

The Oceanographic Condition along 131°E from 30°N to 15°N in June, 1989

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Abstract

The CTD observations were carried out along 131°E from 30°N to 15°N in the Northwestern Pacific from the 10th to 14th of June, 1989.

Vertical sections of water temperature, salinity and dynamic height along 131°E were described, and some representative temperature-salinity relations were drawn from CTD records. The condition of temperature distribution section was related to the existence of the zonal currents. These currents along section from the north to the south were the Kuroshio, the Kuroshio Countercurrent, the Subtropical Countercurrent, the northern part of the North Equatorial Current and the easterly current near 18°N. Numerous small step-like and inversion features were existed in the temperature-salinity relations above 15°C, which showed the existence of surface water mixing.

The oceanic condition in the tropical and subtropical western boundary area of the North Pacific Ocean seems very important for studying of the tuna and skipjack fishing grounds, the Subtropical Ocean circulation system and world's climate changes. For the progress of these studies, the accumulation of oceanographic data is indispensable in the area under consideration.

The Keiten Maru (G.T. 860 tons), fishing training ship of the Kagoshima University has been oceanographic works in her yearly training cruise since 1978. Recently, Masumitsu¹⁾ described some transequatorial CTD sections in the Western Pacific. Yuwaki²⁾ *et al.* also reported the oceanographic conditions in the Western Tropical Pacific. In 1989, we had the cruise for cadets training from Kagoshima, Japan to Jakarta, Indonesia. On the way to Jakarta, the oceanographic observations and tuna long-line fishing were carried out from the 10th of June through the 15th of July.

The present paper describes the oceanographic conditions along 131°E from 30°N to 15°N observed by CTD casts.

Among many oceanographic studies in the Subtropical and Tropical Western Pacific Ocean published in the past, "Beginning of the Kuroshio" by Nitani³⁾ was typical of the general oceanographic description, and "The 137°E oceanographic section" by Masuzawa and Nagasaka⁴⁾ was another outstanding oceanographic study in year to year variations.

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CTD Observations

Fig. 1 shows the locations of oceanographic observations along 131°E in the Northwestern Pacific. The oceanographic observations were made at 16 stations on each whole degree of lat. 30°N–15°N along long. 131°E from the 10th (St. 1) to 14th (St. 16) of June. The first and last stations were the odd lat., 29°–54.9'N, 15°–30.0'N respectively. The distance between two stations was 60 miles with a few exceptions.

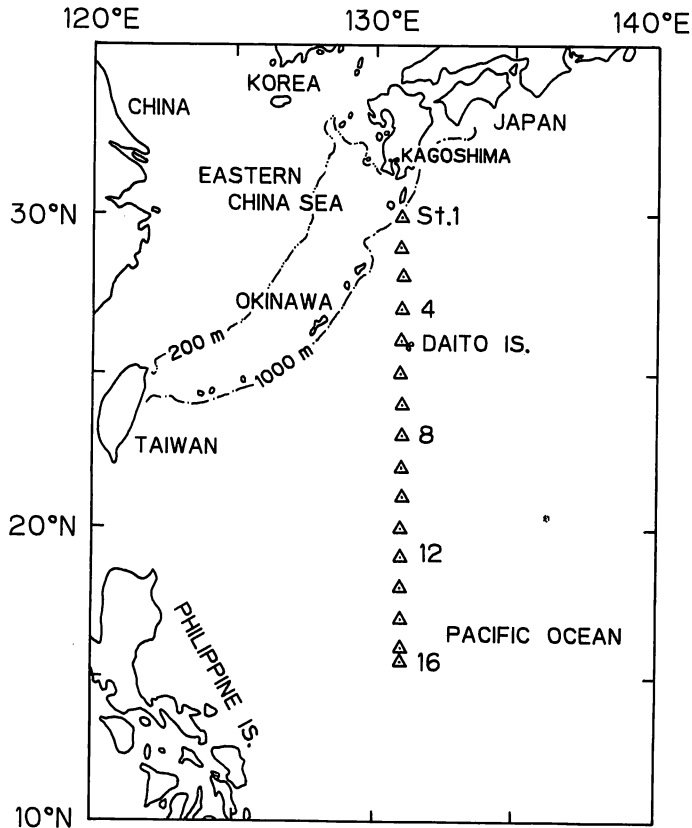


Fig. 1. CTD stations along 131°E from 30°N to 15°–30.0'N.

