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The Oceanographical Research in the Southern Region of the Hawaiian Islands-V

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Abstract

The oceanographical observations were made by the Keiten Maru in the southwestern waters of the Hawaiian Islands in May and June, 1981, and in May, 1982. In 1981, the remarkable upwelling was found at 20°N, 163°W, and the strong current flows southward at the eastern side of the upwelling area with a maximum velocity of about 40 cm/sec or more. The North Equatorial Current was found at south of 17.5°N along the meridional section of 166°W. It's current velocity was 15 cm/sec and it was slower than that of the northward and the southward flows on the latitudinal section of 20 °N. In 1982, no remarkable feature of oceanic structure was found along the latitudinal section of 20°N.

1. Introduction

In successive four years since summer of 1977, the Keiten Maru (G.T 860 ton), training ship of the Kagoshima University, made the meridional oceanographic sections along the meridians of 156°W and 158°W in the southern region of the Hawaiian Islands. The general features of oceanic conditions along these sections on May and June of four years, 1977–1980, were already reported in the previous papers (Yuwaki and Henmi, 1978, 1979, 1980, 1981). In summer of 1981 and 1982, the oceanographical observations were carried out by the Keiten Maru in the southwestern waters of the Hawaiian Islands to investigate relation between the tuna-fishing condition and the oceanographic one, concurrently with the training of cadets. Some oceanographic informations obtained on the bases of their data are reported here.

2. Observations

In 1981, the two oceanographic sections were made, the one was along the parallel of latitude of 20°N between 160°W and 168°W on May 9–19, the other was along the meridian of 166°W between 15°N and 20°N on June 4–9. In 1982, it was along the parallel of latitude of 20°N between 160°W and 173°W on May 10–18. The observation stations are shown in Fig. 1. The S.T.D cast down to 1,200 m at every stations.

The values of water temperature and salinity read from S.T.D recorders are tabulated in

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Appendix 1. Some direct current measurement by G.E.K were carried out at several stations.

