 1979 at the respective stations are tabulated in Appendix 1 and the individual numbers of zooplankton per cubic meter are tabulated in Appendix 2.

3. Results and Discussion

1. Temperature

The vertical distributions of the water temperature ascertained by the serial observations during the summers of the three years, 1977–1979, are shown in Fig. 2. South of 09°N, the surface temperature throughout the three years are noted to be almost equal. The surface temperatures in 1977 and 1978 decreased gradually towards the north from 09°N. On the other hand, the surface temperature in 1979 decreased abruptly towards the north from 09°N. A discontinuous distribution of the surface temperature is supposed to exist near 10°N. The depth of the thermocline, centered at 19°C to 20°C, is in a layer at a depth of about 125 m near 15°N, and about 90 m near 08°N, becoming gradually shallower towards the equator from the north. The thermocline, the center of which is shallowest, was situated near 11°N

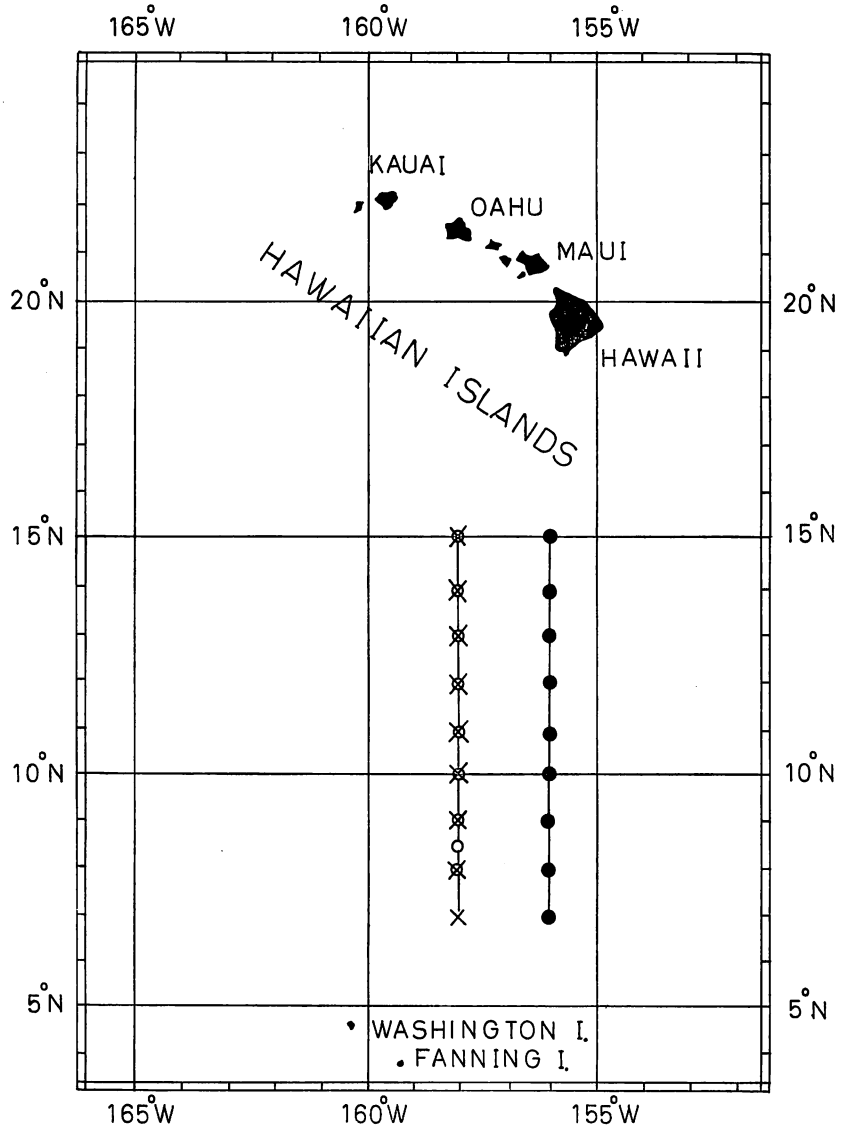

Fig. 1. Map showing the oceanographic stations of S.T.D observation and collection of plankton. Symbols: crosses, 1977; circles, 1978; dots, 1979.

in 1977, and near 09°–30′N in 1978 and 1979. The vertical gradient of temperature in the thermocline was largest where the depth of the thermocline was shallowest. The value of the vertical gradient of temperature was ca. 0.20°C/m, being almost equal throughout the three years. It was reported by Montgomery (1954), Montgomery and Stroup (1962), Masuzawa (1964), Yamanaka *et al.* (1965) that the depth at the top of the thermocline was shallowest in the vicinity of the boundary between the