The oceanographic observations were carried out by CTD system (Neil Brown System Inc., Model 1150). The water temperature and conductivity for pressure were recorded on the magnetic tape, and printed on the recording paper. The CTD cast down to the maximum depth of 1200 dbar.

The values of temperature and salinity at the international oceanographic depth (pressure dbar) were read from the CTD records, and tabulated in Appendix.

Results and Discussion

Vertical section of temperature

Fig. 2 shows the distribution of water temperature in the vertical section drawn from the data in Appendix.

The surface water temperatures were higher than 30.0°C at the area between Sts. 10 and 14, and at St. 16. The highest surface temperature was 30.83°C at St. 12(19°N) and 30.36°C at St. 16 (15°-30.0N).

The strong down slope of isotherms from the north to the south was found in the entire layer in the area between 30°N and 27°N; this was associated with the Kuroshio. The up slope of isotherms from the north to the south around at 26°N showed the existence of the Kuroshio countercurrent.

The other remarkable structure of temperature distribution was the isotherm spreading of 21°C and 19°C, which indicated the existence of the Subtropical Mode Water. From 22°N to 15°N, isotherms in the layer from the surface to 600 m were almost flat, indicating no existence of strong zonal currents.

Vertical section of salinity

Fig. 3 shows the distribution of salinity in the vertical section drawn from the data in Appendix.

The less salinities lower than 34.2‰ were observed at the sea surface at Sts. 1, 4, 10-12, and 14-15. Among the less saline surface water, the lowest value was 33.67‰ at the sea surface of St. 1

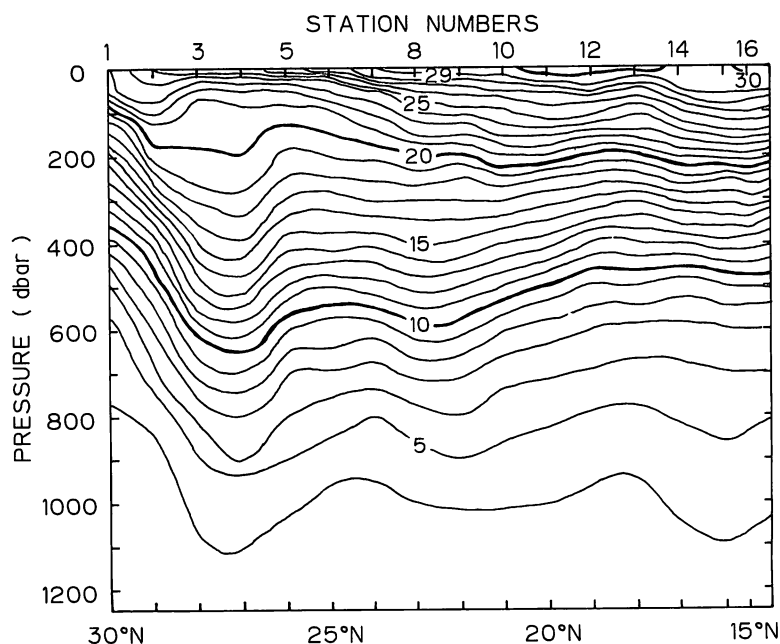


Fig. 2. Distribution of water temperature (°C) in the vertical section.