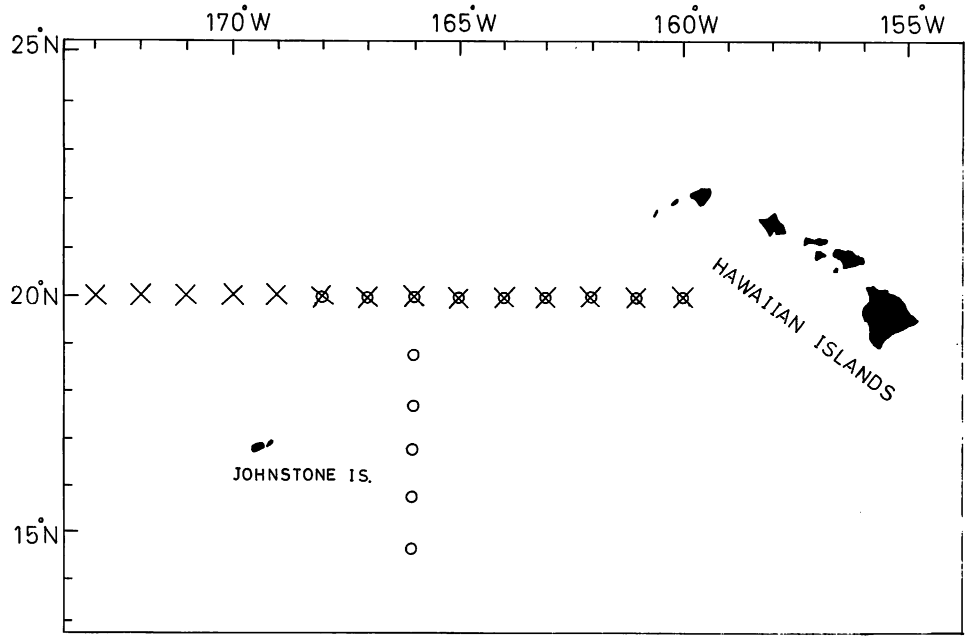
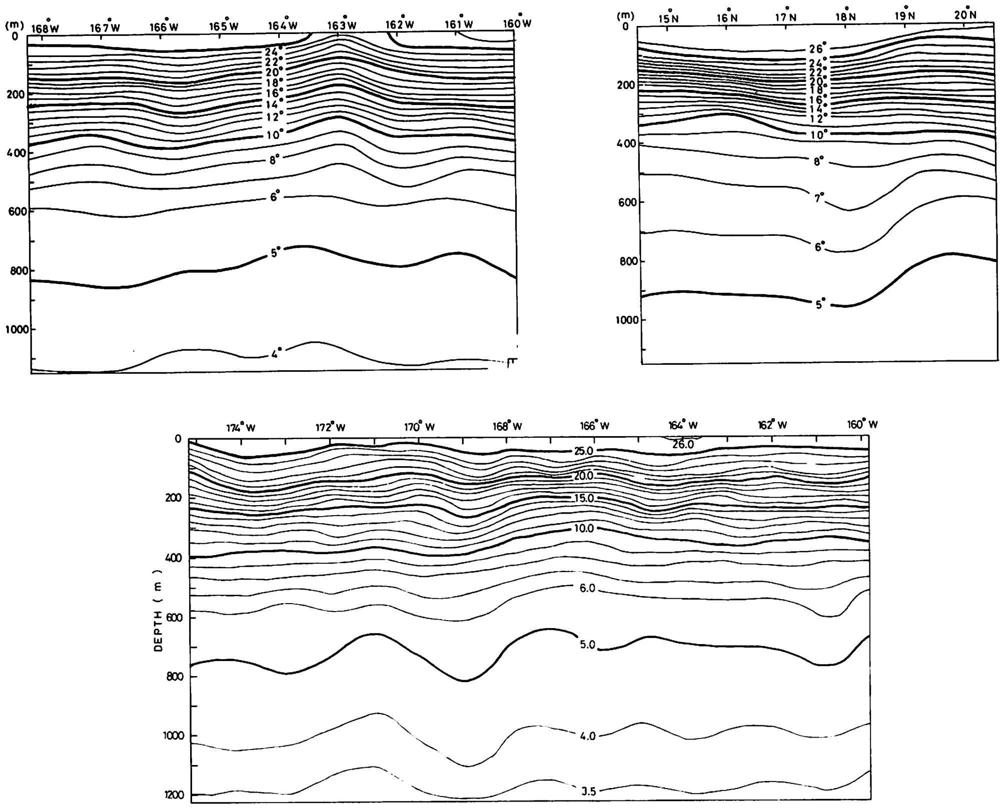


Fig. 1. Oceanographic stations of S. T. D observations in the southwestern waters of the Hawaiian Islands.
circles, 1981; cross, 1982.

3. Temperature

The vertical distributions of temperature on the section of 20°N and 166°W in May and June, 1981, and on the section of 20°N in May , 1982 are shown in Fig. 2,(a), (b), (c), respectively. On the section of 20°N in 1981 (Fig. 2,a), the remarkable convex pattern of the isotherms is found near 163°W and a good indicator of the boundary of strong current between the northward and the southward flow, it seems to be the upwelling take place. The thermocline is found in a layer between about 50 m and 350 m depth. It is shallowest at 163°W and the vertical gradient of temperature is largest here reaching about 0.05°C/m. The temperature decreases very slowly with depth below about 400 m, and it is about 4.0°C in a layer of 1,100 m depth. On the section of 166°W in 1981 (Fig. 2, b), the temperature in the surface mixed layer is about 26°C or more, being gradually increases toward the south. The large slope of the isotherms is found near 16°N corresponding to the North Equatorial Current. The largest vertical gradient of temperature is about 0.08°C/m at 16°N and it is larger than that at 20°N. The isotherms slope slightly up from 18°N toward the north below about 500 m, which may indicate the upwelling of the lower water. On the section of 20°N in 1982 (Fig. 2,c), the large slope of the isotherms is found near 170°W corresponding to strong current, and the largest vertical gradient is found near 166°W having a value of about 0.06°C/m and seems to be indicate the existence of weaker upwelling.



(c)

Fig. 2. Temperature sections on the 20°N line (a) and on the 166°W line (b) in 1981, on the 20°N line (c) in 1982.