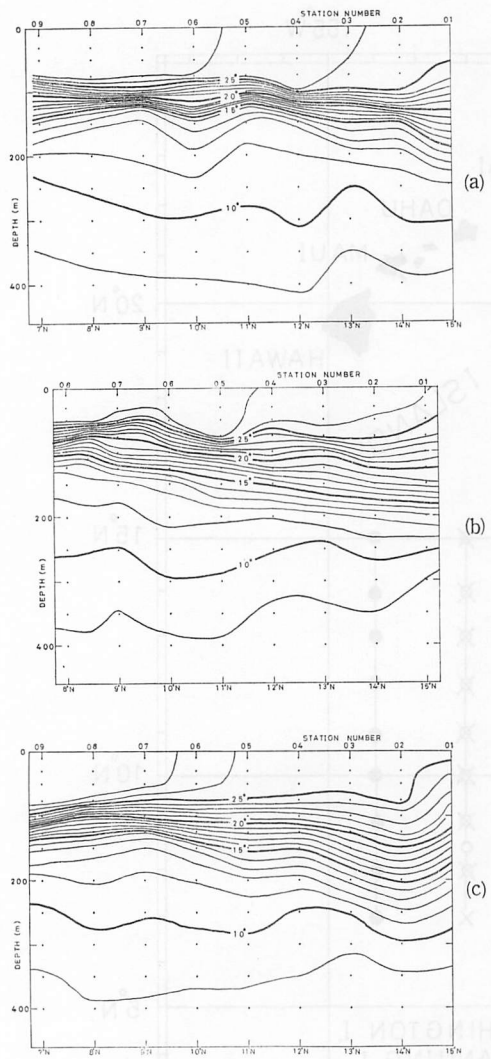

Fig. 2. Distribution of temperature (°C) obtained by serial observation in summer of 1977 (a), 1978 (b) and 1979 (c).

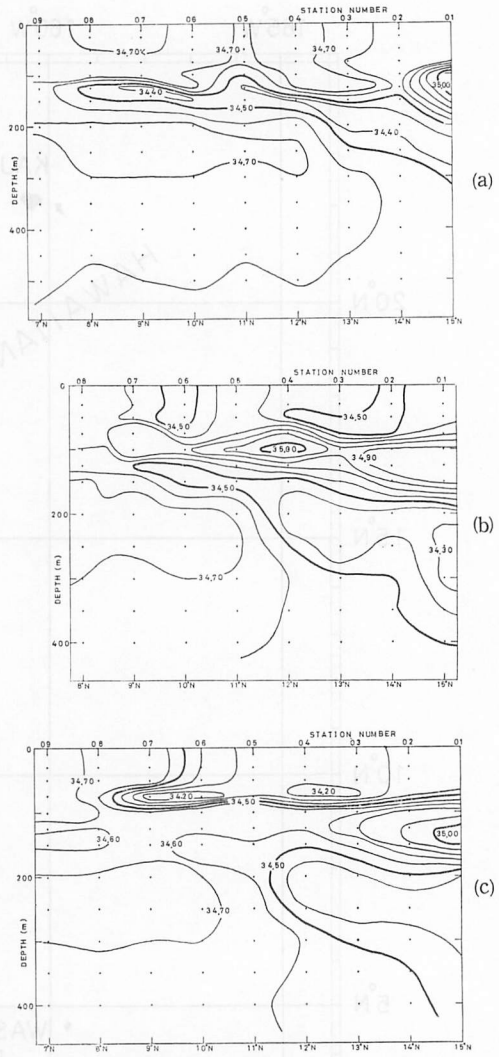

Fig. 3. Distribution of salinity (‰) obtained by serial observation in summer of 1977 (a), 1978 (b) and 1979 (c).

North Equatorial Current and the Equatorial Countercurrent. Estimating from the vertical distributions of water temperature (Fig. 2), the authors considered that the boundary between the North Equatorial Current and the Equatorial Countercurrent was situated near 11°N in 1977 and near 09°–30′N in 1978 and 1979. However, in this chapter, the determination of the boundary between the North Equatorial Current and the Equatorial Countercurrent was assumed to be difficult; Accordingly, the details about the boundary are described hereafter. In the vicinity of 15°N, the

vertical gradient of temperature in the thermocline was noted to be almost the same throughout the three years, with the value being ca. 0.08°C/m, and smaller than the one in the low latitude. A vertical spreading of the thermocline was noted in the north of 15°N. The existence of some upwelling seems to have been suggested by the slope of isotherms in the water temperature distribution near 12°N and 13°N, below the thermocline.