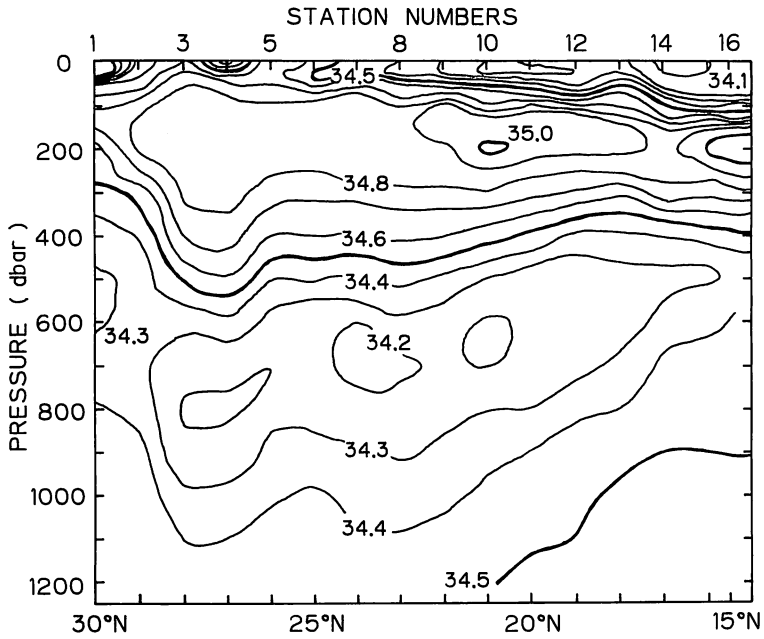


Fig. 3. Distribution of salinity (%) in the vertical section.

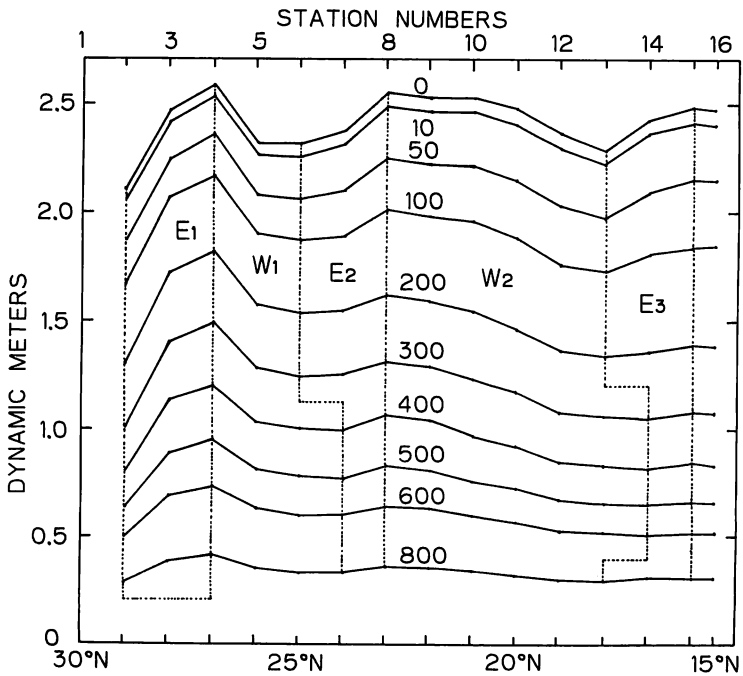


Fig. 4. Dynamic topography (dynamic meters) referred to 1000 dbar.

Below the surface water, the subsurface saline water having a salinity higher than 34.8‰ was noted in the layer 100–300 m deep. This subsurface saline water penetrated from the south with the highest salinity of 35.0‰ at 21°N and 15°N. Below the subsurface saline water, the halocline between 34.7‰ and 34.4‰ was found in the entire section. In the Kuroshio and the Kuroshio Countercurrent area, the strong slope of halocline appeared with the thermocline.

Below the halocline, the intermediate water characterized by the low saline water less than 34.3‰ appeared in the layer 500–800 m deep. The intermediate water deepened at 28°N–27°N, and then it shallowed toward the south.

Dynamic Height Section

Fig. 4 shows the dynamic height section referred to 1000 dbar, in order to describe the distribution of zonal currents in the section.

In this figure, E_1 , E_2 , E_3 and W_1 , W_2 indicate eastward and westward components of the current perpendicular to the section.