4. Salinity

The vertical distributions of salinity on the section of 20°N and 166°W in May and June, 1981, and on the section of 20°N in May, 1982 are shown in Fig. 3, (a), (b), (c), respectively. On the section of 20°N (Fig. 3, a), the salinity maximum waters more than 35.20 ‰ comes from the Subtropical region are found in a layer of about 100m depth at the east of 162°W and the west of 165°W. There is no salinity maximum water at 163°–164°W, where the upwelling is suspected to have take place in the temperature section. On the section of 166°W in 1981 (Fig. 3, b), the salinity maximum water of about 35.00 ‰ extends toward the south in the surface layer and it reaches to near 17°N, the boundary between the eastward flow and the westward flow. The salinity maximum water has become gradually deeper toward the south and its depth is about 150 m near 17°N. According our observations between 1977 and 1980, the salinity water of about 35.00 ‰ was found at a depth of about 200m near 15°N in the meridional section of

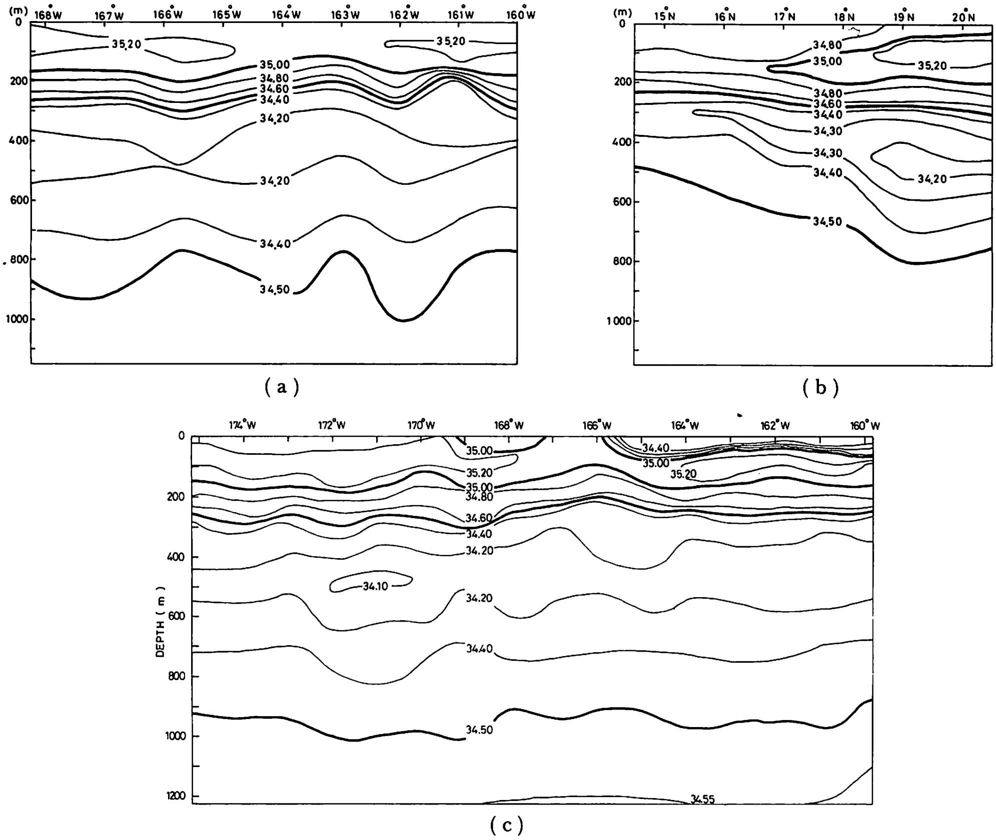


Fig. 3. Salinity sections on the 20°N line (a) and on the 166°W line (b) in 1981, on the 20°N line (c) in 1982.

158°W. North of 19°N, a salinity minimum with a salinity less than 34.20 ‰ associated with the North Pacific Intermediate Water is found in a layer between 400 m and 500 m depth. The salinity minimum extends slightly upward to the south in a layer between 300 m and 400 m depth, and a part of salinity minimum reaches to near 15°N. On the section of 20°N in 1982 (Fig. 3, c), the low salinity less than 34.50 ‰ is found in the surface of the east of 166°W, but it was not found in 1981. The salinity maximum waters more than 35.20 ‰ are found in a layer of about 100 m depth at the east of 164°W and the west of 168°W, and it is shift to the west about 150 miles compared with that in 1981.