2. Salinity

The vertical distributions of salinity ascertained by the serial observations during the summers of the three years, 1977–1979, are shown in Fig. 3. The numerical value of the surface salinity in 1977 was ca. 34.70‰ south of 12°–30′N, ca. 34.60‰ north of 13°N. The surface salinity in 1978 was somewhat lower than that in 1977; its numerical value being ca. 34.60‰ south of 09°N; ca. 34.44‰ at 10°N, as minimum; ca. 34.70‰ at 11°N, as maximum; and ca. 34.50‰ north of 12°N. A local eddy was suspected to exist near 10°–30′N. The surface salinity in 1979 south of 09°N was noted to be almost equal to that in 1977; however it decreased abruptly toward the north from 09°N; and the numerical value of the surface salinity is ca. 34.25‰ at 11°N, which is the lowest throughout the three years. The variation in the values of maximum and minimum of the surface salinity was noted to be far larger in 1979, compared with those in 1977 and 1978. The discontinuous distribution of surface salinity seems to correspond to that of surface temperature. The origin of low salinity water was left unconfirmed in the present research only with the assumption that it may be related, either to much rain in the eastern North Pacific, or to the large-scale vortex in the region of the eastern boundary current in the North Pacific, or to some unknown but important factor of the sorts. The existence of high salinity higher than 35.00‰ extending to the south from the north was ascertained in a layer at a depth of about 150 m. The location of the high salinity was variable due to the shifting over the years, i.e., the extention of a tonguelike protuberance of high salinity was noted to lie near 14°N in the layer between 80 m and 200 m depths in 1977; near 08°–30′N in the layer between 60 m and 170 m depths in 1978; and near 12°–30′N in the layer between 90 m and 170 m depths in 1979, respectively. In 1978, a core of the high salinity with a salinity of ca. 35.00‰ was noted to exist near 12°N in a layer at a depth of about 100 m. As already reported in the previous paper (Yuwaki and Henmi, 1978), the high salinity water was derived from the northeast region of the Hawaiian Islands lying around 29°N, 148°W. The annual variations in the location of the high salinity is supposed not merely to be the result in a change in the current-route, but also to play a part in inducing the variation of the oceanic conditions. Below the high salinity water, a tonguelike protuberance of the low salinity with a salinity of 34.50‰, formed by Intermediate water having an origin in the subarctic North Pacific (Reid, 1965), was noted to extend near 08°N in a layer between 100 m and 300 m depths in 1977; near 09°N in the layer between 100 m and 400 m depths in 1978; and near 11°–30′N in the layer between 200 m and 400 m

depths in 1979. In 1977 and 1979 the upper part of this water of low salinity was found in contact with the lower part of the surface water, but in 1978 that was not to be found, owing to the fact that the protuberance of salinity higher than 35.00‰ extending to the south from the north was predominant. The water with the salinity of 34.70‰ extending from the south to the north in a layer at a depth of about 250 m was noted to extend near 12°N in 1977; near 11°N in 1978; and near 10°–30′N in 1979. The location of the water (34.70‰) shifts somewhat to southward from year to year. This phenomenon is considered to have been affected by the vicissitudes in the surface maximum water in the South Pacific.

3. Eastward and westward flow

The distribution of the east-west components of the geostrophic current referred to 1,200 m depth, and the geopotential profiles referred to 1,000 m depth during the summers of the three years, 1977–1979, are shown in Fig. 4 and 5, respectively. The values of current elements of the eastward and westward flows are listed in Table 1.

Table 1. Values of current elements of the westward and eastward flow.