The eastward currents, E_1 and E_2 indicate the Kuroshio and the Subtropical Countercurrent respectively. According to Uda and Hasunuma⁵⁾, the Subtropical Countercurrent was found at 100–200 m near the Tropic of Cancer and marked the line of demarcation between the Subtropical Mode Water on the north and the Tropical Water on the south. E_3 might be indicated to the easterly current near 18°N with the warm core like a belt on the right-hand side of the North Equatorial Current (NEC), as pointed out by Nitani³⁾.

The westward currents, W_1 and W_2 indicated the Kuroshio Countercurrent and the northern part of the NEC. According to Nitani³⁾, the NEC carried the North Tropical Water to the west, which became one of the main water mass of the Kuroshio.

Temperature-Salinity relations

Fig. 5 shows the Temperature-Salinity (T-S) relations at stations 1, 3, 5, 7 and 11 based on the CTD records.

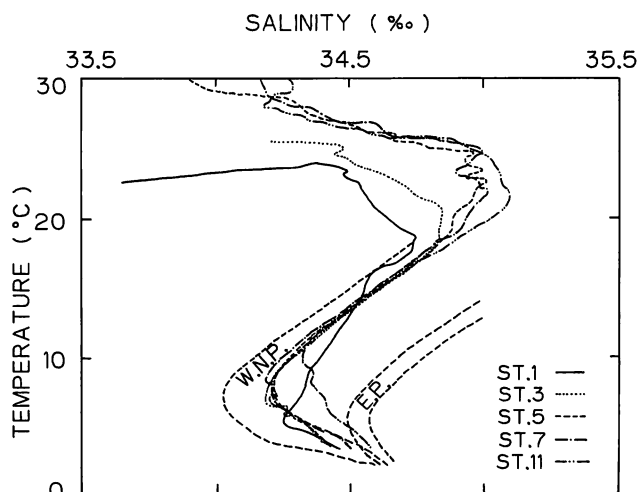


Fig. 5. Temperature-Salinity (T-S) diagrams at St. 1 (30°N), St. 3(28°N), St. 5(26°N), St. 7(24°N), and St. 11(20°N).

Numerous small step-like and inversion features were existed in all T-S curves above 15°C; this showed the existence of mixing of water in the surface layer, though such features could not be seen in the temperature section.

The water having the salinity range of 34.728–35.004‰ and the temperature range of 17.70–22.21°C was the Subtropical Subsurface Water, which existed 125–200 m deep.

All curves in Fig. 5, converged to temperatures 13–14°C, and salinities 34.4–34.6‰. This uniform water might correspond to the Western North Pacific Central Water (Sverdrup *et al.*⁶⁾. The water with the minimum salinity (34.2‰) corresponded to the North Pacific Intermediate Water.

Below the salinity minimum, T-S relations approached the deep water in the Pacific Ocean.

Summary

The following are based on shipboard preliminary processing of the data from CTD observations from the 10th to 14th of June 1989 in the Northwestern Pacific Ocean.

Along 131°E, the structures of water temperature and salinity were described. The Subtropical Mode Water characterized by the isotherms spreading of 21–19°C was clearly found in the region of the Kuroshio and the Kuroshio Countercurrent. From 25°N to 15°N, the isotherms and the isohalines were almost flat along the section, showing that no strong zonal currents perpendicular to the section.

The currents along 131°E from the north to the south were the Kuroshio and the Kuroshio Countercurrent, the Subtropical Countercurrent, the northern part of the North Equatorial Current and the easterly current near 18°N.

The T-S relations by CTD records indicated numerous small step-like and inversion layers. These structures might be attributed to the mixing condition in the surface layer.

The oceanographic structure of the surface water was important to study the fishing ground and the air-sea interaction in earth science. The detailed structure in the surface water will be analyzed in the further processing.