5. Geostrophic Current

The geostrophic current are computed referred to 1,200 m depth. The velocity distributions on the section of 20°N and 166°W in May and June, 1981, and on the section of 20°N in May,

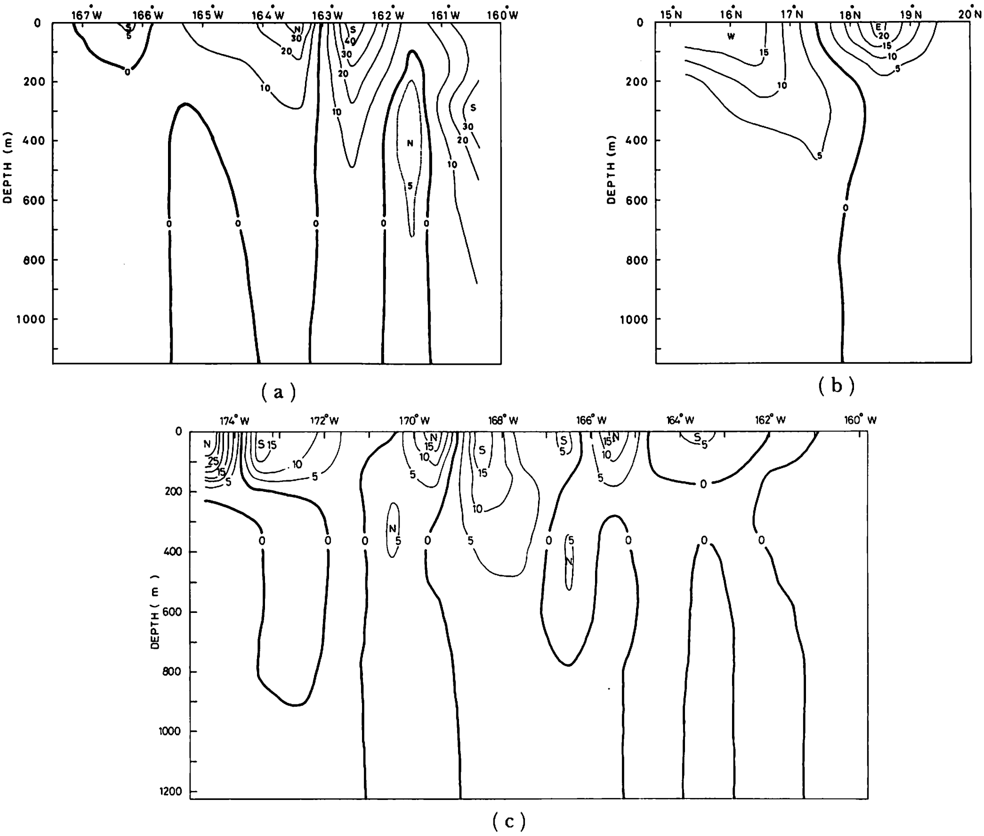
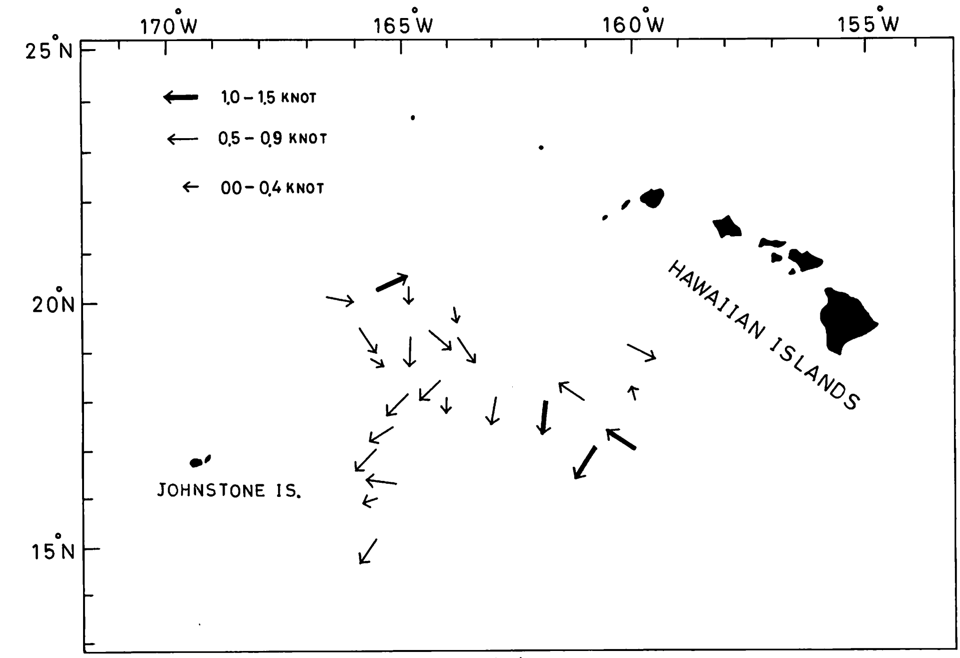
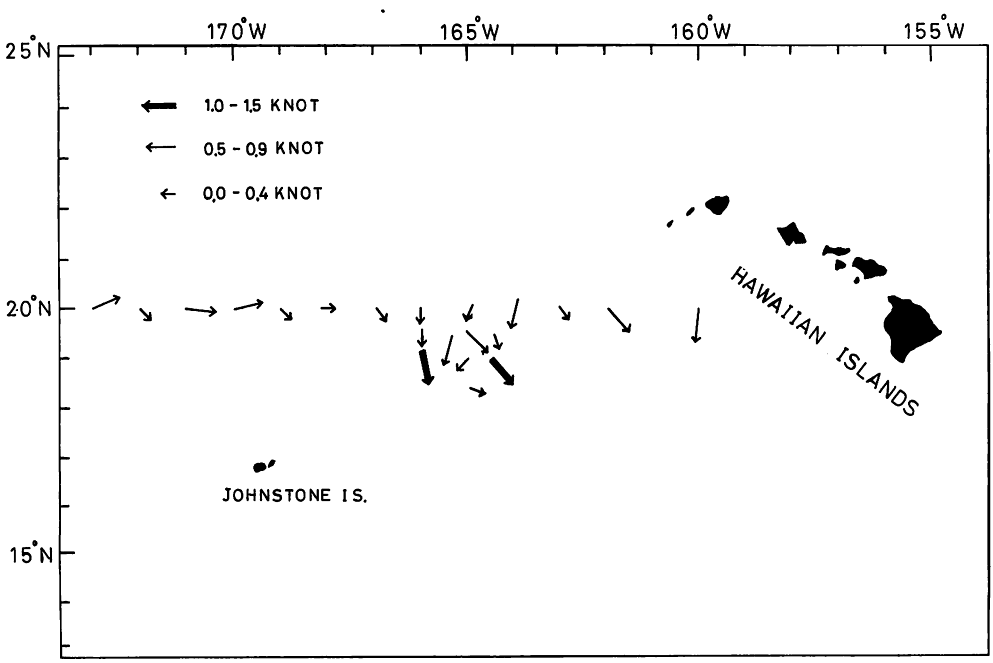