	Current element / flow	Position of current axis (Lat. N)	Speed of east-west component (cm/sec)	Volume transport of east-west component (m^3/sec)
1977	Westward	09°–30′	21	3×10^6
	Eastward	10°–30′	21	5×10^6
	Westward	11°–45′	20	9×10^6
1978	Eastward	08°–45′	23	7×10^6
	Westward	09°–35′	33	13×10^6
	Eastward	11°–30′	7	2×10^6
	Westward	13°–00′	12	6×10^6
1979	Eastward	07°–15′	16	9×10^6
	Westward	09°–30′	20	8×10^6
	Eastward	11°–30′	5	4×10^6
	Westward	13°–30′	20	9×10^6

As is seen in Fig. 4, the main axis of the eastward flow was noted to be situated near 10°–30′N in 1977, near 08°–45′N in 1978 and near 07°–15′N in 1979. The maximum velocity of the eastward flow was 21 cm/sec in 1977, 23 cm/sec in 1978 and 16 cm/sec in 1979, respectively. A weak eastward flow was ascertained between 11°N and 13°N. Although the scale and the situation of the weak eastward flow is supposed to be varied with the wind-system and sea conditions at the time, the eastward flow itself may be a portion of eddies near the southern boundary of the North Equatorial Current. The main axis of the westward flow was noted to be situated near 09°–30′N and 11°–45′N in 1977, and near 09°–30′N in 1978 and 1979. The maximum

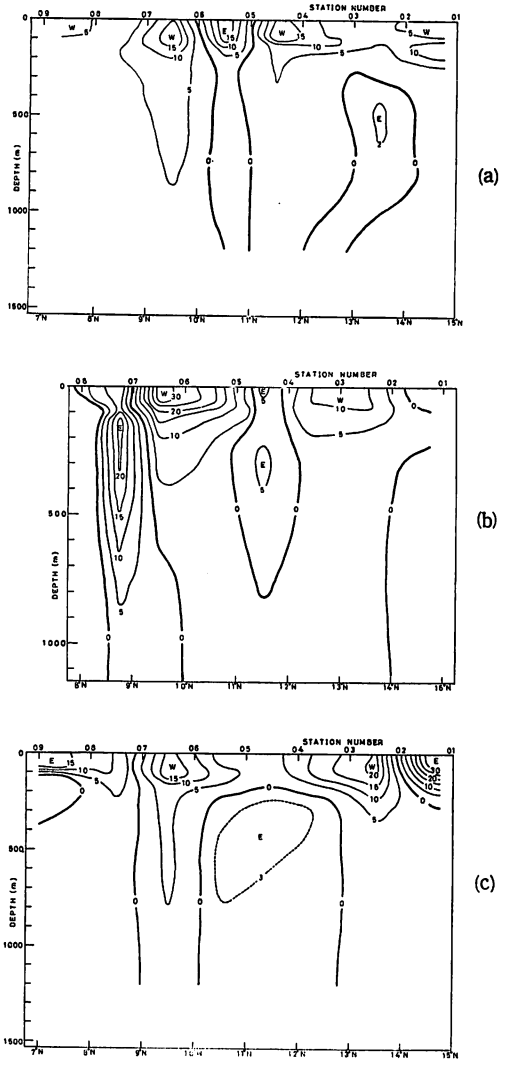

Fig. 4. The east-west component of the geostrophic current referred to 1,200 m depth in summer of 1977 (a), 1978 (b) and 1979 (c).

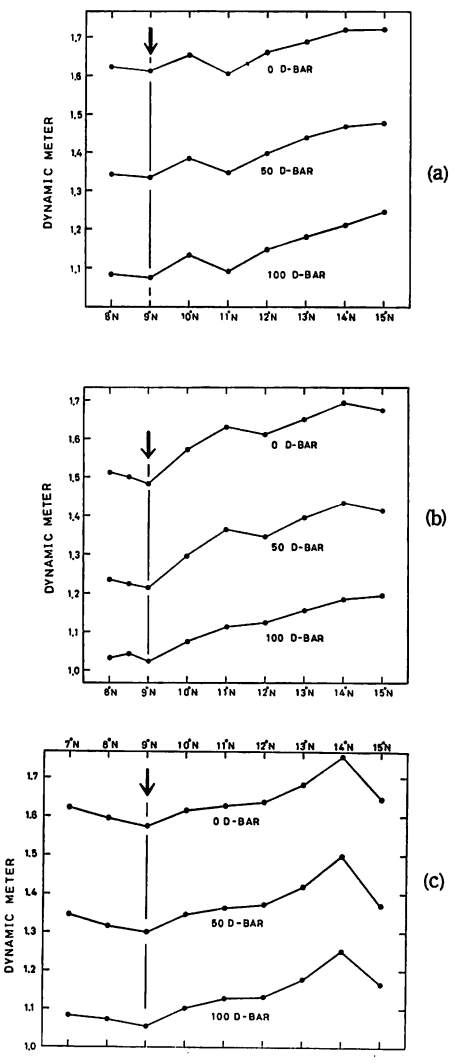

Fig. 5. Profiles of isobaric surfaces referred to 1000-decibar surface in summer of 1977 (a), 1978 (b) and 1979 (c).