Acknowledgements

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References

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Appendix

Date	June 10, 1989		June 11, 1989		June 11, 1989	
Stn.	1		2		3	
Lat.	29°-54.9'N		29°-00.0'N		28°-00.0'N	
Long.	131°-00.0'E		131°-00.3'E		131°-00.2'E	
	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)
0	23.17	33.670	32.98	34.426	25.98	34.585
10	23.49	32.133	24.97	34.425	25.78	34.578
20	23.40	31.702	24.65	34.448	23.91	34.614
30	22.75	33.807	23.94	34.448	22.43	34.701
50	22.75	34.507	23.82	34.519	21.70	34.788
75	20.83	34.602	22.89	34.653	20.66	34.840
100	19.47	34.682	21.96	34.768	20.56	34.845
150	17.00	34.704	20.59	34.833	20.25	34.850
200	14.90	34.562	19.38	34.820	19.75	34.850
250	13.40	34.527	17.59	34.712	19.31	34.847
300	12.05	34.470	15.02	34.517	18.09	34.828
400	8.72	34.344	10.70	34.414	15.90	34.707
500	6.11	34.289	8.79	34.359	13.41	34.520
600	4.66	34.289	7.11	34.338	10.47	34.323
700	4.21	34.350	5.73	34.334	8.21	34.250
800	3.84	34.406	4.19	34.383	6.05	34.180
900	3.40	34.438	3.58	34.424	4.93	34.248
1000	3.11	34.473	3.15	34.467	4.31	34.324
1200			2.64	34.520	3.37	34.442

Date	June 11, 1989		June 11, 1989		June 12, 1989	
Stn.	4		5		6	
Lat.	27°-00.0'N		25°-59.9'N		25°-00.0'N	
Long.	131°-00.0'E		130°-59.9'E		130°-59.9'E	
	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)
0	25.56	34.218	26.65	34.729	27.24	34.574
10	25.18	34.488	24.84	34.699	26.44	34.574
20	24.07	34.511	24.54	34.678	24.37	34.523
30	23.56	34.564	23.04	34.651	24.05	34.499
50	22.13	34.726	22.00	34.685	23.20	34.563
75	21.22	34.803	21.23	34.736	21.90	34.726
100	20.75	34.841	20.44	34.828	20.70	34.831
150	20.42	34.851	19.55	34.841	19.82	34.840
200	20.00	34.846	18.60	34.825	18.82	34.833
250	19.28	34.840	17.91	34.819	17.85	34.806
300	18.74	34.839	16.81	34.768	16.49	34.731
400	16.72	34.762	14.47	34.602	14.44	34.598
500	14.47	34.594	11.69	34.413	11.84	34.406
600	11.30	34.380	9.04	34.242	8.61	34.218
700	8.73	34.228	6.90	34.203	7.07	34.221
800	6.96	34.183	5.92	34.293	5.47	34.269
900	6.01	34.263	4.97	34.308	4.39	34.326
1000	4.71	34.329	4.19	34.376	3.62	34.424
1200	3.38	34.443	2.96	34.493	2.96	34.483

Date	June 12, 1989		June 12, 1989		June 12, 1989	
Stn.	7		8		9	
Lat.	24°-00.0'N		23°-00.1'N		21°-59.9'N	
Long.	131°-00.1'E		130°-59.9'E		131°-00.1'E	
	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)
0	28.91	34.464	29.63	34.413	29.96	33.893
10	28.89	34.460	28.82	34.362	29.10	34.006
20	27.74	34.444	28.34	34.342	28.65	34.175
30	27.48	34.480	28.10	34.363	27.32	34.361
50	23.80	34.654	26.09	34.601	26.38	34.540
75	23.00	34.835	24.58	34.662	25.36	34.739
100	22.04	34.820	23.90	34.803	24.50	34.961
150	20.52	34.889	22.40	34.849	22.21	34.993
200	19.12	34.849	20.12	34.863	19.83	34.885
250	18.14	34.830	18.52	34.861	18.12	34.841
300	17.19	34.789	17.10	34.784	17.09	34.787
400	14.24	34.576	14.90	34.620	14.80	34.619
500	11.33	34.373	12.48	34.433	11.87	34.384
600	8.35	34.199	9.54	34.267	9.25	34.242
700	6.41	34.166	7.21	34.187	7.14	34.207
800	4.96	34.237	5.55	34.220	5.84	34.277
900	4.16	34.319	4.50	34.288	4.97	34.323
1000	3.71	34.369	3.88	34.355	3.94	34.382
1200	2.94	34.475	3.10	34.460	3.13	34.466