Fig. 4. Velocity sections at 20°N (a) and 166°W (b) in 1981 and at 20°N (c) in 1982.

1982 are shown in Fig. 4, (a), (b), (c), respectively. The current speeds on the latitudinal section are larger than that on the longitudinal section. The maximum speeds of the northward and the southward flow are about 0.7 knot at 163°−30′ W and 1.0 knot at 162°−30′W in 1981 (Fig. 4, a), 0.4 knot at 168°−30′ W and 169°−30′ W in 1982 (Fig. 4, c). The maximum speeds of the westward and the eastward flow are about 0.3 knot at 16°N and 0.4 knot at 18°−30′ N (Fig. 4, b). The westward flow is the North Equatorial Current and the eastward flow may be the Subtropical Counter-Current which was showed by Yoshida et al (1967). Based on the G.E.K observations in Fig. 5, (a) and (b), the surface current along the latitude of 20°N between the longitude of 167°W and 173°W flows to the east with a maximum velocity of 0.9 knot and it turns to the south near 165°W. Then, it flows to the south-southeast with a maximum velocity of about 1.4 knot and most parts of it flows to the southwest near 18°N and go round on the righthand side of the Johnstone Islands.



(a)



(b)

Fig. 5. Surface current in the southwestern waters of the Hawaiian Islands obtained by GEK observations in the summer of 1981 (a) and 1982 (b).