velocity of the westward flow was 33 cm/sec in 1978, and 20 cm/sec in 1977 and 1979. The southern boundary of the North Equatorial Current was assumed to lie at a station where the geopotential was at the minimum. As is shown by arrows in Fig. 5, the southern boundaries of the North Equatorial Current in 1977, 1978 and 1979 were estimated to be situated near 09°N. But according to Fig. 4 (a), it is unreasonable to estimate that the southern boundary of the North Equatorial Current in 1977 was situated near 09°N, because the westward flow was found near 09°N. Judging from the shape of isotherm distribution (Fig. 2, a), the southern boundary

of the North Equatorial Current in 1977 was supposed to be situated south of 07°N; however, the detailed discussion of the oceanographic conditions in the southern region of 07°N can not be carried out because of the lack of the systematic observations in our research. On the other hand, in the current velocity cross section (Fig. 4, b, c) the westward flow was noted to be contacted with the eastward flow near 09°N, accordingly the southern boundary of the North Equatorial Current in 1978 and 1979 was estimated to be situated near 09°N. This result is in agreement with the one estimated from the isotherm distribution in Chapter 1.

4. Zooplankton

The distribution of the zooplankton during summers of the three years, 1977–1979, is shown in Fig. 6. The rates of the appearance of the respective species are tabulated in Table 2. The zooplankton communities in this region were represented by the species of *Copepoda*, *Radiolaria*, *Appendicularia*, *Ceratium* and *Foraminifera*. The numerical value of the zooplankton appearance per cubic meter throughout the three years was noted to be 545 individuals as maximum, and 37 individuals as minimum. The average individuals in the appearance in 1977, 1978 and 1979 were 252, 270 and

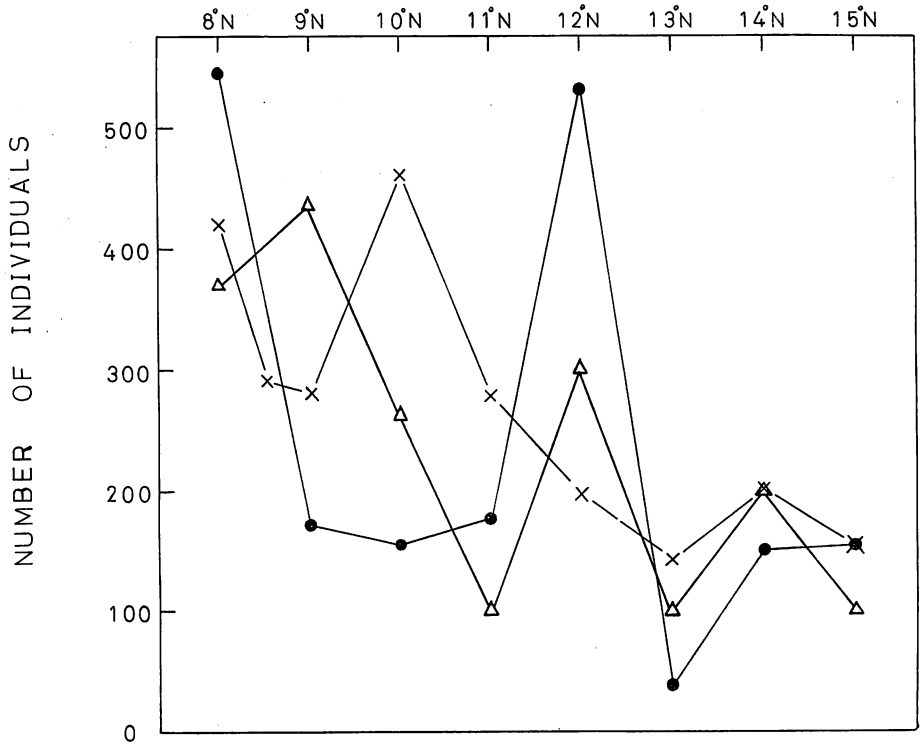

Fig. 6. Distribution of zooplankton per cubic meter. Symbols: dots, 1977; crosses, 1978; triangles, 1979.

Table 2. The rate of appearance of the zooplankton (%).