Date	June 13, 1989		June 13, 1989		June 13, 1989	
Stn.	10		11		12	
Lat.	20°-59.9'N		20°-00.2'N		19°-00.1'N	
Long.	131°-00.0'E		130°-59.8'E		130°-59.9'E	
	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)
0	29.76	34.201	30.49	34.226	30.70	34.208
10	28.89	34.186	30.18	34.190	30.08	34.198
20	28.60	34.158	29.90	34.174	29.88	34.203
30	28.52	34.168	29.25	34.194	29.34	34.209
50	27.21	34.542	27.17	34.413	28.34	34.250
75	25.59	34.636	26.32	34.634	26.20	34.441
100	24.68	34.703	25.62	34.822	25.43	34.722
150	23.39	34.940	23.27	34.911	22.29	34.842
200	21.14	35.023	20.95	34.974	19.70	34.939
250	18.88	34.903	18.14	34.831	17.44	34.807
300	17.14	34.788	16.43	34.739	15.99	34.711
400	14.00	34.540	13.41	34.492	11.71	34.380
500	10.82	34.317	9.84	34.242	8.72	34.225
600	7.91	34.191	7.54	34.212	7.02	34.218
700	6.32	34.190	6.17	34.247	5.71	34.283
800	5.27	34.299	5.17	34.296	4.86	34.378
900	4.75	34.383	4.42	34.397	4.31	34.445
1000	4.05	34.417	3.95	34.464	3.65	34.483
1200	3.13	34.485	2.98	34.516	2.87	34.540

Date	June 13, 1989		June 14, 1989		June 14, 1989	
Stn.	13		14		15	
Lat.	18°-00.1N		16°-59.1N		15°-59.9N	
Long.	131°-00.0E		130°-00.3E		130°-59.9E	
	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)	Temp. (°C)	Sal. (‰)
0	30.36	34.268	29.76	34.090	29.79	34.099
10	30.17	34.259	29.65	34.100	29.69	34.099
20	28.82	34.281	29.59	34.099	29.64	34.100
30	27.83	34.364	29.48	34.103	29.54	34.083
50	26.55	34.469	28.94	34.170	29.31	34.147
75	25.25	34.670	27.10	34.369	28.37	34.211
100	24.19	34.731	25.93	34.547	26.76	34.353
150	22.54	34.981	23.64	34.792	24.46	34.906
200	19.56	34.927	21.20	34.848	21.56	35.007
250	17.52	34.811	18.62	34.850	18.21	34.852
300	15.11	34.622	16.46	34.739	16.26	34.722
400	11.85	34.392	11.98	34.399	12.43	34.427
500	9.09	34.249	8.38	34.272	8.80	34.251
600	6.78	34.206	6.79	34.355	6.95	34.315
700	5.67	34.315	5.68	34.418	5.90	34.405
800	4.77	34.402	5.07	34.471	5.21	34.458
900	4.15	34.461	4.55	34.510	4.68	34.499
1000	3.62	34.521	4.09	34.537	4.20	34.532
1200	2.97	34.576	3.44	34.567	3.44	34.569

Date	June 14, 1989	
Stn.	16	
Lat.	15°-30.0N	
Long.	130°-59.9E	
	Temp. (°C)	Sal. (‰)
0	30.36	34.241
10	29.88	34.240
20	29.85	34.274
30	29.76	34.268
50	29.43	34.285
75	27.88	34.179
100	26.86	34.413
150	24.87	34.929
200	21.62	35.090
250	18.85	34.949
300	16.68	34.762
400	12.47	34.426
500	9.16	34.353
600	7.15	34.400
700	6.06	34.427
800	5.12	34.468
900	4.58	34.507
1000	4.11	34.537
1200	3.40	34.568