6. Summary

The oceanographical researchs were carried out in the southwestern region of the Hawaiian Islands in May and June, 1981, and in May, 1982. The remarkable upwelling was found at 20°N, 163°W in 1981 but it was obscure in 1982. The salinity maximum waters came from the north with a salinity of about 35.20 ‰ were separated two portions owing to the upwelling phenomenon. There were no salinity maximum waters at 163°−164°W in 1981 and 165°−167°W in 1982. The current along the parallel of latitude of 20°N flows from 173°W to the east and it turns to the southward near 165°W. Then, it flows to the south with a maximum velocity of about 40 cm/sec and joins to the North Equatorial Current. The main axis of the North Equatorial Current was located near 16°N with a maximum velocity of about 15 cm/sec. The maximum velocity of the North Equatorial Current are smaller than that of the southward flow.

Acknowledgment

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Appendix 1-1

Date	1981. 5. 9		1981. 5. 10		1981. 5. 11		1981. 5. 14		1981. 5. 18		1981. 5. 19		1981. 5. 19	
Stn	1		2		3		4		5		6		7	
Lat	20°-15′.4N		20°-09′.8N		20°-15′.4N		20°-16′.3N		20°-19′.0N		20°-15′.0N		20°-14′.9N	
Long	168°-01′.1W		166°-39′.3W		165°-43′.8W		164°-48′.8W		163°-45′.8W		163°-00′.2W		162°-00′.4W	
	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰
0	25.3	35.05	25.8	34.87	26.0	34.84	25.8	35.05	25.7	35.10	24.6	35.12	25.6	35.03
10	25.2	35.08	25.4	35.01	26.0	34.84	25.8	35.06	25.7	35.10	24.0	35.12	25.6	35.05
20	25.4	35.14	25.3	35.10	25.9	34.84	25.7	35.06	25.7	35.11	23.0	35.12	25.6	35.07
30	25.0	35.23	25.3	35.11	25.8	34.88	25.6	35.06	25.6	35.11	22.5	35.12	25.6	35.08
50	24.9	35.28	25.0	35.17	25.3	35.22	25.0	35.14	23.8	35.11	21.5	35.17	25.2	35.17
75	23.7	35.26	23.6	35.24	24.2	35.26	23.7	35.17	22.5	35.16	205	35.10	23.7	35.24
100	22.6	35.22	22.1	35.14	23.3	35.25	22.5	35.20	20.7	35.13	19.6	35.15	22.4	35.05
150	20.0	35.11	20.0	35.09	21.0	35.18	19.4	35.06	18.4	34.92	16.3	34.75	19.7	35.08
200	16.5	34.76	16.5	34.77	18.3	34.99	16.8	34.79	15.4	34.60	14.2	34.52	17.4	34.90
300	12.4	34.33	12.0	34.29	13.3	34.44	12.0	34.30	10.9	34.21	9.7	34.19	12.2	34.34
400	9.4	34.15	9.0	34.20	9.5	34.26	8.7	34.14	8.2	34.12	7.7	34.16	8.8	34.16
500	7.2	34.14	7.2	34.20	7.3	34.20	7.0	34.15	6.6	34.19	6.4	34.24	7.6	34.18
600	5.9	34.32	6.1	34.28	5.9	34.34	5.7	34.27	5.6	34.31	5.8	34.36	5.8	34.23
800	5.1	34.48	5.2	34.47	5.0	34.53	5.0	34.49	4.7	34.45	4.8	34.52	5.0	34.48
1,000	4.5	34.52	4.5	34.54	4.2	34.58	4.3	34.56	4.2	34.54	4.2	34.56	4.4	34.50
1,200	3.8	34.55	3.8	34.57	3.7	34.61	3.7	34.59	3.6	34.57	3.7	34.59	3.8	34.59