	1977	1978	1979
Copepoda	57	53	60
Radiolaria	12	16	11
Appendicularia	8	11	7
Ceratium	10	10	9
Foraminifera	7	2	8
Others	6	8	5

229, respectively. The total number of the zooplankton appearance was confirmed to be large in 1978 and small in 1979. As is evident in Table 2, *Copepoda* occupies the greater part of the zooplankton, next comes *Radiolaria*. The appearance rates of *Appendicularia*, *Ceratium* and *Foraminifera* were small, especially the number of *Foraminifera* was quite small in 1978. In general, it was well known that the plankton communities are far more abundant in the cold water at the high latitude than in the warm water at the tropical region. However, in the present study the total number of zooplankton is small north of 13°N, having a tendency to increase as it approaches the low latitude. Especially, the total number of zooplankton was quite large in the area of divergence, corresponding to the boundary between the North Equatorial Current and the Equatorial Countercurrent. It was left unconfirmed whether the greater production of zooplankton in the area of divergence was caused by the surface temperature or due to some other factors, important yet unknown, but at least it may be assumed that it resulted from the nutrient-salt brought to the surface by the action of an upwelling. On the other hand, the surface temperature and salinity were supposed to have some relationships with the zooplankton community, owing to the fact that the value of the surface temperature and salinity in 1979 was lower than those in 1977 and 1978, and the total number of zooplankton in 1979 was smaller as compared with those in 1977 and 1978. But further systematic research will be necessary to make any further studies on the correlationship between the oceanographical environment and the zooplankton community.

4. Summary

The oceanographical research was carried out in the southern region of the Hawaiian Islands during the summers of 1977–1979. The results obtained are summarized as follows:

1) South of 09°N, the surface temperatures in the three years were noted to be almost equal. The surface temperatures in 1977 and 1978 decreased gradually toward the north from 09°N. On the other hand, the surface temperature in 1979 decreased abruptly toward the north from 09°N, accordingly a discontinuous distribution of the surface temperature was supposed to exist near 10°N.

2) The depth of the thermocline, centered at 19°C to 20°C, was in a layer at a depth of about 125 m near 15°N, and about 90 m near 08°N, becoming gradually shallower toward the equator from the north. The thermocline, the center of which is shallowest, was situated near 11°N in 1977 and near 09°–30′N in 1978 and 1979. The vertical gradient of temperature in the thermocline was largest att he section where the depth of the thermocline was shallower and its numerical value was ca. 0.20°C/m, and was almost equal throughout the three years.
3) Below the thermocline, the upwelling was suspected to have taken place near 12°N and 13°N.
4) South of 09°N, the surface salinity were almost equal throughout the three years, decreasing north of 10°N. Concerning the variations in the value of maximum and minimum surface salinity the one in 1979 was the largest, its numerical value being ca. 0.40‰.
5) A tonguelike protuberance of salinity higher than 35.00‰ extending from the north was found in a layer at a depth of about 150 m. The locations of the high salinity were variable due to over the years.
6) The salinity water lower than 34.50‰ extending from the north was found near 15°N in a layer at a depth of about 250 m, the depth of the low salinity water becoming shallower gradually toward the south. The water with a salinity of 34.70‰ extending from the south was found near 08°N in a layer at a depth of about 250 m, the locations of water shifted somewhat to the south from year to year.
7) The main axis of the eastward flow was situated near 10°–30′N in 1977, near 08°–45′N in 1978, and 07°–15′N in 1979. The main axis of the westward flow was situated near 09°–30′N and 11°–45′N in 1977, and near 09°–30′N in 1978 and 1979.
8) The maximum velocity of the eastward flow and the westward flow, were 23 cm/sec and 33 cm/sec, respectively. It was larger in 1978 than those in 1977 and 1979.
9) It was estimated that the boundary between the North Equatorial Current and the Equatorial Countercurrent was situated south of 07°N in 1977, and near 09°N in 1978 and 1979.
10) *Copepoda* occupies the greater part of the zooplankton, next comes *Radiolaria*. The numbers of *Appendicularia*, *Ceratium* and *Foraminifera* are small. The numerical value of the zooplankton appearance per cubic meter throughout these three years was noted to be 545 individuals as maximum, and 37 individuals as minimum. The average individuals of the zooplankton in 1977, 1978 and 1979 were 252, 270 and 229, respectively. The total number of zooplankton has a tendency to increase as it approached the low latitude, especially large in the area of divergence.

References

GRAHAM, H. W. (1941): Plankton Production in relation to character of water in the open Pacific. *J. Mar. Res.*, **4**, 189–197.