Appendix 1-2

Date	1981. 5. 19		1981. 5. 19		1981. 6. 9		1981. 6. 8		1981. 6. 7		1981. 6.4		1981. 6. 5	
Stn	8		9		10		11		12		18		19	
Lat	20°-15′.0N		20°-15′.0N		14°-57′.7N		16°-01′.0N		16°-59′.6N		17°-56′.1N		19°-02′.0N	
Long	160°-59′.8W		160°-00′.0W		165°-46′.9W		165°-39′.2W		165°-41′.4W		165°-43′.8W		165°-45′.1W	
	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰
0	26.1	34.87	26.0	34.74	26.4	34.62	26.4	34.66	26.3	34.60	26.5	34.78	26.5	34.81
10	26.0	34.87	26.0	34.74	26.4	34.62	26.4	34.66	26.3	34.60	26.5	34.78	26.5	34.81
20	25.9	34.88	26.0	34.74	26.4	34.62	26.4	34.66	26.3	34.60	26.5	34.78	26.5	34.81
30	25.7	35.05	26.0	34.74	26.4	34.62	26.3	34.66	26.3	34.60	26.5	34.78	26.3	34.86
50	25.3	35.18	25.5	35.05	26.3	34.62	26.3	34.66	26.3	34.60	26.4	34.78	25.0	35.30
75	24.2	35.22	24.8	35.21	25.2	34.72	26.2	34.66	26.2	34.60	26.0	34.88	24.0	35.33
100	23.0	35.23	23.3	35.16	24.6	34.94	25.1	34.74	25.5	34.64	25.7	35.02	23.2	35.33
150	20.7	35.18	20.8	35.12	19.8	34.90	22.3	34.90	23.0	35.04	22.0	35.02	20.7	35.15
200	18.0	34.19	18.0	34.95	15.7	34.56	17.0	34.66	18.9	34.75	18.9	35.02	18.1	34.96
300	11.9	34.30	13.5	34.46	10.5	34.32	9.7	34.28	12.1	34.34	12.5	34.36	12.1	34.33
400	8.6	34.22	9.1	34.19	8.1	34.42	8.5	34.45	8.6	34.26	8.9	34.23	9.2	34.20
500	6.6	34.21	7.0	34.27	7.0	34.50	7.2	34.43	7.3	34.45	7.8	34.40	7.2	34.18
600	5.8	34.36	6.1	34.38	6.5	34.54	6.6	34.52	6.7	34.49	7.2	34.48	6.2	34.32
800	4.8	34.49	5.2	34.52	5.4	34.54	5.5	34.55	5.5	34.54	5.8	34.54	5.1	34.50
1,000	4.3	34.58	4.4	34.56	4.6	34.58	4.6	34.58	4.7	34.57	4.8	34.57	4.5	34.56
1,200	3.8	34.60	3.8	34.59	3.9	34.60	4.1	34.60	4.0	34.60	4.0	34.60	4.0	34.58

Appendix 1-3

Date	1981. 6. 6		1982. 5. 10		1982. 5. 11		1982. 5. 12		1982. 5. 13		1982. 5. 14		1982. 5.15	
Stn	20		1		2		3		4		5		6	
Lat	20°-15′.4N		20°-13′.1N		20°-16′.8N		20°-18′.7N		20°-36′.4N		20°-30′.7N		20°-11′.6N	
Long	165°-43′.8W		172°-40′.7W		171°-43′.7W		170°-41′.6W		169°-41′.5W		168°-39′.6W		167°-41′.0W	
	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰
0	26.0	34.48	25.6	35.09	25.5	35.08	25.5	35.09	25.4	35.07	25.5	34.89	25.5	34.84
10	26.0	34.84	25.5	35.09	25.5	35.08	25.5	35.09	25.4	35.10	25.5	34.90	25.4	34.88
20	25.9	34.84	25.5	35.09	25.5	35.08	25.5	35.09	25.0	35.24	25.4	34.91	25.3	34.89
30	25.8	34.88	25.5	35.11	24.6	35.08	25.5	35.09	24.6	35.28	25.4	34.91	25.2	34.92
50	25.3	35.22	25:0	35.19	23.8	35.20	23.8	35.35	23.5	35.31	25.0	35.00	24.9	34.99
75	24.2	35.26	24.0	35.26	23.4	35.41	22.6	35.32	22.1	35.32	24.2	35.21	23.8	35.23
100	23.3	35.25	23.3	35.28	22.3	35.38	21.4	35.30	21.2	35.20	23.5	35.26	22.1	35.21
150	21.0	35.18	21.2	35.10	20.3	35.29	19.7	35.14	18.4	34.87	20.5	35.12	19.3	35.02
200	18.3	34.99	18.5	34.80	16.4	34.86	17.5	34.89	15.9	34.69	17.7	34.89	15.8	34.70
300	13.3	34.44	12.7	34.33	13.0	34.49	12.3	34.35	12.6	34.41	14.0	34.50	11.6	34.31
400	9.5	34.26	9.3	34.19	9.6	34.19	9.2	34.15	9.9	34.18	9.5	34.17	8.7	34.15
500	7.3	34.20	6.9	34.17	7.1	34.11	6.8	34.12	7.2	34.12	7.2	34.19	6.7	34.12
600	5.9	34.34	5.8	34.29	5.8	34.15	5.5	34.19	6.0	34.18	6.1	34.31	5.5	34.20
800	5.0	34.53	5.0	34.46	4.7	34.41	4.4	34.36	4.8	34.41	5.1	34.44	4.7	34.46
1,000	4.2	34.58	4.2	34.51	3.9	34.50	3.9	34.50	4.1	34.51	4.3	34.50	4.1	34.51
1,200	3.7	34.61	3.5	34.54	3.4	34.53	3.2	34.53	3.5	34.54	3.7	34.53	3.5	34.54

Appendix 1–4

Date	1982. 5. 16		1982. 5. 17		1982. 5. 17		1982. 5. 17		1982. 5. 17		1982. 5. 18		1982. 5. 18		1982. 5. 18	
Stn	7		8		9		10		11		12		13		14	
Lat	20°-08.′8N		20°-14.′7N		20°-14.′8N		20°-14.′8N		20°-15.′1N		20°-14.′8N		20°-15.′0N		20°-14.′9N	
Long	166°-40.′0W		165°-59.′6W		164°-59.′0W		163°-59.′7W		162°-58.′6W		161°-59.′7W		161°-00.′0W		160°-00.′0W	
	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰	Temp ℃	Sali ‰
0	25.8	34.54	25.9	34.45	26.3	34.29	26.1	34.32	25.7	34.33	25.6	34.37	25.9	34.27	25.9	34.30
10	25.7	34.60	25.8	34.46	26.2	34.27	25.8	34.35	25.7	34.33	25.6	34.37	25.8	34.27	25.7	34.29
20	25.6	34.61	25.5	34.54	26.0	34.26	25.6	34.33	25.6	34.32	25.6	34.44	25.7	34.32	25.7	34.30
30	25.6	34.62	25.3	34.66	25.9	34.26	25.5	34.34	25.1	34.53	25.1	34.76	25.5	34.39	25.4	34.52
50	25.0	34.95	24.7	35.00	25.4	34.56	25.1	34.45	24.7	35.07	24.4	35.15	24.6	34.98	24.9	34.89
75	24.2	35.14	23.6	35.15	24.6	35.08	24.4	35.09	23.4	35.21	23.5	35.21	23.6	35.17	24.0	35.13
100	23.2	35.11	21.9	34.93	23.5	35.14	23.1	35.23	22.6	35.21	22.5	35.20	22.9	35.23	22.7	35.16
150	19.7	34.90	18.3	34.71	20.7	35.00	20.6	35.10	20.2	35.09	19.2	34.95	20.5	35.05	19.7	35.06
200	16.6	34.72	15.7	34.52	16.9	34.49	17.2	34.83	16.4	34.76	16.9	34.79	17.0	34.79	17.4	34.82
300	10.7	34.21	10.2	34.22	11.5	34.25	11.3	34.27	12.3	34.35	12.0	34.30	11.6	34.27	12.0	34.27
400	8.1	34.12	8.4	34.20	8.8	34.23	8.5	34.13	8.8	34.14	8.7	34.14	8.7	34.23	8.5	34.14
500	6.1	34.15	6.1	34.15	6.7	34.20	6.5	34.14	6.7	34.16	6.6	34.15	6.9	34.26	6.4	34.17
600	5.1	34.25	5.5	34.29	5.4	34.25	5.6	34.27	5.6	34.26	5.5	34.22	6.0	34.35	5.3	34.30
800	4.6	34.45	4.7	34.46	4.6	34.46	4.7	34.43	4.6	34.43	4.7	34.44	4.8	34.46	4.6	34.47
1,000	4.0	34.51	4.0	34.52	3.9	34.52	4.1	34.51	4.0	34.51	4.0	34.51	4.1	34.51	4.0	34.53
1,200	3.4	34.54	3.5	34.55	3.4	34.55	3.5	34.54	3.5	34.54	3.5	34.55	3.5	34.55	3.3	34.56