HENMI, T. (1976): The oceanographical research in the Northeastern Pacific — 1. *Mem. Fac. Fish., Kagoshima Univ.*, **25** (1), 161–180.

HENMI, T. (1977): The oceanographical research in the Northeastern Pacific — 2. *Mem. Fac. Fish., Kagoshima Univ.*, **26**, 227–248.

HILL, M. N. ed., (1963): The sea Vol. **2**. *Interscience, New York*. 235–252.

KNAUSS, J. A. Equatorial Current systems.

MONTGOMERY, R. B. (1954): Analysis of a Hugh M. Smith oceanographic section from Honolulu southward across the equator. *Jour. Mar. Res.*, **13**, 67–75.

MONTGOMERY, R. B. and E. D. STROUP (1962): Equatorial waters and currents at 150°W in July-August 1952. *John Hopkins Oceanographic studies*, No. **1**, 7–68.

MASUZAWA, J. (1964): Flux and water characteristics of the Pacific North Equatorial Current. *Studies on oceanography, Tokyo*. 121–128.

MASUZAWA, J. (1967): An Oceanographic Section from Japan to New Guinea at 137°E in January 1967. *Oceanogr. Mag.* **19**, (2), 95–118.

REID, J. L. JR. (1965): Intermediate waters of the Pacific Ocean. *Johns Hopkins Oceanographic Studies*, No. **2**, 7–85.

SVERDRUP, H. U., M. W. JOHNSON and R. H. FLEMING (1942): The ocean. Their physics, chemistry and general biology. *Prentice-Hall, New York*. 605–761.

YAMANAKA, H., N. ANRAKU and J. MORITA (1965): Seasonal and long-term variations in oceanographic conditions in the western North Pacific Ocean (in Japanese). *Rep. Nankai Regional Fish. Res. Lab.*, **22**, 35–70.

YUWAKI, Y. and T. HENMI (1978): The oceanographical research in the southern region of the Hawaiian Islands — 1. *Mem. Fac. Fish., Kagoshima Univ.*, **27** (1), 259–272.

YUWAKI, Y. and T. HENMI (1979): The oceanographical research in the southern region of the Hawaiian Islands — 2. *Mem. Fac. Fish., Kagoshima Univ.* **28**, 217–233.

Appendix

Appendix 1. S. T. D. data.

Depth	Station 1 Lat. 15°-03′.5N Long. 155°-51′.9W May. 11, 1979 Temp. (°C)	Salinity (‰)	Station 2 Lat. 14°-07′.2N Long. 156°-11′.8W May. 12, 1979 Temp. (°C)	Salinity (‰)	Station 3 Lat. 13°-06′.4N Long. 156°-08′.5W May. 13, 1979 Temp. (°C)	Salinity (‰)
0	25.17	34.24	25.52	34.33	25.52	34.23
10	25.17	34.24	25.50	34.33	25.52	34.23
30	24.16	34.24	25.50	34.34	25.52	34.24
50	23.50	34.27	25.51	34.34	25.52	34.24
75	22.50	34.48	25.43	34.40	24.45	34.18
100	20.50	34.84	23.53	34.83	22.67	34.68
125	19.70	35.04	22.56	34.92	20.53	34.79
150	17.05	35.03	19.83	34.91	17.94	34.64
200	12.67	34.40	15.32	34.43	13.37	34.39
250	10.70	34.28	11.60	34.40	10.11	34.35
300	9.52	34.37	9.83	34.46	9.22	34.45
350	8.75	34.47	8.92	34.50	8.64	34.52
400	8.00	34.47	8.32	34.51	8.16	34.55
500	7.34	34.49	7.26	34.52	7.06	34.52
600	6.10	34.48	6.49	34.53	6.34	34.51
700	5.50	34.48	5.82	34.53	5.72	34.52
800	5.00	34.50	5.22	34.53	4.90	34.52
1000	4.25	34.53	4.30	34.54	4.20	34.55
1200	3.78	34.55	3.70	34.57	3.45	34.58

	Station 4 Lat. 11°-54′.8N Long. 156°-02′.4W May. 14, 1979 Temp. (°C)	Salinity (‰)	Station 5 Lat. 11°-00′.3N Long. 155°-59′.0W May. 15, 1979 Temp. (°C)	Salinity (‰)	Station 6 Lat. 9°-59′.6N Long. 155°-59′.7W May. 15, 1979 Temp. (°C)	Sailnity (‰)
0	25.86	34.29	25.62	34.23	26.39	34.40
10	25.86	34.29	25.61	34.23	26.38	34.40
30	25.87	34.29	25.62	34.23	26.38	34.40
50	25.87	34.29	25.58	34.24	26.37	34.39
75	24.58	34.16	24.75	34.30	25.20	34.12
100	21.59	34.67	21.22	34.90	21.15	34.78
125	18.40	34.62	18.65	34.85	18.22	34.69
150	15.07	34.53	15.40	34.54	13.06	34.45
200	11.50	34.30	11.67	34.59	11.10	34.70
250	9.93	34.41	10.40	34.66	10.26	34.72
300	9.67	34.59	9.82	34.67	9.69	34.70
350	9.01	34.59	9.11	34.62	9.19	34.66
400	8.51	34.58	8.77	34.61	8.68	34.64
500	7.29	34.55	7.72	34.57	7.73	34.60
600	6.34	34.52	6.75	34.54	6.88	34.55
700	5.76	34.52	5.95	34.53	6.11	34.54
800	5.07	34.52	5.34	34.54	5.55	34.54
1000	4.23	34.54	4.39	34.56	4.49	34.55
1200	3.55	34.57	3.64	34.58	3.74	34.58

Appendix 1. (Continued)

Depth	Station 7 Lat. 9°–00′.2N Long. 155°–59′.5W May. 15, 1979 Temp. (°C)	Salinity (‰)	Station 8 Lat. 7°–59′.8N Long. 156°–00′.0W May. 15, 1979 Temp. (°C)	Salinity (‰)	Station 9 Lat. 7°–00′.3N Long. 155°–58′.9W May. 16, 1979 Temp. (°C)	Salinity (‰)
0	27.39	34.72	27.48	34.66	27.74	34.80
10	27.38	34.71	27.48	34.66	27.74	34.80
30	27.36	34.72	27.49	34.66	27.75	34.80
50	27.36	34.71	27.49	34.66	27.75	34.80
75	25.10	34.13	26.75	34.63	27.75	34.80
100	21.35	34.60	19.80	34.70	24.40	34.74
125	14.11	34.44	15.65	34.60	16.14	34.65
150	11.88	34.69	12.39	34.58	13.23	34.58
200	10.73	34.73	11.11	34.72	10.57	34.71
250	10.12	34.72	10.27	34.72	9.84	34.71
300	9.64	34.70	9.74	34.71	9.39	34.70
350	9.21	34.67	9.26	34.68	8.94	34.67
400	8.85	34.66	8.85	34.67	8.68	34.66
500	7.92	34.62	7.98	34.61	7.88	34.61
600	6.90	34.56	7.03	34.57	6.92	34.58
700	5.99	34.54	6.09	34.56	6.16	34.56
800	5.22	34.54	5.43	34.56	5.48	34.55
1000	4.31	34.57	4.47	34.57	4.63	34.56
1200	3.72	34.59	3.80	34.58	3.81	34.58

Appendix 2. Individual number of zooplankton per cubic meter.

Date	May 11, 1979	May 12, 1979	May 13, 1979	May 14, 1979
Station No.	1	2	3	4
Latitude	15°–03′.5N	14°–07′.2N	13°–06′.4N	11°–54′.8N
Longitude	155°–51′.9W	156°–11′.8W	156°–08′.5W	156°–02′.4W
Copepoda	62	107	79	117
Radiolaria	26	75	17	15
Appendicularia	7	13	16	10
Pteropoda	2	2	—	3
Thaliacea	1	1	1	1
Ceratium	10	17	7	17
Ostracoda	5	4	1	1
Chaetognatha	3	5	4	5
Polychaeta	1	—	—	1
Foraminifera	12	33	27	26
Decapoda larva	1	2	1	3
Total	100	200	100	300

Date	May 15, 1979	May 15, 1979	May 15, 1979	May 15, 1979
Station No.	5	6	7	8
Latitude	11°–00′.3N	09°–59′.6N	09°–00′.2N	07°–59′.8N
Longitude	155°–59′.0W	155°–58′.7W	155°–59′.5W	156°–00′.0W
Copepoda	47	165	264	273
Radiolaria	14	14	22	11
Appendicularia	—	27	68	28
Pteropoda	8	1	4	2
Thaliacea	—	1	1	—
Ceratium	4	19	35	14
Ostracoda	2	3	2	5
Chaetognatha	2	4	12	6
Polychaeta	—	—	1	1
Foraminifera	7	16	19	14
Decapoda larva	1	—	1	4
Total	100	250	429	358